INDY BERNOSTER

Essays at the Intersection of Psychology, Biology, and Entrepreneurship

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Essays at the Intersection of Psychology, Biology, and Entrepreneurship

Verslagen op het snijvlak van psychologie, biologie en ondernemerschap

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by

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Erasmus University Rotterdam

Doctoral Committee

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Table of Contents

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In January 2014, I missed the deadline for applying for a PhD project, simply because I could not find a topic that suited me well, and started looking for jobs outside academia. A few months later, I received an e-mail from prof. Jan Brinkhuis with the message that there was an open PhD position that did not only focus on economics, but also on psychology and biology. The fact that this topic was multidisciplinary interested me and so I applied for the position.

Now, almost five years later, my PhD thesis is finished. As experienced by many other PhD students before, writing a thesis on one topic for four years is a learning experience that comes with ups and downs. When this is accompanied by having three supervisors in different disciplines, who all have their own opinion, it becomes even more challenging. Nevertheless, I am glad that I have experienced the academic world and thus got the possibility to improve several skills, learn about electrophysiology and psychology in the economic world, and meet people from different cultures. The past four years of work were facilitated by the support and scientific contribution of many people. I want to express my gratitude to everyone who supported me and who contributed to the present thesis, and I would like to mention a few people in particular.

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1. Introduction and Conclusion

Indy Bernoster

The first chapter of the present thesis introduces and defines my research topics. The thesis consists of two parts, with separate, but overarching subjects. The first part adds to our knowledge at the intersection of psychology and entrepreneurship and the second part to our knowledge at the intersection of biology and entrepreneurship. This first chapter also provides summaries of the subsequent chapters – with particular research aims, findings, and contributions – and it concludes the thesis. Finally, it deals with the individual contribution to and publication status of each chapter.

1.1. Motivation

Entrepreneurship is an important area of research (Gorgievski & Stephan, 2016). Entrepreneurs create employment, facilitate productivity growth, and engender high quality innovations (Van Praag & Versloot, 2007). Therefore, they also play a role for economic growth and in the recovery from economic recessions (Erken, Donselaar, & Thurik, 2016; Koellinger & Thurik, 2012). A profound understanding of entrepreneurs enables better policies to stimulate entrepreneurship in modern economies. Although scholars generally agree on the importance of (knowledge about) entrepreneurs, they do not do so with respect to the definition of 'the entrepreneur'.

The definition of 'the entrepreneur' has been subject of debate for years and the answer on the question "what makes an entrepreneur?" depends on which literature one consults (Gartner, 1990). There is no consensus on one confined, clear concept of 'the entrepreneur'. In fact, its conception is broad (Stevenson & Jarillo, 2007) resulting in many definitions that can complement or contradict one another. Hébert and Link (1989) have identified at least twelve distinct roles of 'the entrepreneur', while Shane and Venkataraman (2000) admit difficulty in setting up a conceptual framework for entrepreneurship because of its ambiguous definition. According to them, entrepreneurship studies the sources of opportunities, the process of discovery, evaluation, and exploitation of these opportunities, and the individuals who constitute this process. Eckhardt and Shane (2003) emphasize that this perspective means that entrepreneurship could attribute to both managers and business founders and that not all business founders are entrepreneurs per se. This emphasis does not only apply to the perspective of Shane and Venkataraman, but also to that of others. For instance, Schumpeter's definition describes the role of an entrepreneur as innovating: creating and introducing new products and services (Schumpeter, 1934). Further, Kirzner (1997) argues that entrepreneurs anticipate and solve inefficiencies in a market, Knight (1921) defines entrepreneurs as the ones that are willing to bear uncertainty of an unknown distribution of future profits, and Gartner (1988) marks entrepreneurship as the creation of organizations and he distinguishes between a behavioral approach, i.e. studying activities necessary for organization creation, and a trait approach, i.e. studying personality traits of the entrepreneur.

These different but overlapping definitions indicate the relevance of the present thesis as this thesis investigates the definition of 'the entrepreneur' by analyzing their psychological and biological traits. Hence, Gartner's trait approach is adopted. The reason for using the trait approach lays in recent developments in the field of entrepreneurship, being part of a much bigger research field: economics. Traditionally, economists employ the 'homo economicus' view, in which rational individuals are utility maximizing decision makers. However, partly thanks to Richard Thaler who won the Nobel prize for his contribution to the field of

behavioral economics (Thaler, 2014), the limitations of the traditional 'homo economicus' perspective have become clear and led to the development of the field 'behavioral economics' with ample room for emotional, psychological, and biological effects (Kahneman, 2011). This shift in focus of the economics discipline – from the view of rational individuals to the view of 'softer', irrational individuals – causes entrepreneurship research to also shift in this direction. Therefore, behavioral economics is used as a starting point and non-rational, emotional-based concepts from fields like psychology and biology are associated with entrepreneurship concepts.

When it comes to defining 'the entrepreneur', many aspects of entrepreneurship can serve as the main focus. For instance, the focus could be on entrepreneurial intention, choice, process, activities, orientation/strategy, health, well-being, success/performance, and so on. The present thesis focuses on, but is not confined to, four well-known entrepreneurial concepts: entrepreneurial intention (Liñán & Chen, 2009), entrepreneurial choice, entrepreneurial orientation (Covin & Slevin, 1989), and entrepreneurial success. By using these four entrepreneurial concepts as a guideline for the present thesis, the implicit focus is on micro-level entrepreneurship, i.e. which psychological/biological traits do individuals that score high on the entrepreneurial concepts have?

1.1.1 Entrepreneurial Intention

The first entrepreneurial concept investigated in the present thesis is entrepreneurial intention (Liñán & Chen, 2009). With entrepreneurial intention, the present thesis refers to the willingness to become an entrepreneur. Entrepreneurial intention is related to personality traits such as entrepreneurial self-efficacy (Chen, Greene, & Crick, 1998), optimism, and overconfidence (Giacomin, Janssen, & Shinnar, 2016). Besides this stream of literature, also profound psychological concepts such as four of the Big Five traits – i.e. conscientiousness, openness to experience, extraversion, and neuroticism (Brandstätter, 2011) – and the Behavioral Activation System (BAS; Geenen, Urbig, Muehlfeld, Van Wittelosstuijn, & Gargalianou, 2016) are associated with entrepreneurial intention. Recent literature takes entrepreneurship research to a next level by focusing on psychiatric disorders like Attention-Deficit/Hyperactivity Disorder (ADHD; Verheul, Block, Burmeister-Lamp, Thurik, Tiemeier, & Turturea, 2015) which is found to be related to entrepreneurial intention, although mediated by risk taking propensity.

Although Krueger and Carsrud (1993) first mention intention as the single best predictor of behavior, it recently received some critique and was proposed to be inappropriate because of doubts about whether intention indeed leads to actual behavior (Krueger, 2017). Nevertheless, Ajzen (1991) advocates that intention actually predicts behavior with his Theory of Planned Behavior. This theory states that personal attitude towards the behavior, subjective norm, and perceived

behavioral control forms intentions which in turn lead to actual behavior. Kautonen, Van Gelderen, and Fink (2015) find, with their study on start-up behavior, support for this theory in the entrepreneurship context. Even though Ajzen (1991) and Kautonen et al., (2015) raise confidence in the concept entrepreneurial intention, none of the chapters rely solely on this particular outcome: it is always accompanied with at least one other outcome to take Krueger's (2017) doubts into consideration.

1.1.2 Entrepreneurial Choice

Second, entrepreneurial choice, i.e. the actual choice to become an entrepreneur, is a concept of considerable interest. Several traits that are well-known to exist in entrepreneurs are risk taking propensity (Ahmed, 1985; Stewart Jr & Roth, 2001), need for achievement (Ahmed, 1985; Frese & Gielnik, 2014; Rauch & Frese, 2007), self-efficacy (Chen, Greene, & Crick, 1998; Frese & Gielnik, 2014; Rauch & Frese, 2007), internal locus of control (Ahmed, 1985), opportunity recognition (Baron, 2006), overconfidence (Busenitz & Barney, 1997), and innovativeness (Rauch & Frese, 2007), but also many other traits (Rauch & Frese, 2007) are found in entrepreneurs. Further, wealthier individuals are more inclined to become entrepreneur, but do not necessarily make better entrepreneurs (Evans & Jovanovic, 1989). Also, traits profoundly embedded in psychology, like the Big Five personality traits are associated with entrepreneurs (Brandstätter, 2011; Zhao & Seibert, 2006): entrepreneurs (opposed to managers) score higher on conscientiousness and openness to experience and lower on neuroticism and agreeableness. Results on extraversion are mixed. With respect to psychiatric symptoms, Wiklund, Yu, Tucker, and Marino (2017b) show that ADHD is related to entrepreneurship through aspects of impulsivity and Antshel (2017) reviews associations between ADHD symptoms and entrepreneurship measures and suggests that hyperactivity drives the association.

Inseparably adjacent to the choice of becoming an entrepreneur is the reason behind this choice. Although higher educated entrepreneurs may earn more than their employed counterparts (Sorgner, Fritsch, & Kritikos, 2017), entrepreneurs in the tertiary degree earn less than their counterparts. Åstebro, Herz, Nanda, and Weber (2014) discuss the irrationality of becoming an entrepreneur given the (mostly) negative expected utility: entrepreneurs have lower initial earnings and lower earnings growth than equally educated paid employees (Hamilton, 2000) and suffer from negative side effects such as stress (Blanchflower, 2004; Cardon & Patel, 2013). Åstebro et al. (2014) mention several reasons for entering entrepreneurship despite this negative prospect. They state that not just a risk-loving attitude and nonpecuniary benefits (Hamilton, 2000), i.e. getting pleasure from the organization of setting up a business, being independent of others, and being in control of your own life (Blanchflower, 2004), but also overconfidence could play a role (Åstebro, Jeffrey, & Adomdza, 2007). Further, coercion, in professions such

as farmer or artist, could be a reason to become an entrepreneur as self-employment is the norm in these professions. Hence, in case of coercion, the choice of becoming an entrepreneur is not always voluntary. A similar scenario exist for entrepreneurs in family businesses: children are nurtured such that they can take over the business and this is also expected from them. It is important to distinguish between these different reasons behind the choice of becoming an entrepreneur. Specifically, research should distinguish between entrepreneurs who really chose their occupation themselves and entrepreneurs who are more or less forced into entrepreneurship.

With respect to the role of entrepreneurial choice for the present thesis, the focus is on the reasons to become an entrepreneur as a selection mechanism to identify certain types of entrepreneurs (having different reasons for their entrance as entrepreneurs). The present thesis studies the specific groups resulting from this selection.

1.1.3 Entrepreneurial Orientation

The third entrepreneurial concept is entrepreneurial orientation, or strategic posture. Covin and Slevin (1989) define strategic posture as "a firm's overall competitive orientation" (p. 77). If this orientation is entrepreneurial, a more specific definition is relevant: "the strategy making processes that provide organizations with a basis for entrepreneurial decisions and actions" (Rauch, Wiklund, Lumpkin, & Frese, 2009, p. 763). Hence, entrepreneurial orientation indicates the degree of entrepreneurship in a firm's strategic posture (Lumpkin & Dess, 1996).

Entrepreneurial orientation is usually captured by three dimensions – innovativeness, proactiveness, and risk taking (Miller, 1983) – and measured at the firm-level (Covin & Slevin, 1989). Besides firm entrepreneurial orientation, there is individual entrepreneurial orientation (Langkamp Bolton & Lane, 2012) as not only firm-specific traits, but also individual-specific traits eventually lead to firm decisions according to the upper echelon theory. This upper echelon theory claims that organizational outcomes are predicted by managerial characteristics (Hambrick & Mason, 1984). Hence, entrepreneurs, who usually are (in) the managerial team, determine what will happen to the organization. Thus their individual-specific traits, which could be measured by individual entrepreneurial orientation, lead to a firm's strategic posture.

Entrepreneurial orientation is associated with personality traits such as overconfidence (Engelen, Neumann, & Schwens, 2015) and psychiatric symptoms that are associated with ADHD (Thurik, Khedhaouria, Torrès, & Verheul, 2016).

The present thesis focuses on entrepreneurial orientation in Chapters 2, 3, and 5.

1.1.4 Entrepreneurial Success

The fourth entrepreneurial concept is entrepreneurial success, which is part of a much bigger concept: success. The question 'when is an individual successful?' is a philosophical one of which the answer, when focusing on entrepreneurs, could relate to financial success, but also to firm growth, societal movement, or happiness (Lyubomirsky, King, & Diener, 2005).

When referring to financial success of the entrepreneur, findings show that education plays a role (Dickson, Solomon, & Weaver, 2008). Also, with regard to personality traits, self-efficacy and need for achievement (Frese & Gielnik, 2014; Rauch & Frese, 2007), optimism (Crane & Crane, 2007; Hmieleski & Baron, 2009), human capital (Haber & Reichel, 2007; Unger, Rauch, Frese, & Rosenbusch, 2011), social capital (Baron & Markman, 2000; 2003; Bosma, Van Praag, Thurik, & De Wit, 2004), and many other personal characteristics (Duchesneau & Gartner, 1990; Rauch & Frese, 2007) impact financial success. Further, psychological traits, such as several of the Big Five personality traits, relate to entrepreneurial success (Brandstätter, 2011). Besides, entrepreneurial success is correlated with entrepreneurial orientation (Avlonitis & Salavou, 2007; Lumpkin & Dess, 1996; Wiklund, Patzelt, & Shepherd, 2009) and this correlation is moderately large and robust (Rauch, Wiklund, Lumpkin, & Frese, 2009).

The present thesis focusses on financial success in Chapters 3 and 4 while in Chapter 4 also controlling for individuals that do not strive for financial success.

1.2. Research Topics: Part I and II

As brought forward in the previous section, there is a rising amount of papers at the intersection of psychology and entrepreneurship (Gorgievski & Stephan, 2016). Also, Frese and Gielnik (2014) notice the importance of investigating the psychology of entrepreneurship. Therefore, Part I of the present thesis builds on the intersection of psychology and entrepreneurship and aims to identify personality traits of the entrepreneurial concepts discussed in the previous section.

Although research at the intersection of psychology and entrepreneurship is often claimed to be important, it cannot explain the entrepreneurial concepts to full extent. Besides, most measures in studies empirically addressing this intersection are based on self-report, while self-reported measures – especially for psychological concepts – could contain biases because of, for instance, social desirability, consistency motif, and common method variance (Podsakoff & Organ, 1986). Therefore, recent studies extended the investigation of micro-entrepreneurship with biological factors such as hormones (Van der Loos et al., 2013b) and genes (Koellinger et al., 2010; Nicolaou, Shane, Cherkas, & Spector, 2008; Van der Loos et al., 2013a), but failed to adequately provide a satisfactory sketch of 'the entrepreneur'.

Therefore, Part II of the present thesis investigates the intersection of biological traits (resulting from experimental tasks recorded with electroencephalography (EEG)) and entrepreneurial concepts. This is in line with the suggestions of Ridderinkhof, Van den Wildenberg, Wijnen, and Burle (2004) and Krueger and Welpe (2014) to use behavioral and electrophysiological measures for explaining entrepreneurial constructs. As Krueger and Welpe (2014) state: "If we are to truly understand the entrepreneurial mindset, we need to look deeper" (p. 2). At the present time, there is lack of studies that empirically associate behavior and, in particular, electrophysiology to entrepreneurship, despite the fact that these type of studies is requested for (Pérez-Centeno, 2017).

1.3. Model and Data

The model of Figure 1.1 summarizes all chapters in the present thesis. Chapters 2, 3, and 4 fit in Part I of the present thesis and Chapter 5 and 6 in Part II. The model shows that the (self-reported) entrepreneurial concepts are associated with self-reported psychological measures – such as overconfidence, optimism, affect (Watson, Clark, & Tellegen, 1988), impulsivity, sensation seeking, and reward responsiveness –, and behavioral and electrophysiological measures from four EEG tasks: the Eriksen Flanker task (Eriksen & Eriksen, 1974), the Go/No-Go task (Littel, Van den Berg, Luijten, Rooij, Keeming, & Franken, 2012), the Balloon Analogue Risk Task (BART; Lejuez et al., 2002), and the Reward task (Franken, Van den Berg, & Van Strien, 2010). These EEG tasks constitute a wide variety of behavioral and electrophysiological measures.

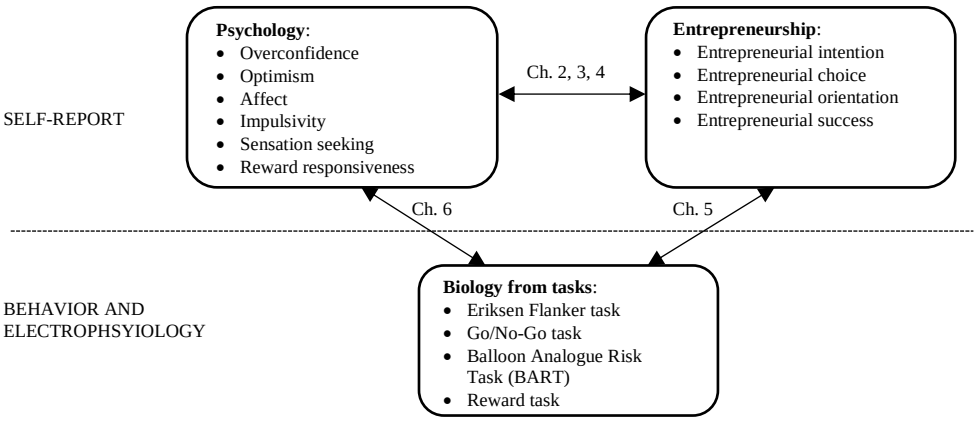

Figure 1.1. The overall model of the present thesis with all chapters (Ch.) presented on the corresponding arrows.

To investigate the presumed associations in the model of Figure 1.1, several samples are employed. The first sample (Sample 1) is a student sample collected by

Wim Rietdijk, a PhD student at the time (September 2013 – May 2014), and consists of 169 third- and fourth-year Erasmus University Rotterdam students. They reported on psychological and entrepreneurial constructs and participated in the Eriksen Flanker task and the Go/No-Go task. The second sample (Sample 2) employed in the present thesis is collected by Indy Bernoster, Plato Leung, and student-assistant Marwan Aboul Magd between May 2015 and April 2016. This sample, consisting of 182 Erasmus University Rotterdam students, provides information about entrepreneurial constructs, psychological constructs, and behavior and electrophysiology from the BART and Reward task. The third sample (Sample 3) is collected by Kristel de Groot, a PhD student (April 2017 – December 2017), and consists of 126 students of the Erasmus University Rotterdam. They reported on psychological and entrepreneurial constructs and participated in, amongst others, the BART. The fourth sample (Sample 4) consist of 851 Dutch sole proprietors. It is collected by Panteia, one of the largest market and policy research institutes in the Netherlands and focusses, amongst many other measures, on affect and entrepreneurial success. The fifth and final sample (Sample 5) used in the present thesis consist of 287 French Small and Medium Enterprise (SME) owners. It is collected by AMAROK, a research institute and partner of Montpellier Business School, of which the primary goal is to analyze the health of SME owners.

Each of the chapters in the present thesis consults one or several of these samples. Specifically, Chapter 2 consults Samples 2 and 5; Chapter 3 Samples 2, 4, and 5; Chapter 4 Sample 4; Chapter 5 Samples 1, 2, and 3; and Chapter 6 Samples 1 and 2. Although samples are used in multiple chapters, aims of these chapters differ such that the exact data used from the samples also differs.

1.4. Thesis Outline: Aims and Results

Chapters 2 through 6 of the present thesis investigate five separate aims. The present section describes the aim(s) and summarizes the results for each of these subsequent chapters.

1.4.1 Part I: The Intersection of Psychology and Entrepreneurship

The second chapter investigates the association between overconfidence and optimism on the one hand and entrepreneurial intention and orientation on the other. Overconfidence consists of three definitions: overestimation (i.e. overestimation of one's actual performance), overplacement (i.e. overplacement of one's performance relative to others), and overprecision (i.e. excessive precision in one's beliefs) (Moore & Healy, 2008) and is often confusingly conflated to optimism (Parker, 2009). Overconfidence is provided as one of the reasons why individuals start a business (Åstebro et al., 2014). Chapter 2 investigates the role of overconfidence in both entrepreneurial intention and entrepreneurial orientation while specifically

controlling for optimism. The findings, based on a student sample (N = 173) and a sample of Small and Medium Enterprise (SME) owners (N = 253), show that overconfidence (measured as overprecision) is positively associated with entrepreneurial intention, but not with entrepreneurial orientation, while optimism is positively associated with both. Others find that overconfidence fosters entrepreneurial orientation, but use overestimation instead of overprecision (Engelen et al., 2015). With these findings, Chapter 2 contributes to the entrepreneurship literature by describing the role of overconfidence and optimism in entrepreneurship. It further contributes to psychology literature by showing that overconfidence and optimism, but also the distinct definitions of overconfidence, play different roles in entrepreneurship.

Chapter 3 investigates the role of affect, the extent to which an individual subjectively experiences feelings and emotions, in entrepreneurial orientation, an important antecedent to entrepreneurial success (Rauch et al., 2009). In their systematic review of affect and entrepreneurship, Delgado García, Quevedo Puente, and Blanco Mazagatos (2015) advocate that one should investigate the consequences of affect across the entrepreneurial process. Also, Hahn, Frese, Binnewies, and Schmitt (2012) mention that affect is a neglected concept in entrepreneurship and that future research should establish its role in the entrepreneurial process. Hence, the third chapter investigates the role of both positive and negative affect in entrepreneurial orientation and, subsequently, entrepreneurial success. The findings, based on 177 Dutch students, 337 Dutch sole proprietors, and 254 French SME owners show that there is a positive association between positive affect and both individual and firm entrepreneurial orientation and a negative association between negative affect and individual entrepreneurial orientation. Further, the chapter hints to a positive association between positive affect and entrepreneurial success and a negative association between negative affect and entrepreneurial success, but the findings show no indirect effect of affect on entrepreneurial success (through entrepreneurial orientation). The third chapter contributes to entrepreneurship literature by exploring the role of affect for entrepreneurial orientation and its consequence, i.e. entrepreneurial success. It further contributes to the field of psychology by showing that the orthogonality of positive and negative affect also holds in entrepreneurship and should not be ignored in studies about affect.

The fourth chapter elaborates on the third by investigating the role of positive affect in the key aspects of the entrepreneurial process and entrepreneurial success. Baron (2008) shows, with his theoretical paper, that positive affect is – via some basic cognitive processes – positively associated with the key aspects of the entrepreneurial process, viz. opportunity recognition, acquisition of financial and human resources, development of broad social networks, capacity to respond effectively to highly dynamic environments, and tolerance for intense levels of stress. In Chapter 4, an adapted version of Baron's model is augmented with

entrepreneurial success, the focal goal of entrepreneurship. With this augmented model, Chapter 4 provides an empirical test for the by Baron (2008) theoretically substantiated associations between positive affect and the key aspects of the entrepreneurial process and it tests whether positive affect is associated with entrepreneurial success (whether or not mediated by these key aspects of the entrepreneurial process). The findings, based on more than 800 Dutch sole proprietors, show that positive affect is positively associated with the key aspects of the entrepreneurial process and that these key aspects are positively associated with entrepreneurial success. The findings also provide evidence for the indirect positive association between positive affect and entrepreneurial success through the key aspects of the entrepreneurial process. With these findings, Chapter 4 contributes to the knowledge about entrepreneurial success. There are many studies associating positive affect and success (Lyubomirsky et al., 2005), but not many studies investigate the role of affect in entrepreneurial success. The fourth chapter also contributes to the entrepreneurship literature by providing an empirical test of Baron's (2008) propositions.

1.4.2 Part II: The Intersection of Biology and Entrepreneurship

Chapter 5 is the first chapter devoting attention to the biology of an entrepreneur. It associates behavior and electrophysiology of four experimental tasks measuring impulsivity (Eriksen Flanker task, Go/No-Go task, BART, and Reward task) and self-reported impulsivity to entrepreneurial concepts such as entrepreneurial intention, choice, and orientation, but also entrepreneurial personal attitude, subjective norm, and perceived behavioral control (Ajzen, 1991). The findings, based on three student samples with sizes 133, 142, and 119 – which are perceived as large in the electrophysiology context, show that behavioral and electrophysiological measures are not associated with self-reported entrepreneurial concepts and thus cannot serve as substitutes to or complements for self-reported impulsivity(-related) constructs.

Chapter 6 builds on this null finding by testing the role of behavior and electrophysiology in self-reported impulsivity-related concepts which are 'closer' to the behavioral and electrophysiological measures than the self-reported entrepreneurial concepts of Chapter 5. Previous studies report significant associations between the behavioral and electrophysiological measures employed in Chapter 6 and the self-reported impulsivity-related concepts to which they are associated. Hence, the expectation is to find similar associations as found in these previous studies. Nevertheless, the analysis, based on the first two samples of Chapter 5, results in null findings again.

The results of Chapters 5 and 6, i.e. Part II of the present thesis, could be interpreted in several ways. The first interpretation is that there simply exists no association between behavior/electrophysiology and entrepreneurship (Chapter

5)/impulsivity-related concepts (Chapter 6). However, in this case it is hard to explain why so many previous studies found significant associations between behavior/electrophysiology and impulsivity-related constructs similar to the ones of Chapter 6 (Geburek, Rist, Gediga, Stroux, & Pedersen, 2013; Lejuez, Aklin, Zvolensky, & Pedulla, 2003; Littel et al., 2012; Potts, George, Martin, & Barratt, 2006; Zheng, Sheng, Xu, & Zhang, 2014). An explanation for the difference between the findings of Chapter (5 and) 6 and previous studies – i.e. null findings versus significant findings – could be the difference in sample size, which is around 20 to 40 participants for these previous studies and about 134 for the samples of Chapters 5 and 6. The key problem regarding small samples is that they lead to low statistical power and thus have a lower chance that discovered effects are genuinely true (Button et al., 2013; Forstmeier, Wagenmakers, & Parker, 2017; Ioannidis, 2005). Hence, this could explain the significant findings in earlier (small sample sized) studies while the present thesis fails to confirm these findings.

Second, experimental EEG tasks such as the Eriksen Flanker task and the Go/No-Go task have, according to Hedge, Powell, and Sumner (2017), low between individual variance in their outcomes (e.g. reaction time, performance). This low between individual variance is beneficial for experiments, but problematic in testing associations to other (economic) individual differences (Meyer, Lerner, De Los Reyes, Laird, & Hajcak, 2017). Hence, the reason of null findings in Part II of the present thesis could be the use of experimental EEG tasks. However, this would not explain the significant findings in earlier studies.

A third reason for the null findings is that the behavioral and electrophysiological measures are implicit, i.e. representing preconscious processes, while self-reported entrepreneurship concepts and impulsivity-related constructs are explicit, i.e. representing the conscious results of preconscious processes (Dittmar, Krehl, & Lautenbacher, 2011; Eysenck, 1992). Dittmar et al. (2011) also failed to find significant associations between electrophysiological, behavioral, and self-reported measures in pain-related information processing and argue that the reason could be the use of both implicit and explicit measures.

The contribution of Chapters 5 and 6 is inducing awareness that steps forward in the world of electrophysiology as explanatory role are needed. The present thesis discusses these steps in more detail in the section ‘Conclusion: Contributions and the Future’.

1.5. Conclusion: Contributions and the Future

The question ‘What makes an entrepreneur?’ has been a fundamental question for economics, management, and psychology researchers over the last decade. A profound understanding of ‘the entrepreneur’ enables the establishment of better policies to stimulate entrepreneurship in modern economies. This is crucial as

entrepreneurship is essential for economic growth (Erken et al., 2016; Koellinger & Thurik, 2012; Van Praag & Versloot, 2007).

The present thesis deals with the definition of 'the entrepreneur' by investigating the roles of psychological traits (Part I) and biological traits (Part II) in several well-known entrepreneurial concepts, such as entrepreneurial intention, entrepreneurial choice, entrepreneurial orientation, and entrepreneurial success. The findings of Chapters 2, 3, and 4 show that overconfidence, optimism, and both positive and negative affect are associated with entrepreneurship. Chapters 5 and 6 fail to provide evidence for the association between biological traits, such as behavioral and electrophysiological traits (obtained from experimental EEG tasks), and self-reported measures of entrepreneurship (and impulsivity).

1.5.1 Overall Contribution

Besides the chapter-specific contributions as discussed earlier, the present thesis provides several overall contributions. First, Chapters 2, 3, and 4 contribute to the great rationality debate of Zhang and Cueto (2017). The great rationality debate asks the question of whether humans are rational such as traditionally assumed. As shown by the results of Chapter 2, overconfidence, a cognitive bias, and optimism are associated with 'rational' economic variables: entrepreneurial intention and entrepreneurial orientation. Although a typical entrepreneurial environment with high levels of uncertainty, novelty, and time pressure, could lead to cognitive biases (Baron, 1998) such as overconfidence, this does not necessarily induce negative side effects, but it could also be a good thing for specific groups of the society such as entrepreneurs. In a similar way, Chapters 3 and 4 show that both positive and negative affect, i.e. someone's subjective experience of feelings and emotions, which are irrational by definition, are associated with more rational concepts such as entrepreneurial process, orientation, and success. Altogether, humans make rational decisions based on irrational psychological traits and hence, in terms of the great rationality debate, the present thesis suggests that human are irrational and that, for some, this irrationality could even lead to preferable outcomes. This is in line with Darwinism: if irrational decisions would not lead to preferable outcomes, humans would have evaluated to being rational.

Second, Chapters 3 and 4 contribute to the urgent request to fill the empirical gaps emerging in the rapidly developed affect-entrepreneurship literature (Cardon, Foo, Shepherd, & Wiklund, 2012; Delgado García et al., 2015; Hahn et al., 2012). Delgado García et al. (2015) write on their research agenda that "entrepreneur's affect might influence subsequent stages in the entrepreneurial process which could in turn have an impact on venture success" (p. 205) and Hahn et al. (2012) mention that "affect is a neglected concept in entrepreneurship research, and scholars are urged to pay more attention to the role of affect in the entrepreneurial process (Baron, 2008)" (p. 99). With Chapters 3 and 4, the present thesis follows these

studies by showing that positive affect and negative affect are associated with entrepreneurial orientation and that positive affect is (indirectly through the entrepreneurial process) positively associated with entrepreneurial success. This is in line with Baron's earlier finding that positive affect may enhance the work environment and hence the attitude and performance of the workers within this environment (Baron, 1990).

A third contribution lays in the field of neuro-entrepreneurship (Krueger & Welpe, 2014). The idea to incorporate electrophysiology in entrepreneurship is novel and much demanded (Pérez-Centeno, 2017). Chapter 5 shows however that there is no association between behavioral and electrophysiological measures on the one hand and self-reported entrepreneurial concepts on the other. The chapter reports null findings despite of using large samples, four different experimental EEG tasks generating many different behavioral and electrophysiological measures, and multiple entrepreneurial concepts. Nevertheless, Chapter 5 contributes to a first step in this neuro-entrepreneurship field. The null findings should encourage the field even more to investigate why there is no association between behavior/electrophysiology from the four experimental EEG tasks of Chapter 5 and entrepreneurship. Many suggestions are given about what these null findings would imply for the way forward.

The fourth contribution is based on the null findings of Chapter 6 and is more fundamental for the field of electrophysiology. The null findings of Chapter 6 could be explained by the fact that there is indeed no association between behavior/electrophysiology and self-reported impulsivity concepts. However, previous studies report significant assocations between our behavioral/electrophysiological measures and self-reported impulsivity concepts. Therefore, Chapter 6 advances this existing field by 'replicating' these earlier findings in large samples. As Chapter 6 fails to find the expected associations between behavior/electrophysiology and self-reported impulsivity concepts, it raises doubt about the actual association found in earlier studies. A possible reason for being unable to find associations in Chapter 6 could be the use of large sample sizes. As explained before, low sample sizes of earlier studies cause a lower chance that discovered effects are genuinely true (Button et al., 2013; Forstmeier, Wagenmakers, & Parker, 2017; Ioannidis, 2005).

Altogether, the present thesis contributes to the field of entrepreneurship by focusing on the psychology of the entrepreneur, with concepts such as overconfidence, optimism, positive affect, and negative affect, and on the biology of the entrepreneur. In other words, the present thesis extends our knowledge of the entrepreneurial profile. It also contributes to the field of psychology by showing the positive role that cognitive biases, such as overconfidence, could play for, for instance, entrepreneurs. Hence, this field will gain insights in why some psychological concepts can be problematic in one person (patient) but beneficial in another (entrepreneur). Finally, the present thesis contributes to the field of biology,

especially electrophysiology, with null findings despite of analyzing large samples and while small samples report significant findings. This field can therefore benefit from the present thesis by investigating why larger samples fail to find presumed associations.

From a practical perspective, the present thesis contributes to our knowledge about the profile of 'the entrepreneur'. This knowledge can help correctly matching personality profiles to occupations which is important according to Person-Environment Fit theory. A mismatch between the two could be detrimental to one's mental and physical well-being. By knowing more about the entrepreneurial personality profile matching principles can improve. Further, knowing whether an individual is better suited for entrepreneurship than for being an employee, especially at an early age, can improve education. For instance, the Dutch education system is better fitted for well-organized, disciplined children than for hyperactive, creative ones. The entrepreneurial profile usually does not match this present educational system, but knowing in the early age that a child is suited for entrepreneurship could result in fitting education.

1.5.2 Future Research

While the focus of the present thesis is on (the psychology (Part I) and biology (Part II) of) entrepreneurship, future studies are certainly not confined to this specific form of occupational choice. Investigating personality, behavior, and electrophysiology is possible in other manifestations of economic behavior and outcomes, such as occupational choice in general, unemployment, or education, but also in success, health, and happiness. In the present thesis, entrepreneurship serves as a proof of concept. Future studies are encouraged to expand profiles, not only of entrepreneurs, but also of other types of people and other types of economic outcomes.

Further, future studies should expand knowledge of personality traits fitting 'the entrepreneur' and focus especially on entrepreneurial success. The amount of studies on entrepreneurial intention is ample (Krueger, 2017) and an imbalance in the amount of studies per well-known and validated entrepreneurial concept should be avoided. Also, entrepreneurial success is focal for entrepreneurship, and thus, the present thesis urges to expand the knowledge of entrepreneurial success.

Not only could studies expand on the entrepreneurship side, future research could and should also expand on the psychology side. Especially when cognitive biases or even psychiatric disorders could be proven to be beneficial for a small amount of people, i.e. entrepreneurs, this would destigmatize 'patients' with certain forms of psychopathology. It would further contribute to the idea derived from evolutionary psychology that psychological 'symptoms' should have evolutionary benefits that are needed for survival of the species. Initiatory studies in the entrepreneurship field that show disorders – or symptoms of these disorders – to

have beneficial value for specific groups are based on ADHD (Antshel, 2017; Canits et al., 2018; Thurik et al., 2016; Verheul et al., 2015).

Also, mostly linear associations are investigated, while for instance, optimism and positive affect, could be beneficial, but not if one has too much of these traits. Therefore, the focus should also shift to the 'optimal' personality profiles for, for instance, entrepreneurs. Baron, Hmieleski, and Henry (2012) and Baron, Tang, and Hmieleski (2011) take first steps in finding an optimal profile by showing that the association between dispositional positive affect and performance tasks closely related to new venture development and growth is curvilinear. Another perspective of positive affect that should be taken into account in future (entrepreneurship) studies is that besides the orthogonality of positive and negative affect, also an activation and deactivation division is present (Feldman Barrett & Russell, 1998).

With respect to Part II of the present thesis, future research options are plentiful. One conclusion arising from the null findings in our large samples is the lower chance that discovered effects are genuinely true in smaller samples. Hence, the present thesis strongly advices to replicate previous findings based on smaller samples in large samples so that the probability of reporting genuinely true effects becomes higher. This means that, also the in the field of electrophysiology, one should shift to modern big data settings.

Further, future studies should aim to increase our knowledge of the biological traits of the entrepreneur by incorporating not only behavior and electrophysiology, but also other dimensions such as health, physiology (e.g. heartbeat and blood pressure), hormones (Van der Loos et al., 2013b), and genetic information (Koellinger et al., 2010; Van der Loos et al., 2013a), to provide a more complete picture. With respect to behavior and electrophysiology, many more measures of other experimental EEG tasks, such as the (uncensored) Columbia Card Task (CCT), could be incorporated. However, before applying the role of biology in, for instance, entrepreneurship, future research should first develop a consistent and comprehensive knowledge of all these biological dimensions in itself.

In sum, although the present thesis contributes to the psychological and biological knowledge of several entrepreneurial concepts, the entrepreneurial profile still contains plenty of non-discovered mysteries.

1.6. Individual Contributions and Publication Status per Chapter

The present section discusses my contributions for each chapter in the present thesis. I wrote the current chapter, i.e. Chapter 1, independently. However, I received valuable comments of my supervisors which I took into account. Further, I based the idea of Figure 1.1 on models presented in earlier (unpublished) work of Professor Thurik.

The research idea of Chapter 2 is based on earlier work of our research group: "Living forever: entrepreneurial overconfidence at older ages" (Rietveld, Groenen, Koellinger, Van der Loos, & Thurik, 2013). The original first draft of this chapter was mainly written by me and Dr. Rietveld, after which we alternately (re)wrote parts of the text. I was responsible for the data analysis. This analysis was based on two datasets. I collected, together with PhD student Leung and student-assistant Aboul Magd, one of these datasets. The other dataset was obtained via AMAROK (of which Professor Torrès is founding president). Together with Dr. Rietveld, I reviewed and edited the text. Professor Thurik had a supervisory role and was, together with Professor Torrès, responsible for 'final check' rounds.

Chapter 3 is based on a research idea developed during the sessions where we (Professor Thurik and I) discussed the role of affect in entrepreneurship. We could not find studies that investigated the role of affect in entrepreneurial orientation and decided to investigate this role. I took the lead in writing the first draft of this chapter and I am responsible for the data analysis refered to in this chapter. Dr. Mukerjee joined in writing and gave suggestions. Together, we processed comments from readers of our manuscript. For the data analysis, three datasets were used. The first dataset was collected by Panteia. I was responsible for several items in Panteia's survey. I obtained the dataset with the help of Dr. De Vries. He also improved the items that I was responsible for. The second dataset, collected by AMAROK, is decribed in the preceding paragraph (about Chapter 2) as is the third dataset that was collected by me, PhD student Leung, and student-assistant Aboul Magd. Professor Thurik supervised and edited the text several times.

The idea of Chapter 4 is based on an idea developed by Professor Thurik and Dr. Khedhaouria. The manuscript was written by me and Dr. Khedhaouria, after which we alternately improved and changed parts of the written text. I was responsible for the data analysis, which was based on the dataset of Panteia (as described in the preceding paragraph about Chapter 3). Professor Thurik had a supervisory role.

The research ideas for Chapters 5 and 6 are based on that of a former PhD student – Dr. Rietdijk – and existed when I started my PhD. I took over his data, and developed the existing ideas in several ways. That is, I added another dataset (collected by me, PhD student Leung, and student-assistant Aboul Magd, as described in the preceding paragraph about Chapter 2) and the entrepreneurship dimension (in Chapter 5). For Chapter 5, a third dataset, collected by PhD student De Groot, was included. For both Chapters 5 and 6, I am responsible for the data analysis and I took the lead in writing. PhD student De Groot reviewed and edited the final manuscripts. Professor Wieser commented on and edited parts of the text in Chapter 6. Also, PhD student Canits gave comments on the positioning of the psychological concepts in these chapters, and Professor Wiklund suggested the idea to analyze results amongst high-impulsivity groups (Chapter 5). Further, Dr. Luijten, Dr. Marhe, and Dr. De Vlaming gave comments to earlier versions of these

chapters. Professor Thurik and Professor Franken supervised, reviewed, and edited the chapters, where the focus of Professor Thurik was on Chapter 5 and the focus of Professor Franken was on Chapter 6.

The publication status of each chapter is shown in Table 1.1. This table also reports the status of studies that fall outside the content of the present thesis.

Table 1.1. Publication status of the chapters and other studies.

Chapter	Title	Reference	Presentations	Publication status
2	Overconfidence, Optimism, and Entrepreneurship	Bernoster, Rietveld, Thurik, & Torrès (2018)	Paris (2017)	Published in *Sustainability*
3	The Role of Affect in Entrepreneurial Orientation	Bernoster, Mukerjee, & Thurik		Manuscript under review
4	Positive Affect, the Entrepreneurial Process, and Entrepreneurial Success of Sole Proprietors	Bernoster, Khedhaouria, & Thurik	Lyon (2016), Montpellier (2016), Siegen (2017)	Manuscript under review
5	The Role of Behavioral and Electrophysiological Measures in Entrepreneurship	Bernoster, De Groot, Franken, & Thurik	Warwick (2018)	Manuscript to be submitted
6	Electrophysiological, Behavioral, and Self-Reported Measures of Impulsivity: Different Sides of the Same Coin?	Bernoster, De Groot, Wieser, Thurik, & Franken		Manuscript submitted
	Other papers			
	Attention-deficit/hyperactivity disorder (ADHD) symptoms and academic entrepreneurial preference: is there an association?	Canits, Bernoster, Mukerjee, Bonnet, Rizzo, & Rosique-Blasco (2018)	Siegen (2017)	Published in *Small Business Economics*
	Psychiatric symptoms and entrepreneurial intention: the role of behavioral activation system	Leung, Bernoster, Franken, & Thurik	Syracuse (2016)	Manuscript in progress
	Accurate Computation of Reliability in Event-Related Potentials Associated with the Erisken Flanker Experiment	Bernoster, Franken, & Groenen		Manuscript in progress

Part I

Psychology and Entrepreneurship

2. Overconfidence, Optimism, and Entrepreneurship

Indy Bernoster
Cornelius A. Rietveld
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Abstract. Overconfidence is one of the alleged drivers for market entry. However, establishing its effect is challenging and much of the existing entrepreneurship literature confusingly conflates overconfidence with optimism. In the present study, we use validated scales to analyze the relationship between overconfidence and two important aspects of entrepreneurship, while explicitly controlling for optimism. Specifically, we study the role of overconfidence in developing intentions about entering entrepreneurship as well as how overconfidence relates to entrepreneurial orientation. Our findings show that overconfidence is related to intended market entry but not to the market position (entrepreneurial orientation) of the business.

2.1. Introduction

Entrepreneurship is crucial for economic growth and development (Audretsch, 2007; Baumol, 2002; Koellinger & Thurik, 2012), but the high failure rate of business start-ups (Dunne, Roberts, & Samuelson, 1988; Geroski, 1995; Hessels, Grilo, Thurik, & Van der Zwan, 2011) and relatively low average returns compared to wage-work (Hamilton, 2000) suggest that too many people become entrepreneurs (Camerer & Lovallo, 1999; Blanchflower, 2004; Koellinger, Minniti, & Schade, 2007). Part of this excess market entry is thought to result from overconfidence about future entrepreneurial success (Cooper, Woo, & Dunkelberg, 1988; Roll, 1986; Wu & Knott, 2006). Evidence for this hypothesis has been provided by experimental studies in which optimal criteria for market entry behavior were examined and both actual behavior and expectations were observed (Camerer & Lovallo, 1999). However, experimental studies using students in a laboratory setting have limited external validity. Establishing overconfidence as a driver of entrepreneurial activity using field data is nevertheless challenging, for at least three methodological reasons.

First, overconfidence is a heterogeneous concept that includes overestimation, overplacement, and overprecision (Weinstein, 1980; Åstebro, Herz, Nanda, & Weber, 2014). Overestimation refers to "overestimation of one's actual performance", overplacement to "overplacement of one's performance relative to others", and overprecision to "excessive precision in one's beliefs" (Moore & Healy, 2008). These three types may relate differently to aspects of the entrepreneurial process (Åstebro et al., 2014).

Second, measures for overconfidence and optimism are often conflated in empirical studies. For example, Trevelyan (2008) used entrepreneurial self-efficacy as a proxy for overconfidence, which is conceptually more closely related to optimism than to overconfidence. Similarly, Giacomin, Janssen, and Shinnar (2016) argued that self-reports on the lack of importance of entrepreneurial skills proxies overconfidence in entrepreneurial abilities. Nevertheless, interpreting overconfidence as a proxy for optimism appears warranted (Åstebro et al., 2014): lacking entrepreneurial skills is unimportant because everything will turn out well (Weinstein, 1980). Unsurprisingly, Parker's review of the empirical literature on entrepreneurial overconfidence, ends with the conclusion that, "Despite the fact that [over]optimism and overconfidence are distinct concepts, much of the literature confusingly conflates them. At the risk of sounding pedantic, this practice should be discouraged in future." (Parker, 2009, p. 191). In this respect, Åstebro et al. (2014) also noted that "multiple measures and definitions across empirical studies have made it hard to pin down the precise bias that may be behind entrepreneurship".

Third, existing field studies linking self-perceptions to entrepreneurial behavior typically used measures of overconfidence that are related to occupational choices and hence are prone to reverse causation problems. For example, the studies

by Koellinger and colleagues (2007, 2013) used data from the Global Entrepreneurship Monitor and asked respondents whether they believe they have sufficient skills to start and run a new company. In such a setting, individual beliefs may cause occupational choices, but occupational choices and experience may also cause changes in individual beliefs as a result of self-justification, learning-by-doing, or new information that becomes available over time (Szerb & Vörös, 2018).

Hence, establishing whether overconfidence drives excess market entry using field data is important. This current study attempts to address this research question by analyzing how a particular underresearched type of overconfidence, overprecision, and optimism are related to two aspects of the entrepreneurial process. First, we analyze entrepreneurial intention (Liñán & Chen, 2009) among students, to circumvent the potential danger of reverse causality between labor market status, and overconfidence and optimism. Students still need to choose their main occupation and effects of entrepreneurial experience on overconfidence or optimism are disregarded. In addition, we analyze how overconfidence and optimism are related to entrepreneurial orientation (Covin & Slevin, 1989) among small and medium-sized enterprise (SME) owners. The market position of a business (i.e., entrepreneurial orientation) plays a crucial role in competitiveness (Lee & Peterson, 2001), business performance (Lumpkin & Dess, 1996; Wiklund & Shepherd, 2003; 2005), and business survival (Rauch, Wiklund, Lumpkin, & Frese, 2009) and is directly linked to the characteristics and behavior of the owner-manager in SMEs.

The main contribution of the present study is the empirical investigation into how overconfidence influences market entry (entrepreneurial intention) and market position (entrepreneurial orientation) using field data. Several studies argued that entrepreneurs are more prone to overconfidence than wage workers (Busenitz & Barney, 1997; Baron, 1998). However, existing field studies on entrepreneurial overconfidence focused only on a relatively specific control group, such as managers (Busenitz & Barney, 1997; Forbes, 2005), or have no control group (Wu & Knott, 2006). More importantly, because entrepreneurial experience may induce overconfidence (Busenitz & Barney, 1997; Forbes, 2005; Hsu, Wiklund, Cotton, 2017) it is difficult to conclude from these studies whether overconfidence is indeed a driver of (excess) business entry. Therefore, the present study investigates the effect of overconfidence on entrepreneurial intention among individuals that still must choose their main occupation to establish if overconfidence is related to entrepreneurial entry. Subsequently, the relationship between overconfidence and entrepreneurial orientation is analyzed among entrepreneurs to understand how overconfidence is related to the business's market position.

Alongside, our study contributes to the literature by distinguishing the effect of overconfidence from the effect of optimism by analyzing validated measures for

both simultaneously.[1] The present study distinguishes overconfidence (viz. overprecision) from optimism, in explaining entrepreneurial intention and entrepreneurial orientation. If the effects of overconfidence and optimism are distinct, this would clearly underscore Parker's warning. However, if not, despite the theoretical distinction between the two concepts, it would indicate the practical (empirical) irrelevance of Parker's advice. Moreover, Cooper et al. (1988) showed that it is empirically impossible to distinguish overestimation and overplacement (as types of overconfidence) from optimism, we attempt to show whether it is possible to empirically distinguish between overprecision and optimism. Hence, our study aims to show the extent to which it is possible and necessary to distinguish between overconfidence (overprecision) and optimism in (future) studies linking cognitive biases to the entrepreneurial process.

2.2. Theory and Hypotheses

The analysis of cognitive biases related to entrepreneurial decision making is an important research area (Åstebro, Herz, Nanda & Weber, 2014; Baron, 1998; Gorgievski & Stephan, 2016; Zhang & Cueto, 2017) and overconfidence is amongst the most studied biases (Busenitz & Barney, 1997; Forbes, 2005; Wu & Knott, 2006). Overconfidence can lead to individually suboptimal decisions. For example, overconfidence in stock investment reduces returns on investment (Barber & Odean, 2001), managerial overconfidence can generate distortions in corporate investment (Malmendier & Tate, 2005), and the trading volume in financial markets is higher than the rational equilibrium expectation due to the presence of overconfident traders (García, Sangiorgi, & Urosevic, 2007). However, overconfidence can also be a positive driver at the individual level. Although accurate judgment and the absence of overconfidence are signs of good mental health (Dunning & Story, 1991; Fu, Koutstaal, Fu, Poon, & Cleare, 2005), overconfidence can also increase ambition, morale, resolve, and persistence (Johnson & Fowler, 2011; Szerb &

1 Two other studies relate both overconfidence and optimism simultaneously to aspects of the entrepreneurial process. The working paper by Koudstaal et al. (2015) shows that entrepreneurs are more optimistic than managers and employees, but they find no difference between entrepreneurs and managers with regard to overconfidence (viz. overestimation). We note that their incentivized measure of overestimation (congruence between the number of correctly solved test questions and the number of forecasted correct questions is awarded with 100 euro) may have led to situations in which individuals purposely fail all test questions to correctly forecast 0 correct answers and to win 100 euro. Åstebro, Jeffrey and Adomdza (2007) study the role of optimism and overconfidence in perseverance of inventors after they got the advice to stop their activity. Their overconfidence measure relates to overplacement as it compares the participant's estimate of being right to the group's estimate of being right. They find that investors are more optimistic and overconfident than the general population, and that optimism is related to continue spending money (not time) after receiving advice to stop. Overconfidence is not related to continue spending time and money after receiving advice to stop.

Vörös, 2018). In addition, at the social level, a certain amount of overconfidence can provide positive information externalities (Bernardo & Welch, 2001).

Due to the differences in economic uncertainty and the type of authority faced by entrepreneurs compared to employees, two different mechanisms lead to a higher level of overconfidence among entrepreneurs (Forbes, 2005). The first mechanism assumes that overconfident individuals self-select into entrepreneurship. Those who are more susceptible to the use of bias and heuristics to make decisions may be more inclined to become entrepreneurs because these biases and heuristics can be effective and efficient guides to decision-making in highly uncertain and complex environments (Busenitz & Lau, 1996; Busenitz & Barney, 1997). This view implicitly implies that the source of overconfidence is in the individual and it is thought to be a personality trait that is not limited to one specific situation or point in time. The second mechanism assumes that the entrepreneurial environment itself triggers overconfidence. Entrepreneurs constantly face situations that tend to overload their information-processing capacities and that are characterized by high levels of uncertainty, novelty, emotion, and time pressure. Together, these factors may increase entrepreneurs' susceptibility to a number of cognitive biases (Baron, 1998). Thus, overconfidence could be a function of the contextual factors encountered by entrepreneurs.

The first mechanism relates to the finding in experimental settings that overconfidence is related to market entry (Camerer & Lovallo, 1999). When subjects' post-entry payoffs are based on their own abilities, individuals tend to overestimate their chances of relative success and enter more frequently than they should. The second mechanism underscores the importance of measuring overconfidence in field data before market entry, to analyze its effect on entrepreneurial entry. Measuring (over)confidence by asking individuals about whether they believe they have sufficient skills to start and run a new company after actual market entry as reported by Koellinger et al. (2007, 2013), makes it difficult to draw definite conclusions about the relationship between overconfidence and (excess) market entry, due to Baron's (1998) argument as well as self-justification. Hence, to draw conclusions about whether overconfidence drives market entry, individuals should be followed throughout their working life, and overconfidence should be measured before and after actual entry.

To draw conclusions about the relation between overconfidence and entrepreneurship, distinguishing between types of overconfidence is important (Åstebro et al., 2014). Three subtypes of overconfidence exist: overestimation, overplacement, and overprecision, where overestimation refers to the "overestimation of one's actual performance", overplacement to the "overplacement of one's performance relative to others", and overprecision to the "excessive precision in one's beliefs" (Moore & Healy, 2008). Overestimation is closely related to optimism, because optimists overestimate the probability of success (Parker, 2009; Sharot, 2011). Overplacement requires a direct comparison with a reference

group, but is often observationally equivalent to overestimation and optimism. For instance, Cooper et al. (1988) could not distinguish between them in a sample of entrepreneurs. Overestimation and overplacement (and optimism) both lead to positively biased perceptions about expected returns in entrepreneurship, so are therefore expected to be positively related to entrepreneurial entry (Åstebro et al., 2014).

Overprecision involves a somewhat different cognitive bias, corresponding to Parker's (2009) conceptualization of overconfidence as underestimation of the degree of variation in possible outcomes. The effects of overprecision on entrepreneurship are underexplored (Åstebro et al., 2014). However, a positive relation with entrepreneurial entry may be expected. Overprecision may lead to positively biased perceptions about expected returns in entrepreneurship, but for a different reason than overestimation and overplacement. Overprecise individuals underestimate the variance in possible outcomes. The distribution in entrepreneurial income is known to be extremely skewed, with median returns far below the mean (Hamilton, 2000; Sorgner, Fritsch, & Kritikos, 2017). For occupational choice decisions, considering this strong left-skewness of the entrepreneurial income distribution is essential. Overprecision may lead to an overly strong focus on the mean of the income distribution and may hence lead to biased perceptions about the expected returns in entrepreneurship.

To circumvent the potential problem of examining an effect from the entrepreneurial context on entrepreneurship (Baron, 1998), in our empirical analysis we focused on a sample of individuals that still need to choose their main occupation to test whether overconfidence (overprecision) drives market entry. Specifically, we analyzed entrepreneurial intentions among students. Even though this analysis requires a trade off with not measuring actual entrepreneurial behavior, according to the theory of planned behavior (Ajzen, 1985) and several empirical studies (e.g. Krueger & Carsrud, 1993), actual (entrepreneurial) behavior is well predicted by (entrepreneurial) intentions (Kolvereid, 1996). For instance, a study by Kautonen, Van Gelderen, and Fink (2015) found a significant and positive relationship between intentions to start a business and actual activities aimed at starting a business. Hence, we analyzed entrepreneurial intention among students to test whether overconfidence (overprecision) drives market entry. Our first hypothesis is:

Hypothesis 1. *Overconfidence (overprecision) is positively associated with entrepreneurial intentions among students.*

Despite the fact that those susceptible to the use of biases and heuristics are expected to be more likely to become entrepreneurs because overconfidence may help to cope with highly uncertain and complex environments (Busenitz & Barney, 1997; Forbes, 2005), overconfidence remains a cognitive bias that distorts rational decision making. For example, it is associated with distortions in corporate investments (Malmendier & Tate, 2005) and investments in high-risk innovation

projects (Li & Tang, 2010; Tang, Li, & Yang, 2015). Upper echelon theory (Hambrick & Mason, 1984) describes how business outcomes, such as the market position of the business, are influenced by the background characteristics of the managerial team. In line with this theory, Simsek, Heavey, and Veiga (2010) found evidence that the personality of the chief executive officer (CEO) influences their firms' entrepreneurial orientation. Entrepreneurial orientation is the strategic position of a business in the market. The degree of entrepreneurial position in this strategy includes the level of proactivity (for instance, in attacking competitors), risk taking, and innovativeness (Covin & Slevin, 1989).

Engelen, Neumann and Schwens (2015) argued that overconfidence (overestimation) fosters entrepreneurial orientation, because overconfident CEOs may depart from established practices to pursue new opportunities as they feel in control of all current activities and believe that they are better than others in successfully completing challenging tasks (Hayward, Shepherd & Griffin, 2006). Nevertheless, the search for challenging tasks may also result in cognitive overload and goal conflict when the CEO sees new opportunities everywhere (Hmieleski & Baron, 2009). In addition, overconfidence may cause the CEO to commit resources very quickly which may adversely affect the business' ability to exploit even more profitable opportunities. Specifically, overprecision may deteriorate the entrepreneur's experimentation phase (Åstebro et al., 2014). Along the same vein, Herz, Schunk, and Zehnder (2014) stated that overprecision reduces the perceived value of exploring new ideas. In an experimental setting they found that overprecision was negatively related to experimentation and realized profits. Hence, some types of overconfidence may make individuals less fit for entrepreneurship.

Altogether, we hypothesize that overconfident (i.e. overprecise) entrepreneurs are more likely to exploit their current business strategy rather than explore alternative business opportunities. This lowers their entrepreneurial orientation, in particular their proactivity and innovativeness. All entrepreneurs in our sample operated in small and medium sized enterprises, and the link between personality and entrepreneurial orientation is likely to be even stronger for them than for entrepreneurs running large businesses. Hence, in line with upper echelon theory, our second hypothesis is:

Hypothesis 2. *Overconfidence (overprecision) is negatively associated with entrepreneurial orientation among entrepreneurs.*

2.3. Data and Methods

2.3.1 Samples

For the purpose of the present study, scales for overconfidence and optimism were included in ongoing data collection efforts on entrepreneurship at our

institutions. Our first dataset contained data about students from Erasmus University Rotterdam in the Netherlands who were recruited from different faculties by various university recruitment systems, including the economics department, the psychology department, and one where students of all faculties could apply. Data were collected between May 2015 and April 2016. A total of 182 participating students filled in a questionnaire, but due to missing observations, our analyses were performed on 173 students. The average age of the Dutch students was approximately 21 years, and 55 percent were female.

Our second dataset contained data collected by Observatoire AMAROK[2], partner of the Montpellier Business School in France. AMAROK runs a panel of small and medium enterprise (SME) owners to analyze the health of entrepreneurs. Measures for overconfidence and optimism were included in the survey that ran from the end of 2015 to the beginning of 2016. There are 287 individuals in the dataset, but due to missing observations, our analysis was performed with 253 SME owners. The average age of these SME owners was 50 years, and 21 percent were female.

2.3.2 Variables and Measures

Dependent variables. In the Dutch dataset, we measured entrepreneurial intentions with the 6-item scale introduced by Liñán and Chen (2009). The items on this scale can be answered on a 7-point Likert scale, and include "I am ready to do anything to be an entrepreneur", "My professional goal is to become an entrepreneur", "I will make every effort to start and run my own firm", "I am determined to create a firm in the future", "I have very seriously thought of starting a firm", and "I have the firm intention to start a firm someday". Cronbach's alpha was .95, which indicates high internal reliability. Entrepreneurial orientation was measured in the French dataset using the French version of the 9-item scale of Covin and Slevin (1989), also measured on a 7-point Likert scale. Of these nine items, three items addressed innovativeness, three addressed proactiveness, and three addressed risk-taking. Cronbach's alpha was .73, indicating that internal reliability was good.

Overconfidence. The overconfidence scale of Russo and Schoemaker (1989) was used in both the Dutch and French dataset. This scale measures overprecision and includes ten general knowledge items for which participants have to provide a lower and an upper bound such that they are 90 percent sure the correct answer falls within their interval. The items are "Martin Luther King's age at death", "Length of the Nile River", "Number of countries that are members of OPEC", "Number of books in the Old Testament", "Diameter of the moon", "Weight of an empty Boeing 747", "Year in which Wolfgang Amadeus Mozart was born", "Gestation period (in days) of an Asian elephant", "Air distance from London to Tokyo", and "Deepest

2 http://www.observatoire-amarok.net/en.

(known) point in the oceans". The challenge is not to demonstrate general knowledge, but to be neither too narrow (overconfident) nor too wide (underconfident). The individual's score for overconfidence equals the number of questions for which the true answer falls outside the indicated interval, minus one (the expected number of answers outside the interval).

Optimism. To measure optimism, both datasets included the Life Orientation Test-Revised (LOT-R) 10-item scale, which is measured on a 5-point Likert scale. The items are "In uncertain times, I usually expect the best", "It's easy for me to relax" (F), "If something can go wrong for me, it will" (R), "I'm always optimistic about my future", "I enjoy my friends a lot" (F), "It's important for me to keep busy" (F), "I hardly ever expect things to go my way" (R), "I don't get upset too easily" (F), "I rarely count on good things happening to me" (R), and "Overall, I expect more good things to happen to me than bad". The items indicated with (R) were reverse coded before inclusion. As usual, the fillers (F) in the LOT-R scale were not included in the final optimism measure. Cronbach's alpha was .69 and .70 for the Dutch and French dataset, respectively, indicating that internal reliability is good and similar across the two datasets.

Control variables. Due to the well-documented relationship between entrepreneurship and age (Levesque & Minniti, 2006) and sex (Minniti & Nardone, 2007) and some indications exist that overconfidence is related to these variables (Bengtsson, Persson, & Willenhag, 2005; Bruine de Bruin, Parker, & Fischhoff, 2012), we controlled for age (in years) and sex (0 = female, 1 = male). We also controlled for education, measured as the average grade over the past year for the Dutch students and as the highest completed education level for the French SME owners, because of the relationship between entrepreneurship and education (Dickson et al., 2008) as well as between overconfidence and education (Bhandari & Deaves, 2006).

2.3.3 Analysis

The dependent variables in our analyses were continuous and hence we used Ordinary Least Squares (OLS) regression to test our hypotheses. For each dataset, two models were analyzed. In Model 1, only overconfidence was included as an explanatory variable in addition to the control variables. Model 2 included both overconfidence and optimism, to analyze the distinctness from optimism of the relationship between overconfidence and our dependent variables. To facilitate the comparison of effect sizes, all variables except sex were standardized before analysis.

2.4. Results

Tables 2.1 and 2.2 show the means, standard deviations (SDs), variance inflation factors (VIFs), and correlations of the main variables in our analysis of the Dutch and the French datasets, respectively. An unpaired two-sample t-test showed that the mean value for overconfidence in the French SME owners (7.08) was significantly higher ($p < .001$) than that of the Dutch students (5.73). A possible interpretation for this difference is that entrepreneurs are more overconfident than students, but factors like culture complicate the direct comparison of means across our two samples. The means for optimism were similar across the two datasets: 3.69 in the French dataset and 3.44 in the Dutch dataset, although a t-test on the difference provided a p-value less than .001. Among the independent variables, correlations ranged from -.17 to .21 for the Dutch dataset and from -.14 to .17 for the French dataset. Notably, the correlation between overconfidence and optimism was weakly negative ($r = -.17$, $p < .05$) in the Dutch dataset and insignificant ($r = -.11$) in the French dataset.

To check for multicollinearity, we examined the VIFs (see Table 2.1 and 2.2). The highest VIF is 1.10 in the Dutch dataset and 1.06 in the French dataset, indicating a low danger of multicollinearity (Diamantopoulos, Riefler, & Roth, 2008). We also controlled for common method bias (CMB) by applying Harman's single-factor test. The rule of thumb is that a single unrotated principal component should not explain more than the threshold level of 50 percent of the variance (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003) for all the indicators measured using the same method. Our results show an explained variance of 31.7 percent for the Dutch dataset and of 16.9 percent for the French dataset, indicating no danger of CMB issues.

Table 2.1. Descriptive statistics of the Dutch Dataset (N = 173). Mean, Standard Deviation (SD), Variance Inflation Factor (VIF), Correlations, and Cronbach's Alpha (diagonal) are displayed.

	Mean	SD	VIF	1	2	3	4	5
1. Entrepreneurial Intention	3.28	1.55		0.95				
2. Overconfidence	5.73	2.20	1.07	0.21**	-			
3. Optimism	3.44	0.56	1.10	0.16*	-0.17*	0.69		
4. Age	20.64	2.02	1.05	0.15*	-0.01	0.05	-	
5. Gender	0.45	0.50	1.02	-0.04	-0.11	0.01	0.07	-
6. Education	6.89	0.84	1.10	-0.15*	-0.16*	0.12	0.10	0.01

Note: *: $p < .05$, **: $p < .01$, ***: $p < .001$.

Table 2.2. Descriptive statistics of the French Dataset (N = 253). Mean, Standard Deviation (SD), Variance Inflation Factor (VIF), Correlations, and Cronbach's Alpha (diagonal) are displayed.

	Mean	SD	VIF	1	2	3	4	5
1. Entrepreneurial Orientation	4.06	0.93		0.73				
2. Overconfidence	7.08	1.50	1.05	-0.02	-			
3. Optimism	3.69	0.65	1.02	0.17**	-0.11	0.70		
4. Age	50.04	8.09	1.06	-0.10	-0.13*	0.05	-	
5. Gender	0.79	0.41	1.01	-0.04	-0.01	-0.02	-0.01	-
6. Education	3.79	1.18	1.04	-0.02	-0.11	0.02	-0.14*	-0.07

Note: *: $p < .05$, **: $p < .01$, ***: $p < .001$.

Table 2.3 shows the results of the regression analyses using the two datasets. Overconfidence was positively associated with entrepreneurial intentions among the Dutch students (Model 1). The coefficient in Model 1 indicates that a one SD increase in overconfidence was associated with an increase of 0.189 SD, on average, in entrepreneurial intention. The inclusion of optimism in Model 2 increases the coefficient of overconfidence (0.221). Optimism was also significantly positively associated with entrepreneurial intentions. A one SD increase in optimism was associated with a 0.208 SD increase in entrepreneurial intention, on average. These results provide statistical support for Hypothesis 1.

To alleviate concerns about possible confounding by individual risk preferences (Nosić & Weber, 2010) or having parents with entrepreneurial experience (Carr & Sequeira, 2007), we performed a robustness check by controlling for these factors in the model. We used the 8-item Brief Sensation Seeking Scale (BSSS) which uses a 5-point Likert scale (Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002). Cronbach's alpha was .78. In Models 1 and 2, a positive and significant association between risk and entrepreneurial intention was found ($\beta = 0.356$, SE = 0.070, $p < .001$ and $\beta = 0.326$, SE = 0.071, $p < .001$ respectively). Nevertheless, the coefficients of overconfidence remained similar in size, magnitude and significance. The coefficient for optimism in Model 2 decreased to 0.129 (SE = 0.072, $p = .075$) and was only significant at the ten percent level. Hence, the effect of optimism in Table 2.3 was attributed to risk preferences in this extended model. However, our conclusion about Hypothesis 1 did not change when risk preferences were included in the model.

Using a t-test, we found that the average overconfidence level of students who grew up with at least one of their parents owning a firm (N = 57) did not significantly differ ($p = .57$) from the average of students who did not grow up with at least one parent owning a firm (N = 124). However, the mean of entrepreneurial intention was significantly ($p < .05$) higher for students with parents having their own firm (mean = 3.71, N = 57) than for students without that kind of parent (mean = 3.03, N = 124). Hence, we tested whether our main results changed when including a binary variable in the regression indicating whether at least one of the parents owns a

business. Although this binary variable was significantly associated with entrepreneurial intention in both Model 1 ($\beta = 0.434$, SE = 0.157, $p < .01$) and Model 2 ($\beta = 0.378$, SE = 0.156, $p < .05$), the coefficients for overconfidence and optimism were similar as in our main specification. That is, in Model 1, overconfidence was significantly associated with entrepreneurial intention ($\beta = 0.201$, SE = 0.073, $p < .01$) and in Model 2, both overconfidence and optimism were significantly associated with entrepreneurial intention ($\beta = 0.228$, SE = 0.073, $p < .01$ and $\beta = 0.182$, SE = 0.074, $p < .05$, respectively).

Also, 7.5 percent of the Dutch students (N = 13) indicated that they were in the process of starting or had stared a business at the time of measurement. After removing these individuals from the analysis sample, we found that the coefficients for overconfidence and optimism were similar in size and significance as in our main specification. In Model 1, overconfidence was significantly associated with entrepreneurial intention ($\beta = 0.213$, SE = 0.078, $p < .01$) an in Model 2, both overconfidence and optimism were significantly associated with entrepreneurial intention ($\beta = 0.255$, SE = 0.077, $p < .01$ and $\beta = 0.228$, SE = 0.078, $p < .01$, respectively). Hence, these findings were in line with our main results.

Table 2.3. OLS Regression Results: Coefficients with Standard Errors in Parentheses.

	Entrepreneurial Intention (Dutch students)		Entrepreneurial Orientation (French entrepreneurs)	
	Model 1	Model 2	Model 1	Model 2
Intercept	0.057	0.048	0.123	0.113
	(0.099)	(0.097)	(0.137)	(0.135)
Overconfidence	0.189*	0.221**	-0.040	-0.023
	(0.075)	(0.074)	(0.062)	(0.061)
Optimism		0.208**		0.166**
		(0.074)		(0.062)
Age	0.174*	0.167*	-0.116	-0.123
	(0.075)	(0.074)	(0.067)	(0.066)
Gender	-0.066	-0.060	-0.108	-0.102
	(0.148)	(0.146)	(0.153)	(0.151)
Education	-0.141	-0.160*	-0.039	-0.041
	(0.077)	(0.076)	(0.064)	(0.063)
F-value	4.113	5.004	0.914	2.189
p-value	(0.003)	(0.000)	(0.456)	(0.056)
R-squared (adj.)	0.068	0.104	-0.001	0.023
N	173	173	253	253

Note: *: $p < .05$, **: $p < .01$, ***: $p < .001$.

The analysis of entrepreneurial orientation in the French dataset provided a different picture. As shown in Model 1 of Table 2.3, we found that overconfidence was not significantly associated with entrepreneurial orientation. The coefficient for overconfidence barely changed after including optimism in Model 2, and hence, we concluded that overconfidence is not associated with the entrepreneurial orientation of SME owners. Accordingly, we did not find evidence supporting Hypothesis 2. However, optimism (Model 2) was significantly and positively associated with entrepreneurial orientation. A one SD increase in optimism was associated with a 0.166 SD increase in entrepreneurial orientation. Dropping overconfidence from this model, which resulted in a model with only optimism and the control variables, did not alter this result ($\beta = 0.142$, SE = 0.058, $p < .05$).

To further analyze these unexpected results, we included two additional control variables in our analysis. First, we amended Models 1 and 2 with firm size (number of employees including the entrepreneur), because the larger the business, the smaller the influence of the individual characteristics of the owner-manager on entrepreneurial orientation (upper echelon theory). Nevertheless, we found that neither firm size nor the interaction between firm size and overconfidence were

significantly associated with entrepreneurial orientation ($p > .05$). Secondly, we amended Models 1 and 2 with the number of years the owner-manager had been in leadership. According to Baron (1998), being in entrepreneurship may increase overconfidence, but this variable was neither significantly correlated with overconfidence ($p > .05$) nor with entrepreneurial orientation ($p > .05$). The interaction term with overconfidence was also not significant.

Table 2.4. OLS Regression Results: Coefficients with Standard Errors in Parentheses. Analysis of Subscales of Entrepreneurial Orientation.

	Entrepreneurial Orientation Innovation (French entrepreneurs)		Entrepreneurial Orientation Proactiveness (French entrepreneurs)		Entrepreneurial Orientation Risk Taking (French entrepreneurs)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Intercept	0.201	0.198	0.057	0.049	-0.008	-0.018
	(0.137)	(0.137)	(0.133)	(0.132)	(0.139)	(0.137)
Overconfidence	-0.029	-0.025	-0.114	-0.099	0.058	0.077
	(0.062)	(0.063)	(0.060)	(0.060)	(0.063)	(0.063)
Optimism		0.038		0.147*		0.177**
		(0.063)		(0.061)		(0.063)
Age	-0.004	-0.005	-0.170*	-0.176**	-0.076	-0.083
	(0.067)	(0.067)	(0.065)	(0.065)	(0.068)	(0.067)
Gender	-0.245	-0.244	0.017	0.023	0.016	0.022
	(0.154)	(0.154)	(0.149)	(0.148)	(0.156)	(0.154)
Education	-0.034	-0.035	-0.072	-0.073	0.023	0.021
	(0.064)	(0.064)	(0.062)	(0.062)	(0.065)	(0.064)
F-value	0.719	0.646	2.364	3.105	0.661	2.113
p-value	(0.579)	(0.665)	(0.054)	(0.010)	(0.619)	(0.064)
R-squared (adj.)	-0.004	-0.007	0.021	0.040	-0.005	0.022
N	253	253	253	253	253	253

Note: *: $p < .05$, **: $p < .01$, ***: $p < .001$.

Additionally, we analyzed the three subscales (innovation, proactiveness, and risk-taking) of entrepreneurial orientation separately. Table 2.4 shows that for none of the subscales was there a significant association with overconfidence. The results indicated that the significant association between optimism and entrepreneurial orientation (overall) was primarily present in the proactiveness and risk-taking subscales. Overall, we did not find evidence to support Hypothesis 2.

2.5. Discussion

The present study shows that, using field data, overconfidence is positively associated with the intention to enter entrepreneurship but it is not associated with the market position of the business (i.e., entrepreneurial orientation). The positive association between overconfidence (i.e. overprecision) and entrepreneurial intention in the Dutch students provides evidence for the argument that market entry

may result from overconfidence in future entrepreneurial success (Roll, 1986; Cooper et al., 1988; Wu & Knott, 2006). No significant association was found between overprecision and entrepreneurial orientation among French SME owners, and this was confirmed using several robustness checks. A possible explanation for this null finding, is that overprecision may influence SME owners to depart from established practices to pursue new opportunities which increases entrepreneurial orientation (Engelen et al., 2015). This effect of overconfidence has been linked to overestimation rather than overprecision, but it may nevertheless negate the expected negative association between overprecision and entrepreneurial orientation (Åstebro et al., 2014; Herz et al., 2014).

Together, our results suggest that overconfidence (overprecision) may encourage people to enter entrepreneurship, but does not influence people to develop a particular entrepreneurial orientation in the market. Hence, whereas the overconfident individuals are most likely to enter entrepreneurship, the low average financial returns in entrepreneurship and chances of business failure seem to be the result of an overcrowded market rather than a group of relatively poorly performing overconfident entrepreneurs. In addition, the results showed that overconfidence and optimism play different roles in the entrepreneurial process. First, the correlation between overprecision and optimism was significantly negative among Dutch students and insignificant among French SME owners. Secondly, in our multivariate models, overconfidence was only significantly associated with entrepreneurial intention, whereas optimism was associated with both entrepreneurial intention and entrepreneurial orientation. These findings fit with the results of Åstebro et al. (2007) who found that, among investors, overconfidence was not related to continuing spending time and money after receiving advice to stop, whereas optimism was related to continuing spending money (not time) after receiving this advice. The results for optimism are in line with earlier research showing that students with the intention of starting their own business are more optimistic than students without such an intention (Macko & Tyszka, 2009) and that positive orientation (optimism is one of the components of this construct) is positively related to entrepreneurs' striving to achieve particular goals (Laguna, Alessandri & Caprara, 2016).

Therefore, the hypothesis that too many people become entrepreneurs because of overconfidence seems to only partially explain the relatively low financial returns in entrepreneurship as well as the high failure rates. Our results indeed suggest that overconfidence regarding entrepreneurship starts at the phase of expressing intention to enter an entrepreneurial career. However, entrepreneurial overconfidence does not express itself in the market position of the business. An alternative explanation could be that overconfident entrepreneurs are eliminated from the market quickly after market entry. However, the descriptive statistics in Tables 2.1 and 2.2 showed that the French entrepreneurs scored significantly higher in overconfidence than the Dutch students. Assuming no difference in the level of

overconfidence between Dutch and French citizens in general, this suggests that the French entrepreneurs score high on overconfidence but they nevertheless do not have a certain market position (i.e., entrepreneurial orientation) because of their overconfidence. Hence, overconfident persons select themselves into entrepreneurship, but do not have a greater proclivity toward a certain market position that could eventually lead to success. As such, overconfidence should be regarded primarily as a driver of excess market entry and not as a driver of lower entrepreneurial orientation. Thus, an overcrowded market rather than a group of relatively poorly performing overconfident entrepreneurs seems to drive the low financial returns and failure rates.

The overcrowded market explanation preempts policies targeted at reducing the overconfidence of a particular individual entrepreneur, because an overcrowded market is not necessarily bad for society. Economists maintain that the crucial role of entrepreneurs in the economy is to absorb uncertainty and to contribute to the accumulation of human capital (Audretsch, 1995). New business prospects are always highly uncertain, in particular if the business is set up around a novel product, service, market, or production method. This uncertainty will result in failures because, for instance, entrepreneurs overestimate their own ability to manage, underestimate the characteristics of competing products, or misinterpret market sentiments. High levels of business births, deaths, expansions, and contractions may thus lead to significant learning processes by improving the capabilities of the workforce from which entrepreneurs typically originate (Metcalfe, 1997).

2.6. Conclusion

The present study analyzed how a particular type of overconfidence (overprecision) and optimism are related to two important aspects of the entrepreneurial process: intention and orientation. Using newly collected field data, we showed that overconfidence and optimism play distinct roles in entrepreneurship. Overconfidence selects people into entrepreneurship but does not place entrepreneurs in a particular position regarding entrepreneurial orientation. Hence, we found only partial evidence for the suggestion that overconfidence drives excess market entry, because the entry of many entrepreneurs in the market also positively impacts competition and learning. Optimism, on the contrary, drives individuals into entrepreneurship and is related to the market position entrepreneurs have, in particular with respect to proactiveness and risk taking. The clearly different roles that overconfidence and optimism play in the entrepreneurial process and the fact that optimism and overconfidence were negatively correlated in our samples, means that the two are indeed distinct phenomena. Hence, Parker's warning that overconfidence and optimism should not be conflated is not only warranted from a theoretical but also from a practical point of view. Overconfidence (overprecision)

and optimism should be treated as distinct constructs in studies investigating their consequences.

The present study does not come without limitations, which can also be considered as directions for future research. First, the present study focused on overprecision, which is a specific underresearched type of overconfidence, and optimism. A more encompassing study could analyze overprecision and optimism in conjunction with overestimation and overplacement. Moreover, whereas our study employed general measures for overconfidence and optimism, future studies may want to use domain-specific measures such as overconfidence in entrepreneurial skills. The latter measures may be more directly associated with particular aspects of the entrepreneurial process than general measures. Second, we believe that future studies will benefit from linking types of overconfidence to a more diverse set of aspects of the entrepreneurial process. In particular, the link between overconfidence and entrepreneurial performances deserves research attention. A key aspect may be exit from entrepreneurship, an event that may ultimately be expected to occur due to overconfidence in line with Hypotheses 2. Finally, our samples were cross-sectional in nature. If longitudinal data would have been available, then changes in overconfidence and optimism could have been linked to changes in relevant aspects of the entrepreneurial process. In the present study, we proxied the time dimension by investigating the relation between overconfidence and entrepreneurial intention among Dutch students, and the relation between overconfidence and entrepreneurial orientation among French entrepreneurs. Future studies could collect longitudinal data originating from one country to further investigate the revealed associations in the present study.

3. The Role of Affect in Entrepreneurial Orientation

Indy Bernoster
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Roy Thurik

Abstract. Although the literature on affect (i.e. the extent to which an individual subjectively experiences feelings and emotions) is burgeoning in the general field of entrepreneurship, it has not received sufficient attention with respect to an important antecedent to entrepreneurial success – entrepreneurial orientation. In the present paper, we investigate the role of both positive and negative affect in entrepreneurial orientation (i.e. the strategic posture of a firm or individual with respect to innovativeness, proactiveness, and risk taking) and entrepreneurial success. The results of our analysis, based on two samples (337 Dutch sole proprietors and 254 French small business owners), show that positive affect is positively associated to entrepreneurial orientation, while negative affect is negatively associated to entrepreneurial orientation for sole proprietors. With respect to entrepreneurial success, results are mixed. The present study does not only contribute to the understanding of the role of affect in entrepreneurial orientation, but also to that of entrepreneurial success, the ultimate objective in the field of entrepreneurship.

3.1. Introduction

An appropriate strategy leads to high firm performance (Hitt, Bierman, Shimizu, & Kochlar, 2001; Mills & Bourne, 2002). Not only large firms but also the small ones, and even sole proprietors (entrepreneurs without employees) can benefit from an appropriate strategic posture. Indeed, research shows that an entrepreneurial strategic posture, or an entrepreneurial orientation, is positively associated with small business success (Khedhaouria, Gurău, & Torrès, 2015; Rauch, Wiklund, Lumpkin, & Frese, 2009; Wiklund & Shepherd, 2005). For instance, an entrepreneurial strategic posture can lead to enhanced positive association between knowledge-based resources and small business performance (Wiklund & Shepherd, 2003) and effective corporate entrepreneurship (Dess & Lumpkin, 2005).

Entrepreneurial orientation is an important antecedent to entrepreneurial success (Rauch et al., 2009; Wiklund & Shepherd, 2005) which is the ultimate goal of entrepreneurship. Knowledge about the strategic posture and its drivers could lead to better evaluation of future success; it could also enable individuals to make well-informed choices about being an entrepreneur on the first place. Firm-level innovation (Avlonitis & Salavou, 2007), as well as individual-level concepts like self-evaluation (Simsek, Heavey, & Veiga, 2010), CEO narcissism (Chatterjee & Hambrick, 2007), and overconfidence (Engelen, Neumann, & Schwens, 2015) have been identified in the literature as drivers for entrepreneurial orientation.

Although these drivers provide insightful understanding of entrepreneurial orientation, the general state of knowledge on entrepreneurial orientation could benefit from identifying more drivers that explain this important concept. Therefore, our study takes research on entrepreneurial orientation a step further and investigates whether affect, a well-known psychological measure for feelings and emotions, plays a role in entrepreneurial orientation.

There are two reasons to conjecture that affect is relevant for entrepreneurial orientation. First, several scholars have pointed out that investigating the role of affect in entrepreneurship is important (Delgado García, Quevedo Puente, & Blanco Mazagatos, 2015; Hahn, Frese, Binnewies, & Schmitt, 2012). For example, Hahn et al. (2012) mention that although entrepreneurs experience extreme emotions in their work-life, "affect is a neglected concept in entrepreneurship research, and scholars are urged to pay more attention to the role of affect in the entrepreneurial process (Baron, 2008)" (p. 99). Similarly, Baron (2008) characterizes entrepreneurial environments as highly unpredictable and rapidly changing and states that affect "most likely exert powerful effects on cognition and behavior", which could lead to specific actions or decisions. Further, the meta-analysis of Delgado García et al. (2015) shows that there is considerable evidence that affect is associated with a wide range of issues in managing an entrepreneurial venture and plays an important role in several aspects of entrepreneurship, such as self-efficacy, task performance,

negotiation, conflict (Baron, 1990), venture effort (Foo, Uy, & Baron, 2009), opportunity evaluation and exploitation (Grichnik, Smeja, & Welpe, 2010). However, while it has been suggested that affect may influence the different stages of the entrepreneurial process, which could in turn impact entrepreneurial success, there exist no empirical studies associating affect to entrepreneurial orientation, an important stage in the entrepreneurial process (Delgado García et al., 2015).

Second, affect is associated with the three dimensions of entrepreneurial orientation: innovativeness, proactiveness, and risk taking. For instance, affect has been associated with innovation in business (Baron & Tang, 2011; Rutherford & Holt, 2007) as it enhances creativity, which in turn has a positive effect on firm-level innovation. Also, happy individuals work actively towards new goals (Lyubomirsky, King, & Diener, 2005), which means that individuals with higher positive affect has a proactive work attitude. Induced positive affect has also been shown to lead to higher risk taking when stakes are high (Isen & Geva, 1987). Moreover, Baron's (2008) theoretical work notes that affect has a strong effect on decision making and judgements, which play a key role in the formation of strategy. Thus, it seems that affect could be relevant for entrepreneurial orientation.

With the aim to addresses this *affect-entrepreneurial orientation gap* in the literature, the present study takes into account both (orthogonal) dimensions of affect, i.e. positive and negative, and the two variants of entrepreneurial orientation (i.e. the original firm-level variant and the individual-level variant). It additionally aims to distinguish between the dimensions of entrepreneurial orientation: innovativeness, proactiveness, and risk taking. Since entrepreneurial success is vital to entrepreneurship, we also aim to analyze the role of affect and entrepreneurial orientation in entrepreneurial success. To summarize, the importance of the two main concepts that we investigate – affect and entrepreneurial orientation, the suspicion in the literature that they could be associated (Baron, 2008; Delgado García et al., 2015; Hahn et al., 2012), and the absence of any empirical investigation in this regard highlights the importance of the present study. The awareness and knowledge of a possible association between affect and entrepreneurial orientation is important because strategy ultimately determines entrepreneurial success.

For our empirical study, we use three samples: one consisting of 337 Dutch sole proprietors and the other consisting of 254 French small business owners. We analyze the affect-entrepreneurial orientation gap further with a sample of 177 Dutch students. However, since students have no or little experience with entrepreneurship, we present the results of this sample in Appendix A. Our results show that positive affect is positively associated with entrepreneurial orientation. Negative affect is negatively associated with entrepreneurial orientation, but for sole proprietors only. However, the positive associations are stronger than the negative associations. Our results further indicate that the associations are mainly visible for the innovativeness dimension. With respect to entrepreneurial success, our results show that positive affect is positively associated to entrepreneurial success, while

negative affect is negatively associated to success. This latter finding is more evident for the sole proprietors than for the business owners.

The present paper contributes to the literature in several ways. *First*, it contributes to our knowledge of the entrepreneurial profile (Gartner, 1990) by exploring the role of affect in entrepreneurial orientation and thereby fills the (empirical) affect-entrepreneurial orientation gap. We address this gap in several ways. First, we explore multiple measures and dimensions of entrepreneurial orientation. That is, we investigate the role of affect in both firm entrepreneurial orientation and individual entrepreneurial orientation. Second, we analyze all three dimensions of entrepreneurial orientation, i.e. innovativeness, proactiveness, and risk taking. Third, we analyze the affect-entrepreneurial orientation association in three different sample (two presented in the main text and one in Appendix A).

Second, the present paper contributes to our knowledge of entrepreneurial success by analyzing the role of affect and entrepreneurial orientation in entrepreneurial success, in two samples. Although the investigation of entrepreneurial success is an additional goal, our results also contribute to the existing knowledge of the affect-entrepreneurial success association (Baron, 1990; Baron et al., 2011; Lyubomirsky et al., 2005) and the entrepreneurial orientation-success association (Khedhaouria et al., 2015; Rauch et al., 2009; Wiklund & Shepherd, 2005).

Third, the present paper contributes to the field of psychology by taking into account that positive and negative affect are unipolar, and hence they both need to be investigated. Studies analyzing affect and entrepreneurial outcomes tend to neglect this unipolarity as they investigate either positive affect (Baron & Tang, 2011; Baron, Tang, & Hmieleski, 2011; Delgado García et al., 2015, p. 203; Foo, Uy, & Baron, 2009) or negative affect (Doern & Goss, 2014; Shepherd, Patzelt, & Wolfe, 2011). However, positive and negative affect are orthogonal dimensions and should be treated as separate concepts (Watson, Clark, & Tellegen, 1988). In other words, a positive association between positive affect and an entrepreneurial outcome does not imply a similar, but negative association between negative affect and the same entrepreneurial outcome. By showing that the roles of positive affect and negative affect differ – not only in sign, but also in magnitude – we demonstrate that ignorance of this orthogonality does not provide the full picture.

Fourth, from a practical point of view, the present paper is important because it gives entrepreneurs insight in their strategic posture, which could partly determine their entrepreneurial success. Knowledge and awareness of a possible association between one's feeling and emotions, i.e. affect, and one's strategic posture, i.e. entrepreneurial orientation, could provide insights on the ultimate entrepreneurial success (as orientation leads to success (Rauch et al., 2009)) and lead to a more deliberate choice of entering entrepreneurship on the first place. This would help select successful entrepreneurs such that less entrepreneurial failures occur.

The rest of the paper is organized as follows. First, we provide an overview of the principle variables under examination – affect and entrepreneurial orientation – and delineate the relationship between the two in order to justify our hypotheses. Then, we present our research method and our empirical results. We conclude by discussing our results and its limitations and suggesting future research directions.

3.2. Literature Review

The present section explains the concept of affect, entrepreneurial orientation, and entrepreneurial success and gives an overview of the current literature with respect to the association between these concepts. It also motivates our two hypotheses as well as the general aims of the present paper. Figure 3.1 summarizes our research set-up. Unlike many other papers, we have used bidirectional arrows (i.e. from affect to entrepreneurial orientation and from entrepreneurial orientation to affect) to clarify that we do not claim causality. As Lyubomirsky et al. (2005) mentioned "success leads to happy people, but happiness, often characterized by high positive affect, leads to success" (p. 803). We hold a similar view for affect and entrepreneurial orientation, i.e. feelings and emotions could lead to a certain strategic posture, but similarly, a particular strategic posture could lead to success and thus (eventually) lead to certain feelings and emotions. Hence, we use the word 'association' throughout the paper to highlight these bidirectional arrows.

In the figure, the bold font indicate our main aim of filling the (empirical) affect-entrepreneurial orientation gap, while the non-bold font identifies our additional aims, i.e. investigating the role of affect in the different dimensions of entrepreneurial orientation, and, the role of affect and entrepreneurial orientation in entrepreneurial success.

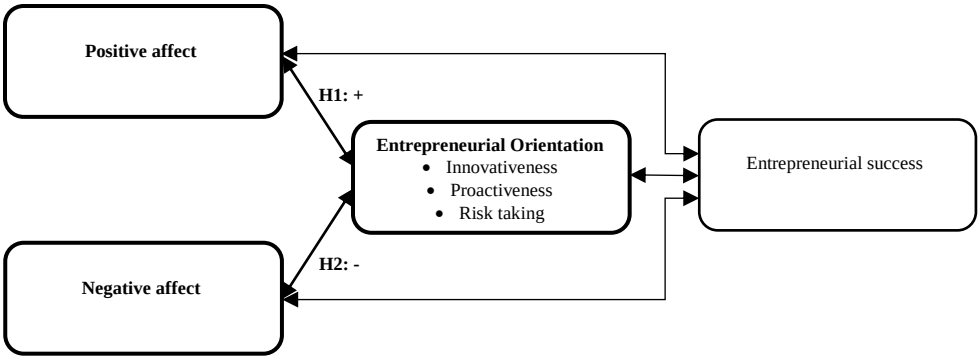

Figure 3.1. Our main model and hypotheses (in bold) and our additional aims (in non-bold).

3.2.1 Affect

Affect is the extent to which someone subjectively experiences positive or negative feelings and emotions, resulting in positive or negative affect (Watson et al., 1988). High positive affect is associated with "high energy, full concentration, and pleasurable engagement", whereas low positive affect is associated with "sadness and lethargy" (Watson et al., 1988, p. 1063). On the other hand, high negative affect is associated with "anger, contempt, disgust, guilt, fear, and nervousness", while low negative affect is associated with "calmness and serenity" (Watson et al., 1988, p. 1063). Affect can be defined over various time frames. Feelings and emotions experienced in general is referred to as trait affect, while feelings and emotions experienced at this moment is referred to as state affect. Watson et al. (1988) developed a reliable, valid, and efficient scale for measuring positive and negative affect while taking the various time frames into account: the Positive and Negative Affects Scale (PANAS). The reliability of the PANAS was tested over a period of two months and proven to be high, independent of the chosen time frame.

Many studies associating affect to entrepreneurship focus on either positive or negative affect (Delgado García et al., 2015). However, positive affect and negative affect are independent concepts (Watson et al., 1988). Hence, investigating one of them does not imply the result for the other. In other words, a positive association between positive affect and an outcome measure does not imply a similar but negative association between negative affect and the same outcome measure. Therefore, in the present study, we focus on both positive affect and negative affect and treat them as separate concepts.

3.2.2 Entrepreneurial Orientation

Different types of strategic postures or orientations exist, such as entrepreneurial orientation and market orientation (Boso, Story, & Cadogan, 2013). Covin and Slevin (1989) define strategic posture as "a firm's overall competitive orientation" (p. 77). In the present paper, we focus on entrepreneurial orientation which can be defined as "the strategy making processes that provide organizations with a basis for entrepreneurial decisions and actions" (Rauch et al., 2009, p. 763). In other words, entrepreneurial orientation indicates the degree of entrepreneurship in a firm's strategic posture (Lumpkin & Dess, 1996). Entrepreneurial orientation can be captured by three dimensions: innovativeness, proactiveness, and risk taking (Miller, 1983). However, the scale for measuring entrepreneurial orientation (Covin & Slevin, 1989) is unidimensional with a high factorial validity such that it is also appropriate to combine all three dimensions in a single scale.

Entrepreneurial orientation is usually measured at the firm-level. Besides firm entrepreneurial orientation, another type of entrepreneurial orientation exists:

individual entrepreneurial orientation (Langkamp Bolton & Lane, 2012). The upper echelon theory claims that organizational outcomes are predicted by managerial characteristics (Hambrick & Mason, 1984). Thus, not only firm-specific traits, but also individual-specific traits eventually lead to firm decisions. Hence, for sole proprietors, individual entrepreneurial orientation is now deemed an appropriate concept.

Entrepreneurial orientation has an impact on entrepreneurial success (Khedhaouria et al., 2015; Rauch et al., 2009; Wiklund, Patzelt, & Shepherd, 2009; Wiklund & Shepherd, 2003; 2005). For this reason, one of the aims of entrepreneurship literature is to investigate its drivers, of which several have been identified. For instance, Khedhaouria et al. (2015) mentions creativity, while Avlonitis and Salavou's (2007) study of SME owners shows a clear association between innovation and entrepreneurial orientation. Simsek et al.'s (2010) work shows that CEOs personality reflecting higher core self-evaluations have a stronger positive influence on the firms' entrepreneurial orientation, especially for firms facing dynamic (instead of stable) environments. Similarly, Chatterjee and Hambrick (2007) found CEO narcissism to play a role in both strategic posture and firm performance. Overconfidence of CEOs have also been shown to play a role in firm's entrepreneurial orientation (Engelen et al., 2015), since such CEOs feel more in control, consider themselves to be better than others in successfully completing challenging tasks, and are more likely to depart from established practices to pursue new opportunities (Hayward, Shepherd, & Griffin, 2006). Since entrepreneurial orientation is considered to be an important concept in entrepreneurship literature and different scholars have hinted that affect could play a role in entrepreneurial orientation (Baron, 2008; Delgado García et al., 2015; Hahn et al., 2012), the present paper explores the nature of this concept by investigating the role that affect plays in entrepreneurial orientation.

3.2.3 Affect and Entrepreneurship

Scholars have recently pointed out the importance of investigating the role of affect in entrepreneurship (Delgado García et al., 2015; Hahn et al., 2012). The recent and rapid development of the affect-entrepreneurship literature has yielded several results. For instance, Baron's (2008) theoretical framework indicates the important role played by positive and negative affect in entrepreneurship via opportunity recognition, acquisition of financial and human resources, development of broad social networks, capacity to respond effectively to highly dynamic environments, and tolerance for intense levels of stress. Baron's work serves as an excellent starting point for further research. For instance, affect has been associated with innovation in the business (Baron & Tang, 2011; Baron et al., 2011; Rutherford & Holt, 2007); affect has also been associated to the level of effort, personal initiative and persistence, propensity to continue investments in an underperforming

project, the types of goals set (Delgado García, Rodrigues-Escudero, & Martin-Cruz, 2012), performance and attitude (Baron, 1990), and creativity (Isen, Daubman, & Nowicki, 1987). However, we seem to be lacking in work that focuses on affect and entrepreneurial orientation.

Furthermore, most studies investigating the role of affect in entrepreneurship focus on either positive or negative affect. For instance, positive affect has been found to be positively associated with firm performance (Baron et al., 2011), attitude (Baron, 1990), and individual innovativeness in mid-sized organizations (Baron & Tang, 2011; Rutherford & Holt, 2007). What seems surprising though is that none of the above-mentioned studies take negative affect into account. Studies that investigate negative emotions have shown that it plays a role in moving forward after project failure (Shepherd et al., 2011) or in social processes of entrepreneurship (Doern & Goss, 2014). However, these latter studies do not take positive affect into account.

Studies that have investigated both the bright and dark side of feelings and emotions, have used concepts like passion (Cardon & Kirk, 2015), affective well-being (Hahn et al., 2012), and emotion (Brundin & Gustafsson, 2013; Grichnik, Smeja, & Welpe, 2010) instead of affect. Studies that investigate the role of both positive and negative affect in entrepreneurship are scarce. As mentioned earlier, Baron's (2008) conceptual paper indicated that both positive and negative affect influences the entrepreneurial process. Foo et al.'s (2009) empirical work showed that both positive and negative affect positively influences venture effort, while negative affect is only related to the immediately required effort for the venture. Positive and negative affect have also been empirically shown to be associated with positive orientation towards personal goal realization (consisting of the subscales self-esteem, life satisfaction, and optimism) in entrepreneurs (Laguna, Alessandri, & Caprara 2016).

Thus, although affect, a prominent psychological construct (Watson et al., 1988) seems to be playing an important role in entrepreneurship (Baron, 2008; Delgado García et al., 2015; Hahn et al., 2012), we are not aware of any empirical study that has investigated the role of affect in *entrepreneurial orientation*.

Summarizing the extant literature reviewed above, we can conclude that positive affect positively influences (firm-specific) characteristics such as the entrepreneurial process (Baron, 2008) and innovation (Baron & Tang, 2011; Rutherford & Holt, 2007), which are positively associated to entrepreneurial orientation (Avlonitis & Salavou, 2007), and personal goal orientation (Laguna et al., 2016); while negative affect negatively influences the entrepreneurial process (Baron, 2008) and personal goal orientation (Laguna et al., 2016). However, it is not clear whether and how affect is associated to entrepreneurial orientation (Rauch et al., 2009, Wiklund et al., 2009; Wiklund & Shepherd, 2005). Therefore, in the present paper we aim to investigate the direct link between affect and entrepreneurial orientation in order to supplement the indirect and scattered

evidence that this link may exist. Based on the indications of prior studies, we expect a positive association between positive affect and entrepreneurial orientation and a negative association between negative affect and entrepreneurial orientation. Hence, we hypothesize:

Hypothesis 1. *Positive affect is positively associated with entrepreneurial orientation.*
Hypothesis 2. *Negative affect is negatively associated with entrepreneurial orientation.*

3.2.4 Additional Test

To obtain a deeper understanding of the role of affect in entrepreneurial orientation, we distinguish its role on the three dimensions of entrepreneurial orientation, i.e. innovativeness, proactiveness, and risk taking. It is possible that the association between affect and entrepreneurial orientation is driven by one of these dimensions. That is, there is stronger evidence in the literature of the association between affect and innovativeness or risk taking than between affect and proactiveness (Mittal & Ross Jr, 1998; Rutherford & Holt, 2007). For instance, positive affect was found to be associated with individual innovativeness in the field of corporate entrepreneurship using a sample of mid-sized organizations (Rutherford & Holt, 2007), and with firm-level innovation (Baron & Tang, 2011). Further, Isen and Geva (1987) showed that induced positive affect leads to higher risk taking when stakes were high, but to being more risk prone when stakes were low, while Mittal and Ross Jr (1998) showed that MBA students with a positive mood, (as compared to those with negative mood), displayed lower levels of risk taking. Positive affect has been shown to induce active work attitude towards new goals, the latter being similar to a proactive attitude (Lyubomirsky et al., 2005). Due to the possibility of different associations per dimension of entrepreneurial orientation, we also tested our Hypothesis 1 and 2 for each of these dimensions.

We have also enriched our main model by including entrepreneurial success (see Figure 3.1). This model has two additional goals. It helps us to analyze the role of affect in entrepreneurial success; it also allows us to analyze the role of entrepreneurial orientation in entrepreneurial success. Several studies serve as a rationale for investigating these associations. For instance, with respect to the affect-entrepreneurial success association, studies show that (environmentally induced) dispositional positive affect is positively associated with firm performance (Baron, 1990), but after a certain point, higher dispositional positive affect could lead to a decline in firm performance (Baron et al., 2011). Further, positive affect has been associated to several dimensions of the Big Five, which in turn impact entrepreneurial success. Specifically, positive affect is associated with extraversion (Shiota, Keltner, & John, 2006), while negative affect is associated with neuroticism (Costa & McCrae, 1980). This is confirmed by Gutiérrez, Jiménez, Hernández, and

Penacoba Puente (2005). Besides, Roccas, Sagiv, Schwartz, and Knafo (2002) mention that positive affect is associated with openness to experience and conscientiousness. Additionally, conscientiousness, openness to experience, and extraversion are positively associated with entrepreneurial performance, while neuroticism negatively associated with entrepreneurial performance (Brandstätter, 2011). Hence, as positive affect is associated with conscientiousness, openness to experience, and extraversion, and since these are associated with entrepreneurial performance, positive affect may also impact entrepreneurial performance. A same reasoning holds for negative affect and entrepreneurial success: negative affect is associated with neuroticism which has a negative impact on entrepreneurial performance. Thus it may be possible that negative affect has a negative impact on entrepreneurial performance.

With respect to the entrepreneurial orientation-entrepreneurial success association, Wiklund et al.'s (2009) model has linked entrepreneurial orientation and success, and several scholars have pointed to evidence for this association (Chatterjee & Hambrick, 2007; Khedhaouria et al., 2015; Rauch et al., 2009; Wiklund & Shepherd, 2005). For instance, Khedhaouria et al., (2015) show that self-efficacy and entrepreneurial orientation are positively and directly associated to firm performance, while creativity is positively associated to firm performance indirectly through entrepreneurial orientation. Further, Kreiser, Marion, Kuratko, and Weaver (2013) found that different dimensions of entrepreneurial orientation have a difference impact on SME performance. Where innovativeness and proactiveness display a positive U-shape relation with SME performance, risk taking displays a negative U-shape relation.

Together with our two main hypotheses, the associations between affect/entrepreneurial orientation and entrepreneurial success suggest the possibility that entrepreneurial orientation could play an indirect or mediating role in the association between affect and entrepreneurial success. Therefore, we also intent to investigate this mediation, which would contribute to our existing knowledge of entrepreneurial success. However, investigation of the association between affect and entrepreneurial success remains our secondary goal, as the main focus of our paper is to fill the affect-entrepreneurial orientation gap in the extant literature. We believe that such a focus is justified as it has not been done yet (compared to some evidence that already exist regarding the role of affect in entrepreneurial success (Baron, 1990; Baron et al., 2011). Additionally, since entrepreneurial success is an immensely broad construct and latent in nature, it is hard to validate measures for entrepreneurial success. For this reason, our measure of entrepreneurial success is not validated. Therefore, our main focus is on entrepreneurial orientation for which we use validated measures.

3.3. Method

To investigate the association between affect and entrepreneurial orientation, we used two samples: Panteia and AMAROK. The present section discusses each sample and their measures and presents the analysis that we performed on these samples.

3.3.1 Panteia

The Panteia sample consisted of 851 Dutch sole proprietors. However, for this study, our sample consists of 337 sole proprietors. Panteia[3] used to be one of the largest market and policy research institutes in the Netherlands, maintaining a nationally representative panel of Dutch sole proprietors. The data was collected between December 2014 and January 2015[4]; however, the data on entrepreneurial orientation was collected in 2013. The fact that our data on entrepreneurial orientation was collected a year before the data on affect does not affect the credibility of our results, because we looked at *trait* affect which is considered to be stable over time (Watson et al., 1988). The average age of the final 337 sole proprietors was 53 years and 69 percent of them are male. Majority of them had obtained a university or higher education degree (58 percent), followed by those with secondary vocational education (21 percent).

Variables and Measures

Entrepreneurial Orientation. Sole proprietors fully represent their own business. To measure entrepreneurial orientation amongst sole proprietors, it is appropriate to use an individual-level scale since it is hard to discriminate between individual and firm entrepreneurial orientation (since the sole proprietors' individual strategy matches that of the firm, given they solely decide). Hence, we used the individual entrepreneurial orientation scale of Langkamp Bolton and Lane (2012) that was especially developed for the purpose of measuring entrepreneurial orientation in individuals solely responsible for the firm's strategic posture. Similar to the regular firm entrepreneurial orientation scale of Covin and Slevin (1989), this individual entrepreneurial orientation scale consists of three dimensions: innovativeness, proactiveness, and risk taking. In total, ten items – four for innovativeness, three for proactiveness, and three for risk taking – were rated on a five-point Likert scale. Sample items for each category were "I often like to try new and unusual activities that are not typical but not necessarily risky.", "I usually act

3 http://www.panteia.nl/

4 An e-mail with a link to a questionnaire was sent to 2,498 registered e-mail addresses of the panel. In total three reminders were sent, ultimately resulting in responses of 851 sole proprietors and hence a response rate of 34.1 percent.

in anticipation of future problems, needs or changes.", and "I like to take bold action by venturing into the unknown.", respectively. Cronbach's alpha is equal to .81 indicating a good reliability for this scale.

Affect. To measure positive and negative affect, a Dutch version of the PANAS (Watson et al., 1988) was used. The PANAS consists of twenty items: ten for positive affect and ten for negative affect. An item is basically a single word indicating a certain feeling or emotion, such as 'inspired' for positive affect and 'afraid' for negative affect. Prior to this word, the PANAS instructs participants to indicate how often they feel this particular way. The PANAS can be framed with various temporal perspectives, such as 'at this moment', 'over the past few days', and 'in general'. As we investigated a stable concept, i.e. entrepreneurial orientation, we focused on trait affect and thus framed the instructions of the PANAS as 'Indicate to what extent you *generally* feel this way, that is, how you feel on average'. Cronbach's alpha for positive affect was .84 and for negative affect .87. These values are similar to/the same as the values of .88 for positive affect and .87 for negative affect reported in Watson et al. (1988).

Entrepreneurial Success. Entrepreneurial success was measured using an average measure of standardized measures of past and current revenue growth (Hmieleski & Baron, 2009; Wiklund et al., 2009). Past revenue growth indicated whether the revenue in 2014 was less than, equal to, or more than the revenue in 2013. Current revenue growth was measured with an indication of whether the revenue at the end of 2014 was much lower (less than 20%), lower, similar, higher, or much higher (more than 20%) than the expectation of revenue in 2014 measured at the beginning of 2014. Cronbach's alpha was .76.

Control variables. Three control variables were used because of their well-documented associations with affect and entrepreneurship: gender (where male is 1) (Kring and Gordon (1998) and Minniti and Nardone (2007), respectively), age of the entrepreneur (Santorelli, Ready, and Mather (2018) and Levesque and Minniti (2006), respectively), and education (Demenescu et al. (2014) and Dickson, Solomon, and Weaver (2008), respectively). Education was measured as the highest finished type of education, where the options range from primary education to university. We also controlled for experience, measured as the number of years one is a sole proprietor at the moment of measuring.

3.3.2 AMAROK

The AMAROK sample consisted of 349 French small business owners and was collected by Observatoire AMAROK[5], partner of Montpellier Business School. AMAROK runs a panel of these owners with the primary goal of analyzing the health of entrepreneurs. The data was collected in the winter of 2015-2016. There are 254 individuals in the final sample since some small business owners exited the

5 http://www.observatoire-amarok.net/en.

panel and there were some incomplete observations. Of these small business owners, most had two to three years higher education or had obtained a Bachelor's degree (37 percent); the second largest group had four to five years higher education or had obtained a Master's degree (26 percent). Four percent owned a business of size 1 (i.e. these owners can be classified as sole proprietors), 25 percent fitted the definition of a micro-sized business (less than 10 employees), 56 percent fitted the definition of a small-sized business (10 to 49 employees), and the remaining 15 percent were medium-sized business with more than 50 employees. The average age of these small business owners was 50 years, and 80 percent of them were male.

Variables and Measures

Entrepreneurial Orientation. As the AMAROK sample consisted of small business owners, who usually have employees, the strategic posture of the business usually depended not only on the owner, but also on other board members. Therefore, firm entrepreneurial orientation was the appropriate measure for small business owners and hence, we measure entrepreneurial orientation using the (slightly adapted) French version of the 9-item scale of Covin and Slevin (1989), using a seven-point Likert scale. Of these nine items, there were three items for innovativeness, three for proactiveness, and three for risk-taking. Sample items were "In general, the top managers of my firm favor a strong emphasis on R&D, technological leadership, and innovation", "In dealing with its competitors, my firm typically responds to actions which competitors initiate" (reversed), and "In general, the top managers of my firm have a strong proclivity for high-risk projects (with chances of very high return)", respectively. Cronbach's alpha was .73, indicating that internal reliability was good.

Affect. For measuring affect, we used the PANAS with time frame 'generally' as we did for the Panteia sample. Cronbach's alpha for positive affect was .71 and for negative affect .83, similar to the values reported in Watson et al. (1988).

Entrepreneurial Success. We used two measures for entrepreneurial success. The first measure, referred to as 'entrepreneurial success', was an average of three questions regarding finance, profitability, and turnover. The question regarding finance was 'Was your business this year?': 'strong beneficiary', 'beneficiary', 'balanced', 'deficient', and 'strongly deficient'. Regarding profitability, the question was 'Compared to last year, your profit is?': 'strong increase', 'increase', 'stable', 'decrease', and 'strong decline'. Regarding business turnover, it was 'Compared to last year, your turnover is?': 'strong increase', 'increase', 'stable', 'decrease', and 'strong decline'. Cronbach's alpha over these items is .78. The second measure, referred to as 'entrepreneurial success (%)' or 'percentage measure of entrepreneurial success' simply asked small business owners 'All things considered, how would you evaluate the success of your company/venture?', where they responded with a number between 1 ('very unsuccessful') and 100 ('very

successful'). These two success measures were acquired at the same time as our measures for the main analysis.

Control variables. In line with the controls used in the Panteia sample and due to the well-documented association between affect/entrepreneurship and these controls, we used gender (where male is 1), age of the entrepreneur, education, and experience as control variables. Education was measured as the highest completed education level. Experience was measured as the number of years the small business owner owned the business. The larger the number of years one owns a business, the higher is the change that the business's entrepreneurial orientation is based on the owner (Quigley & Hambrick, 2012).

3.3.3 Analysis

To investigate the role of positive and negative affect in entrepreneurial orientation, we used linear regression models with entrepreneurial orientation as the dependent variable and both positive affect and negative affect, together with the controls, as independent variables. Positive affect and negative affect were assumed to be orthogonal meaning that including them in one regression model did not cause danger for multicollinearity. The coefficients of the regression models were estimated by Ordinary Least Squares (OLS). To easily compare coefficients across the samples, we standardized all variables except gender. For our additional tests, we developed our model further. First, we analyzed our models by replacing entrepreneurial orientation with its different dimensions: innovativeness, proactiveness, and risk taking. Second, we analyzed our models by replacing entrepreneurial orientation with entrepreneurial success and we added entrepreneurial orientation to our set of independent variables such that we could analyze the role of affect in entrepreneurial success (possibly indirectly through entrepreneurial orientation).

Besides, to get a more thorough view of our main goal, the association between affect and entrepreneurial orientation, we repeated the analysis (with respect to entrepreneurial orientation) for a student sample (referred to as Woudestein). The motivation behind using this sample, a description of the sample, and the corresponding results are presented in Appendix A.

3.4. Results

Tables 3.1 and 3.2 present the unstandardized means, standard deviations (SD), minima (min), maxima (max), percentage of missing observations (missing (%), variance inflation factors (VIF), and a correlation matrix with the value of Cronbach's alpha on the diagonal for the Panteia and AMAROK sample, respectively. The correlations of the Panteia sample (Table 3.1) varied from -.20 till .75. The correlations between positive affect and entrepreneurial orientation (.27)

and between negative affect and entrepreneurial orientation (-.12) were significant and in the expected direction. For the AMAROK sample (Table 3.2), the smallest correlation was -.31 and the highest was .62. For this sample, the correlation between positive affect and entrepreneurial orientation was significant and positive (.16), but the correlation between negative affect and entrepreneurial orientation was not significant (.07). For both samples, correlations between positive affect and entrepreneurial orientation were larger in absolute values than the correlations between negative affect and entrepreneurial orientation. Also, correlations between positive affect and negative affect were (close to) zero (.00 for Panteia and .02 for AMAROK) indicating that positive affect and negative affect are indeed orthogonal.

Furthermore, the maximum variance inflation factors for Panteia and AMAROK were 2.54 and 1.87 respectively. These variance inflation factors were below 4, thus indicating no danger of multicollinearity (Diamantopoulos, Riefler, & Roth, 2008; Hair, Anderson, Babin, & Black, 2010). Also, common method bias was checked for by applying Harman's single factor test (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). The rule of thumb is that a single unrotated principal component should not explain more than the threshold level of 50 percent of the variance for all of the indicators measured with the same method. The first principal component of Panteia explained 16.8 percent and that of AMAROK explained 15.4 percent. Hence, these low percentages indicated no serious threat of common method bias.

Table 3.1. Means, standard deviations, minima, maxima, percentage of missing values, variance inflation factors, correlations, and Cronbach's alpha's of the unstandardized variables of the Panteia sample (N = 337).

							Correlations and Cronbach's alpha						
	Mean	SD	Min	Max	Missing (%)	VIF	1	2	3	4	5	6	7
1. Entrepreneurial Orientation	3.52	0.61	1.7	5	0	1.12	0.81						
2. Entrepreneurial Success	3.72	0.76	1	5	0	2.39	0.22***	0.76					
3. Positive Affect	3.52	0.52	1	5	0	2.54	0.27***	0.75***	0.84				
4. Negative Affect	1.56	0.54	1	5	0	1.10	-0.12*	-0.10	0.00	0.87			
5. Gender	0.69	0.47	0	1	0	1.07	0.11	-0.05	-0.04	0.06	-		
6. Age	53.07	8.77	24	76	0	1.19	0.04	0.02	-0.08	-0.19***	-0.03	-	
7. Education	5.05	1.29	1	6	0	1.12	0.09	0.12*	0.21***	-0.01	-0.19***	-0.07	-
8. Experience	14.47	9.82	1	52	0	1.22	0.03	-0.12*	-0.17**	0.09	0.10	0.32***	-0.20***

Note: *: p < .05, **: p < .01, ***: p < .001.

Table 3.2. Means, standard deviations, minima, maxima, percentage of missing values, variance inflation factors, correlations, and Cronbach's alpha's of the unstandardized variables of the Amarok sample (N = 254).

							Correlations and Cronbach's alpha							
	Mean	SD	Min	Max	Missing (%)	VIF	1	2	3	4	5	6	7	8
1. Entrepreneurial Orientation	4.05	0.94	1	7	0	1.08	0.73							
2. Entrepreneurial Success	3.01	0.92	1	5	1	1.21	0.09	0.78						
3. Entrepreneurial Success (%)	66.15	19.22	2	100	13	1.24	0.14*	0.33***	-					
4. Positive Affect	3.56	0.51	1.4	4.7	0	1.08	0.16*	0.13*	0.11	0.71				
5. Negative Affect	2.25	0.65	1	4.4	0	1.08	0.07	-0.06	-0.13	0.02	0.83			
6. Gender	0.80	0.40	0	1	0	1.03	0.00	0.04	-0.01	-0.10	-0.06	-		
7. Age	50.44	7.80	27	74	0	1.78	-0.08	-0.13*	0.08	-0.10	-0.10	-0.03	-	
8. Education	3.80	1.17	1	6	0	1.17	-0.01	0.09	-0.15*	0.03	-0.07	-0.04	-0.13*	-
9. Experience	16.32	8.86	0.33	42	0	1.87	0.03	-0.06	0.16*	-0.08	0.03	0.04	0.62***	-0.31***

Note: *: p < .05, **: p < .01, ***: p < .001.

Table 3.3 shows the results of the linear regression models. We found confirming results for Hypothesis 1 (the positive association between positive affect and entrepreneurial orientation) in both samples. Indeed, a significant and positive association between trait positive affect and individual entrepreneurial orientation was found for the 337 sole proprietors of the Panteia sample (coefficient = 0.27, p < .001) and the 254 small business owners of the AMAROK sample (coefficient = 0.15, p < .05).

With respect to Hypothesis 2, we found confirming results for Panteia, but not for AMAROK. That is, we found a significant and negative association between trait negative affect and individual entrepreneurial orientation in the Panteia sample (coefficient = -0.13, p < .05). In the AMAROK sample, however, the association between trait negative affect and firm entrepreneurial orientation was insignificant and not even in the right direction (coefficient = 0.05, p = .44).

Moreover, we noted that the absolute coefficients between positive affect and entrepreneurial orientation were larger than the absolute coefficients between negative affect and entrepreneurial orientation. As variables were standardized, the table presents standardized, and thus comparable, coefficients. In both the samples, the coefficient for positive affect was more than two times as large as the coefficient for negative affect.

Table 3.3. OLS results of the linear regression models for both samples.

	Entrepreneurial Orientation (Panteia)	Entrepreneurial Orientation (AMAROK)
Intercept	-0.01	0.03
	(0.05)	(0.06)
Positive Affect	0.27***	0.15*
	(0.05)	(0.06)
Negative Affect	-0.13*	0.05
	(0.06)	(0.06)
Gender	0.13*	0.01
	(0.05)	(0.06)
Age	0.03	-0.15
	(0.06)	(0.09)
Education	0.07	0.01
	(0.06)	(0.07)
Experience	0.07	0.12
	(0.05)	(0.08)
F-statistic	6.80***	1.76
p-value	0.00	0.11
Adjusted R squared	0.09	0.02
Number of observations	337	254

Note: *: $p < .05$, **: $p < .01$, ***: $p < .001$, SEs between brackets, p-value for F-statistic.

To test robustness of the linear regression models, we repeated the procedure but with either positive or negative affect. Positive affect had a coefficient of 0.27 ($p < .001$) for Panteia and 0.15 ($p < .05$) for AMAROK, while negative affect had a coefficient of -0.13 ($p < .05$) for Panteia and 0.05 ($p = .43$) for AMAROK. Hence, results were, based on two decimals, the same for the main results. This is not surprising, as positive affect and negative affect are independent dimensions (Watson et al., 1988) and orthogonal in a statistical sense (see also Table 3.1 and 3.2). Fredrickson and Losada (2005) has argued the usefulness of the ratio of positive affect to negative affect. Therefore, we also repeated the procedure with positive affect divided by negative affect as independent variable. We found a coefficient of 0.22 ($p < .001$) for Panteia and 0.04 ($p = .49$) for AMAROK. Thus, although the coefficients obviously have a different interpretation, results remained similar.

As our first additional test, we analyzed the three dimensions of entrepreneurial orientation, i.e. innovativeness, proactiveness, and risk taking, separately (see Table 3.B.1 in Appendix B). For positive affect, the results of Panteia sample were similar to the main results. That is, positive and significant associations were found between positive affect and all entrepreneurial orientation dimensions. For negative affect, we found that innovativeness and risk taking are mainly responsible for the association. With respect to the association between positive affect and the entrepreneurial orientation dimensions in AMAROK, the results showed that innovativeness mainly drove the association.

For the second additional aim, we augmented the model with entrepreneurial success to investigate whether affect is associated (either directly or indirectly

through entrepreneurial orientation) to entrepreneurial success. The results are presented in Table 3.B.2 in Appendix B. In the Panteia sample, we found a direct association between trait positive affect and entrepreneurial success (coefficient = 0.16, $p < .01$), and between trait negative affect and entrepreneurial success (coefficient = -0.12, $p < .05$). For the AMAROK sample however, neither did we find a significant association between positive affect and entrepreneurial success (coefficient = 0.11, $p = .10$), nor between positive affect and the percentage measure of entrepreneurial success (coefficient = 0.12, $p = .05$) although this latter coefficient was significant (coefficient 0.14, $p < .05$) when the total effect was examined (i.e. without controlling for entrepreneurial orientation). With respect to negative affect, there was no significant and direct association for entrepreneurial success (coefficient = -0.08, $p = .05$), but there was a significant association between negative affect and the percentage measure of entrepreneurial success (coefficient = -0.16 $p < .05$). Note that some p-values were just higher than .05, such that the results were insignificant. However, these low p-values hint an association between affect and entrepreneurial success.

In both samples we tested for indirect associations (i.e. the association of positive or negative affect and entrepreneurial success through entrepreneurial orientation) using a Sobel test (Sobel & Leinhart, 1982) but found no significant results. This is possibly due to the fact that none of the coefficients for entrepreneurial orientation (when associated to entrepreneurial success) were significant. That is, there was no significant association between entrepreneurial orientation and entrepreneurial success for the Panteia sample (coefficient = -0.07, $p = .22$), nor between entrepreneurial orientation and entrepreneurial success/the percentage measure of entrepreneurial success for the AMAROK sample (entrepreneurial success: coefficient = 0.07, $p = .22$; percentage measure of entrepreneurial success: coefficient = 0.13, $p = .05$)

Finally, we investigated the role of affect in entrepreneurial orientation in a sample of students (see Appendix A). The results of this student sample confirmed both our hypotheses.

3.5. Discussion

Although affect plays a key role in the entrepreneurship literature (Baron, 2008; Delgado García et al., 2015; Hahn et al., 2012), its role as a driver for entrepreneurial orientation has not yet been established. To fill this gap, the present study investigated the association between (both positive and negative) affect and entrepreneurial orientation in two main samples: 337 Dutch sole proprietors (Panteia) and 254 French small business owners (AMAROK). Additionally, we investigated the role of affect in three dimensions of entrepreneurial orientation and its role in entrepreneurial success. Our investigation led to several findings.

First, we found a positive association between positive affect and entrepreneurial orientation in both samples, despite using slightly different measures for entrepreneurial orientation (i.e. the individual variant versus the firm variant). Hypothesis 1 was convincingly confirmed: positive affect is positively associated to individual entrepreneurial orientation in sole proprietors and to firm entrepreneurial orientation in small business owners. This indicates that positive feelings and emotions are associated with acting more entrepreneurial in terms of innovativeness, proactiveness, and risk-taking; although for the small business owners, positive feelings and emotions are mostly associated to innovativeness. The positive association between positive affect and innovativeness is in line with earlier findings (Baron & Tang, 2011; Rutherford & Holt, 2007).

Second, the unambiguous result for positive affect did not hold for negative affect. Although there was a negative association between negative affect and individual entrepreneurial orientation for sole proprietors, there was no significant negative association between negative affect and firm entrepreneurial orientation in small business owners. Therefore, Hypothesis 2 was only confirmed for sole proprietors. For these sole proprietors, the association was mainly visible in the innovativeness and risk taking dimensions of entrepreneurial orientation. The extant literature indeed shows more evidence for the associations between affect and these dimensions then between affect and proactiveness (Baron & Tang, 2011; Isen & Geva, 1987; Mittal & Ross Jr, 1998; Rutherford & Holt, 2007). Our finding could mean that for sole proprietors, having negative feelings and emotions is associated with less entrepreneurial strategic posture (especially with respect to innovativeness and risk taking), while negative feelings and emotions experienced by small business owners do not impact their *firm*'s strategic posture. A possible reason could be that the business owner's affect is 'too distant' from *firm's* entrepreneurial orientation. In other words, *firm* entrepreneurial orientation is perhaps not only based on the small business owner's affect, but also on characteristics of other (important) members of the board as predicted by Hambrick and Mason's (1984) upper echelon theory. Another reason could be that firms, opposed to sole proprietors, are confronted with task conflicts as well as relationship conflicts in entrepreneurial tasks both which impact negative affect (Breugst & Shepherd, 2017). These conflicts may also impact the strategic posture of the firm. Therefore, our estimated coefficient between negative affect and (firm) entrepreneurial orientation may be biased because conflicts have not been incorporated in our study. Hence, the affective characteristics of the small business owner alone do not impact *firm* entrepreneurial orientation as dramatically when compared to sole proprietors.

Third, although prior studies focus on either positive affect or negative affect (Delgado García et al., 2015), our results show that it is important to distinguish between positive and negative affect and investigate both, as they represent separate and independent dimensions (Watson et al., 1988). Our results confirm this in three ways. First, the correlations between both dimensions of affect are very small or

even zero. Second, the coefficients of the linear regression models including only one of the affect dimensions, i.e. either positive affect or negative affect are the same as the coefficients of the linear regression models including both affect dimensions simultaneously. Third, our results show that rather than just being opposites, positive and negative affect constitutes completely separate associations with different signs, strengths, and significance.

Indeed, the positive association between positive affect and entrepreneurial orientation was stronger than the negative association between negative affect and entrepreneurial orientation. The absolute coefficient for positive affect was more than two times as large as the absolute coefficient of negative affect in the Panteia sample. Due to the insignificant association between negative affect and entrepreneurial orientation in the AMAROK sample, we did not compare the absolute coefficients for the AMAROK sample. Nonetheless, we may conclude that positive feelings and emotions play a more important role for entrepreneurial orientation than negative feelings and emotions.

Finally, we investigated the role of affect in entrepreneurial success. We found evidence for a positive association between positive affect and entrepreneurial success and a negative association between negative affect and entrepreneurial success in the Panteia sample. This is in line with the meta-analytic results of Luybomirsky et al. (2005) showing that positive affect is associated with many successful outcomes across different domains of life. The findings, however, were less evident in the AMAROK sample, where we found a negative association between negative affect and the percentage measure of entrepreneurial success, but no clear association between positive affect and entrepreneurial success. Nevertheless, p-values for positive affect (when associated to entrepreneurial success) were low and thus hint to the existence of an association between affect and entrepreneurial success.

3.5.1 Implications for Theory and Practice

The findings of the present study have several theoretical implications. *First*, the present study adds to our knowledge of the entrepreneurial profile (Gartner, 1990). Specifically, it investigates the role of affect in entrepreneurship (Delgado García et al., 2015; Hahn et al., 2012) Our findings reveal that both positive and negative affect play different but significant roles in entrepreneurial orientation – and partly in entrepreneurial success – and thus qualify as drivers of entrepreneurial orientation and entrepreneurial success. This is in line with other findings related to the present study. For instance, in their review, Shepherd, Williams, and Patzelt (2015) explain the characteristics of the entrepreneurial decision maker. They explain that decision making strategies can differ across entrepreneurs because of gender, national and cultural heritage, but also in the amount of experience – which in itself enhances self-efficacy, such that strategy may be more aggressive and

seemingly riskier. Further, emotions may indeed also impact entrepreneurial decision making as Baron (2008) mentions first. As Shepherd et al. (2015) show, not only affect explains entrepreneurial orientation, but also risk and problem framing do. Particularly, Lawrence, Clark, Labuzetta, Shahkian, and Vyakarnum (2008) write that there is no difference in entrepreneurs and managers when they perform in cold decision making, i.e. risk-free decision making, while entrepreneurs behaved significantly riskier in hot decision making, i.e. decision making with risk involved. This higher risk taking found in entrepreneurs was accompanied with an enhanced score on impulsivity. Further, Dew, Read, Sarasvathy, and Wiltbank (2009) show that problems are framed completely different by expert entrepreneurs when compared to MBA students. Where expert entrepreneurs use 'effectual' logic, the students go by the textbook. Hence, next to gender, culture, risk taking, and problem framing, the importance of affect in strategic posture and success of entrepreneurs is underlined.

Second, results of our study show the importance of investigating both positive affect and negative affect as separate concepts. We found no correlations between both dimensions of affect and the results differed in sign, strength, and significance. While many studies have reported results of only one measure of affect (Baron & Tang, 2011; Baron et al., 2011; Foo et al., 2009), our work shows the importance of investigating both.

Third, the affect-Big Five literature is connected with the Big Five-entrepreneurship literature. With respect to literature linking affect and the Big Five, findings show that there is a positive association between positive affect and conscientiousness, extraversion, and openness to experience and between negative affect and neuroticism (Costa & McCrae, 1980; Gutiérrez et al., 2005; Roccas et al., 2002; Shiota et al., 2006). With respect to the Big Five-entrepreneurship literature, Zhao and Seibert (2006) show that entrepreneurs score higher than managers on conscientiousness and openness to experience and lower on neuroticism and agreeableness. Similarly, Caliendo, Fossen, and Kritikos (2014) show that entry into self-employment is positively impacted by extraversion and openness to experience. The Big Five further plays a role in entrepreneurial performance (Zhao, Seibert, & Lumpkin, 2010), where conscientiousness, extraversion, and openness to experience positively impact success, while neuroticism negatively impacts it. Taking these two fields of literature together, we expect a positive association between positive affect and entrepreneurship (as both are positively associated with conscientiousness, extraversion, and openness to experience) and a negative between negative affect and entrepreneurship (as both are negatively associated with neuroticism). Indeed, the present study shows positive associations between positive affect and entrepreneurial orientation and success and negative associations between negative affect and (some of) our entrepreneurship measures.

Fourth, the present study contributes to the great rationality debate which concerns the rationality of individuals in (economic) decision making. This debate

is recently recognized to play a role in entrepreneurship (Zhang & Cueto, 2017). With the present study, we show that irrational characteristics, such as affect, could have an impact on (rational) strategic postures. Additionally, the findings of Smith, Gannon, Grimm, and Mitchell (1988) showed that entrepreneur's decision behavior follows a less formal rational decision process than professional managers from a larger firm. For both the entrepreneur and the manager however, a lower organizational performance is obtained when the degree of formality and rationality in the decision process declines.

From a practical point of view, the present study adds value to the understanding of how affect influences the degree of entrepreneurship in the strategic posture of sole proprietors and small business owners. For sole proprietors, trait positive affect implies a more entrepreneurial strategic posture in terms of innovativeness, proactiveness, and risk-taking, while for small business owners, trait positive affect implies a more entrepreneurial strategic posture in terms of innovation. However, while for sole proprietors, negative affect is negatively associated with individual entrepreneurial orientation, for small business owners, negative affect does not impact their strategic posture. One could speculate that having other members in the organization buffers the negative affect of small business owners from influencing the firm's strategic position negatively, as these other members also influence the firm's strategy, either directly or indirectly (Quigley & Hambrick, 2012). Since an appropriate strategic posture leads to higher performance in business environment, this knowledge of the association between affect and entrepreneurial orientation can inform sole proprietors and small business owners on how to better run their business, and help future entrepreneurs make a deliberate choice on whether to start a business. Encouraging everyone to become entrepreneur is not our message: only the high growth potential enterprises are beneficial for the economy (Shane, 2009). Finally, knowledge about the important link between affect and entrepreneurial orientation can also guide mental health intervention programs to help entrepreneurs unleash their full potential.

3.5.2 Limitations and Future Research Directions

Our study has certain limitations, and at the same time, has opened the avenue for future research directions.

First, some may view using both individual and firm entrepreneurial orientation as a limitation. Indeed, one may be concerned about using two different measures and comparing their results. However, we believe that in this specific situation, the use of both individual entrepreneurial orientation and firm entrepreneurial orientation is appropriate. There are several reasons that guide our belief in this regard. First, the measure of entrepreneurial orientation fits the type of subjects we studied in our sample: while sole proprietors are individually responsible for their firm outcomes, small business owners are influenced

by/influence their employees so that the firm-level outcome is a more appropriate measure. Second, although the items of the measures differ in their wording, they show similarity in the sub dimensions (innovativeness, proactiveness, and risk taking). Third, although one could argue that affect is an individual-level measure and hence cannot be associated with a firm-level concept like entrepreneurial orientation, the upper echelon theory suggests that individual characteristics can predict organizational outcomes (Hambrick & Mason, 1984).

Second, one may question the credibility of the results from the Panteia sample due to the fact that two different temporal points were used while collecting the data. Nevertheless, we believe that our results are trustworthy for two reasons. First, we intentionally measured trait affect instead of state affect. Trait affect measures *general* affect, i.e. affect deeply embedded in a person. This deeper form of affect is more stable and is considered to remain the same over years. Second, the results of the Panteia sample are in line with the results of the Woudestein sample (Appendix A) and AMAROK sample, which gives confidence in our results.

Third, our measure of entrepreneurial success is not embedded in the literature, which could raise doubt about our results with regard to entrepreneurial success. For this reason, we included multiple measures and multiple-item constructs. The constructs show high internal reliability and are therefore trustworthy. Also, results are in the expected direction. Nevertheless, the use of well-validated measures of entrepreneurial success in the future could lead to clearer (i.e. significant) results, since our results signal such a significance. The insignificant results for entrepreneurial success could also lay in the focus on entrepreneurial orientation – instaed of its dimensions – in our analysis. As mentioned by Kreiser et al., (2013), the different dimensions of entrepreneurial orientation may have different impact on entrepreneurial success. Therefore, future studies should adopt well-validated measures of entrepreneurial success and investigated the relationship of entrepreneurial orientation and success through the three dimensions of entrepreneurial orientation.

Our work does not claim to have identified any causality between affect and entrepreneurial orientation. On the one hand, feelings and emotions may influence strategy, but on the other hand, strategy may also lead to certain feelings and emotions, possibly through entrepreneurial success. Hence, we used the word ‘associations’ throughout the paper. Although we cannot formally identify causality, we can surmise that the direction of affect to entrepreneurial orientation is a more reasonable direction, given that we investigated trait affect in two of the three samples. Trait affect is related to a general characteristic of a person and is a long-term concept. However, entrepreneurial orientation is more likely to change since the characteristics of the market, the product, the competitors, and the business itself may change. Therefore, it is more conceivable that long-term affect influences dynamic strategic posture, rather than a dynamic strategic posture influencing the long-term feelings and emotions of an entrepreneur. Nevertheless, we recommend

future studies to use experimental or panel data to obtain a clearer understanding of which of the two causal direction prevails.

3.6. Conclusion

Entrepreneurial orientation is often associated with venture success (Rauch et al., 2009). However, the drivers of entrepreneurial orientation have not yet been firmly established. Recent literature has called for investigating the links between affect and entrepreneurial orientation (Delgado García et al., 2015; Hahn et al., 2012). Our study empirically investigated the role of both (orthogonal) dimensions of affect, i.e. positive and negative, on two variants of entrepreneurial orientation (i.e. the original firm-level variant and the individual-level variant). It additionally tested the role of affect on the separate dimensions of entrepreneurial orientation and on entrepreneurial success. Using two samples, we show that positive affect is positively associated to both variants of entrepreneurial orientation, while negative affect is negatively associated to only individual entrepreneurial orientation. Results for entrepreneurial success are mixed. Our findings add to our knowledge about the roles of both positive and negative affect on *entrepreneurial orientation* and links two fields of literature: the field investigating the association between affect and the Big Five and the field investigating the role of the Big Five in entrepreneurship.

3.7. Appendix A

Appendix A presents the results with regard to a student sample (referred to as Woudestein). These results are not part of the main text for two reasons. First, the focus is on actual sole proprietors/business owners, who possess a strategic posture or entrepreneurial orientation because they own a business. Students can answer question about a strategic posture, but for most students, the answers are hypothetical and hence not based on actual behavior. Further, it is hard, if not impossible, to measure entrepreneurial success in students who are in a different phase of life. The few that started a business probably could not say much about actual success yet.

Nevertheless, we see merit in adding the results for students. Although the results are not an internal replication, they do add to our knowledge of the main goal: investigating the affect-entrepreneurial orientation association. In the present appendix, we discuss the sample and present the results.

3.7.1 Woudestein

The Woudestein sample consisted of 182 students of the Erasmus University of Rotterdam in the Netherlands who were recruited from different faculties by various university recruitment systems, i.e. that of the economics department, that

of the psychology department, and one where students of all schools could apply. Most students studied economics (41 percent), psychology (28 percent), or other social sciences (14 percent). About 35 percent of the students was taking entrepreneurship courses. The data was collected between May 2015 and April 2016. Although 182 students filled in the questionnaire, only 177 were analyzed due to missing observations. The average age of these 177 students was 21 years (median was 20 years) and slightly more than half of the sample (56 percent) was female.

Variables and Measures

Entrepreneurial Orientation. To measure entrepreneurial orientation amongst students, who are usually individuals without a business, it was appropriate to use an individual-level scale. Hence, we used the individual entrepreneurial orientation scale of Langkamp Bolton and Lane (2012). To avoid repetition, we referred to the subsection 'Variables and measures' in our Panteia section for more information about this scale. Cronbach's alpha was equal to .76 indicating a good reliability for this scale.

Affect. To measure affect, we used the PANAS (as explained in the section for the Panteia sample) with the time frame '*generally*', i.e. participants have to indicate to what extent they *generally* feel a certain feeling or emotion. Cronbach's alpha for positive affect was .79 and for negative affect .89, similar to the ones (.88 for positive affect and .87 for negative affect) reported by Watson et al. (1988).

Control variables. For the same reasons as mentioned in the Panteia/AMAROK section and to be able to compare results across samples, we included the same three control variables as we did for the Panteia sample, viz. gender (where male is 1), age, and education. Education was measured as the average grade of the last year. Experience was not added because (most) students simply had no experience in their own business.

3.7.2 Results

Table 3.A.1 presents the unstandardized means, standard deviations (SD), minima (min), maxima (max), variance inflation factors (VIF), and a correlation matrix with the value of Cronbach's alpha on the diagonal for the Woudestein sample. The correlations range from -.16 till .44. These two extreme correlations are exactly the correlations of our focal associations, i.e. the correlation between negative affect and entrepreneurial orientation is significantly negative (-.16) and the correlation between positive affect and entrepreneurial orientation is significantly positive (.44). Results for the Woudestein sample were similar to the results for the Panteia and AMAROK samples. The correlation between positive affect and entrepreneurial orientation was larger in absolute values than the correlation between negative affect and entrepreneurial orientation. Also, the

correlation between positive affect and negative affect was .00 indicating that positive affect and negative affect are indeed orthogonal.

The maximum variance inflation factor for Woudestein was 1.30 and thus far below 4, indicating no danger of multicollinearity (Diamantopoulos et al., 2008; Hair et al., 2010). Also, common method bias was checked for by applying Harman's single factor test (Podsakoff et al., 2003). The first principal component of Woudestein explained 17.0 percent of the variance indicating no serious threat of common method bias.

Table 3.A.1. Means, standard deviations, minima, maxima, variance inflation factors, correlations, and Cronbach's alpha's of the unstandardized variables of the Woudestein sample (N = 177).

						Correlations and Cronbach's alpha				
	Mean	**SD**	**Min**	**Max**	**VIF**	**1**	**2**	**3**	**4**	**5**
1. Entrepreneurial Orientation	3.55	0.50	2.3	5.0	1.29	0.76				
2. Positive Affect	3.68	0.45	2.2	4.9	1.30	0.44***	0.79			
3. Negative Affect	2.25	0.68	1.1	4.0	1.05	-0.16*	0.00	0.89		
4. Gender	0.44	0.50	0	1	1.02	-0.02	-0.02	-0.12	-	
5. Age	20.67	2.06	18	30	1.02	0.04	0.04	0.04	0.04	-
6. Education	6.86	0.86	4.0	9.0	1.05	-0.01	0.17*	0.05	-0.01	0.10

Note: *: $p < .05$, **: $p < .01$, ***: $p < .001$.

Table 3.A.2 shows the results of the linear regression models. Similar as for our main samples, we find confirming results for Hypothesis 1: a significant and positive association between trait positive affect and individual entrepreneurial orientation is found for the 177 students of the Woudestein sample (coefficient = 0.45, $p < .001$). With respect to Hypothesis 2, we also find confirming results: a significant and negative association (coefficient = -0.16, $p < .05$) between trait negative affect and individual entrepreneurial orientation. Moreover, we note that, also for the Woudestein sample, the absolute coefficients between positive affect and entrepreneurial orientation are larger than the coefficients between negative affect and entrepreneurial orientation: the coefficient for positive affect is almost three times larger than coefficient for negative affect.

To test robustness of these results, we repeat the procedure but with either positive or negative affect. Positive affect has a coefficient of 0.45 ($p < .001$) while negative affect has a coefficient of -0.16 ($p < .05$) such that results are the same as the main results. This proves independency of positive and negative affect (Watson et al., 1988) and orthogonal in a statistical sense (see also Table 3.A.1). For the same reason as explained in the main text, we repeat the procedure with positive affect divided by negative affect as independent variable. We find a coefficient of 0.33 ($p < .001$). Hence, although coefficients obviously have a different interpretation, results remain similar.

Table 3.A.2. OLS results of the linear regression models (with the three dimensions of entrepreneurial orientation as dependent variable) for the Woudestein sample.

	Entrepreneurial Orientation (Woudestein)	Entrepreneurial Orientation - Innovativeness (Woudestein)	Entrepreneurial Orientation - Proactiveness (Woudestein)	Entrepreneurial Orientation - Risk taking (Woudestein)
Intercept	0.02	0.01	0.01	0.01
	(0.07)	(0.07)	(0.07)	(0.07)
Positive Affect	0.45***	0.22**	0.43***	0.40***
	(0.07)	(0.07)	(0.07)	(0.07)
Negative Affect	-0.16*	-0.12	-0.16*	-0.09
	(0.07)	(0.07)	(0.07)	(0.07)
Gender	-0.03	-0.08	-0.12	0.12
	(0.07)	(0.07)	(0.07)	(0.07)
Age	0.04	0.08	-0.05	0.04
	(0.07)	(0.07)	(0.07)	(0.07)
Education	-0.08	-0.12	0.14*	-0.18*
	(0.07)	(0.08)	(0.07)	(0.07)
F-statistic	10.06***	2.86*	11.64***	8.29***
p-value	0.00	0.02	0.00	0.00
Adjusted R squared	0.21	0.05	0.23	0.17
Number of observations	177	177	177	177

Note: *: p < .05, **: p < .01, ***: p < .001, SEs between brackets, p-value for F-statistic.

For the student sample, we could also analyze the three dimensions of entrepreneurial orientation, i.e. innovativeness, proactiveness, and risk taking (see Table 3.A.2). Positive affect is significantly and positively associated to all three dimensions. With respect to negative affect, we find that it is mostly proactiveness that drives the negative association for the students in the Woudestein sample.

3.8. Appendix B

In Appendix B, we present the tables for our additional tests. The first table (Table 3.B.1) shows results when analyzing the different dimensions of entrepreneurial orientation and the second table (Table 3.B.2) shows results corresponding to the analysis of entrepreneurial success.

Table 3.B.1. OLS results of the linear regression models for the three dimensions of entrepreneurial orientation.

	Entrepreneurial Orientation - Innovativeness (Panteia)	Entrepreneurial Orientation - Proactiveness (Panteia)	Entrepreneurial Orientation - Risk taking (Panteia)	Entrepreneurial Orientation - Innovativeness (AMAROK)	Entrepreneurial Orientation - Proactiveness (AMAROK)	Entrepreneurial Orientation - Risk taking (AMAROK)
Intercept	-0.02	0.02	-0.01	0.02	0.03	0.02
	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Positive Affect	0.23***	0.23***	0.17**	0.17**	0.07	0.07
	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Negative Affect	-0.11*	-0.04	-0.12*	0.06	0.06	0.09
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Gender	0.07	0.04	0.18***	0.04	0.04	0.02
	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)
Age	0.09	0.00	-0.05	0.06	-0.22*	0.05
	(0.06)	(0.06)	(0.06)	(0.09)	(0.09)	(0.09)
Education	0.12*	-0.02	0.04	0.02	0.00	0.04
	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)	(0.07)
Experience	0.02	0.07	0.09	0.11	0.12	0.02
	(0.05)	(0.06)	(0.06)	(0.08)	(0.08)	(0.09)
F-statistic	5.71***	2.98**	4.32***	1.97	1.49	0.72
p-value	0.00	0.01	0.00	0.07	0.18	0.63
Adjusted R squared	0.08	0.03	0.06	0.02	0.01	0.01
Number of observations	337	337	337	254	254	254

Note: *: $p < .05$, **: $p < .01$, ***: $p < .001$, SE between brackets, p-value for F-statistic.

Table 3.B.2. OLS results of the linear regression models for entrepreneurial success.

	Entrepreneurial Success (Panteia)		Entrepreneurial Success (AMAROK)		Entrepreneurial Success (%) (AMAROK)	
Intercept	0.05	0.05	0.00	-0.00	-0.00	-0.01
	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)
Entrepreneurial Orientation		-0.07		0.07		0.13
		(0.06)		(0.06)		(0.07)
Positive Affect	0.14*	0.16**	0.12	0.11	0.14*	0.12
	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)
Negative Affect	-0.11	-0.12*	-0.07	-0.08	-0.15*	-0.16*
	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)
Gender	0.02	0.03	0.05	0.05	-0.00	-0.01
	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)
Age	-0.15*	-0.14*	-0.17	-0.16	-0.03	-0.01
	(0.06)	(0.06)	(0.09)	(0.09)	(0.10)	(0.10)
Education	-0.01	-0.01	0.09	0.09	-0.12	-0.11
	(0.06)	(0.06)	(0.07)	(0.07)	(0.07)	(0.07)
Experience	-0.06	-0.05	0.07	0.06	0.16	0.14
	(0.06)	(0.06)	(0.08)	(0.08)	(0.09)	(0.09)
F-statistic	3.41**	3.14**	1.98	1.87	2.78*	2.90**
p-value	0.00	0.00	0.07	0.08	0.01	0.01
Adjusted R squared	0.04	0.04	0.02	0.02	0.05	0.06
Number of observations	331	331	252	252	221	221

Note: *: $p < .05$, **: $p < .01$, ***: $p < .001$, SE between brackets, p-value for F-statistic.

4. Positive Affect, the Entrepreneurial Process, and Entrepreneurial Success of Sole Proprietors

Indy Bernoster
Anis Khedhaouria
Roy Thurik

Abstract. Despite its widely researched role for individual success in many life domains, there is little evidence explaining how positive affect (viz., the extent to which an individual subjectively experiences positive feelings and emotions) plays a role for entrepreneurial success. The present study proposes and tests an extended model of Baron's conceptual framework (2008) to investigate the role of positive affect for entrepreneurial success of sole proprietors by using a dataset of more than 800 sole proprietors. Our research model relates positive affect to Baron's key aspects of the entrepreneurial process (viz., opportunity recognition, financial resource acquisition, social network development, response to dynamic environment, and tolerance to stress) and entrepreneurial success of sole proprietors. Our findings show that positive affect is indirectly and positively associated with entrepreneurial success of sole proprietors through this entrepreneurial process. Indeed, sole proprietors who express general positive feelings and emotions are more likely to succeed due to their increased capacity to recognize opportunities, develop broad social networks, respond effectively to rapid change in highly dynamic environments and tolerate intense levels of stress. Our findings have important implications for theory and practice.

4.1. Introduction

Entrepreneurial success has been largely associated with individual characteristics, firm-specific attributes, and business environment characteristics (Rauch, Frese, & Utsch, 2005; Wiklund & Shepherd, 2005). A prime aspect of individual characteristics, positive affect, is defined as the extent to which someone subjectively experiences positive feelings and emotions (Baron, 2008; Watson, Clark, & Tellegen, 1988). Lyubomirsky, King, and Diener (2005, p. 804) emphasize the importance of positive affect for individual success and posit that "people who experience a preponderance of positive emotions tend to be successful and accomplished across multiple life domains … not merely because success leads to happiness, but because positive affect engenders success". Indeed, some papers address this association between positive affect and entrepreneurial success (Baron, 1990; Baron, Tang, & Hmieleski, 2011). However, there is little empirical evidence in the entrepreneurship literature explaining *how* positive affect is associated with entrepreneurial success, while entrepreneurial success is such an ultimate goal of entrepreneurship and although several scholars suggested to investigate the role of positive affect in entrepreneurial success in their future research directions (Cardon, Foo, Shepherd, & Wiklund, 2012; Delgado García, Quevedo Puente, & Blanco Mazagatos, 2015). To overcome this gap, the present study investigates whether and, in particular, how positive affect plays a role for entrepreneurial success of sole proprietors.

From the existing literature, the entrepreneurial process naturally arises as a possible explanation of how positive affect plays a role for entrepreneurial success (Baron, 2008; Baron, Hmieleski, & Henry, 2012; Foo, 2011; Foo, Uy, & Baron, 2009; Hayton & Cholakova, 2012). Baron (2008) captures the dimensions of the entrepreneurial process that he terms "key aspects of the entrepreneurial process" as the entrepreneur's capacity to recognize opportunities, to acquire financial and human resources, to develop broad social networks, to respond quickly and effectively to highly dynamic environments, and to tolerate intense levels of stress. In his conceptual framework, he associates affect to these key aspects. The present paper analyzes the mediating role of these key aspects for the association between positive affect and entrepreneurial success of sole proprietors.

Hence, the present study addresses the question: *Is the entrepreneurial process mediating the association between positive affect and entrepreneurial success of sole proprietors?* By investigating this question, we have two aims. *First*, the present paper provides empirical tests of hypotheses implied by Baron's conceptual framework (Baron, 2008). Note that we do not have the intention to investigate the exact same hypotheses of Baron but we derive hypotheses *using* his framework. *Second*, it tests the role of this framework for entrepreneurial success of sole proprietors and thereby explains *how* positive affect and entrepreneurial success of sole proprietors are associated.

It is important to note that most empirical studies that deal with the association between positive affect and the entrepreneurial process/entrepreneurial success, use samples of small and medium sized businesses (Baron et al., 2011; Grichnik, Smeja, & Welpe, 2010). Surprisingly, to our knowledge such studies do not exist for sole proprietors (also referred to as 'self-employed (without personnel)' in American contexts or as 'entrepreneurs (without personnel)' in European ones). Nevertheless, a sample of sole proprietors – opposed to a sample of small and medium sized businesses – is advantageous in studies addressing phenomena that pertain to persons rather than to businesses such as positive affect (Baron & Tang, 2011), because potential bias from impactful employees is ruled out. In other words, sole proprietors are purer to investigate when it comes to personal characteristics. This reasoning is in line with Baron (2008). Hence, we use a sample of sole proprietors who are personally and emotionally responsible for their business success (Duchesneau & Gartner, 1990). We will use the word 'entrepreneur' instead of 'sole proprietor' throughout the main text to stay close to the literature which uses terms like 'entrepreneurial process' and 'entrepreneurial success'. Only when referring to our sample we use 'sole proprietor'.

The present study contributes in two ways to the existing literature. *First*, we test the association between positive affect and all key aspects of the entrepreneurial process as defined in Baron's framework (2008) in *one* single study, while previous studies addressed the association between positive affect and only one or a few of the key aspects (Grichnik et al., 2010). An obvious but small downside of using sole proprietors is that we have to adjust Baron's key aspect 'acquisition of financial and human resources' to 'acquisition of financial resources' as the definition of sole proprietors practically excludes the use of additional human resources.

Second, we contribute to the explanation of entrepreneurial success, a principle goal of entrepreneurship research, by extending Baron's framework with entrepreneurial success because entrepreneurial success has been predicted to be influenced by both positive affect and the entrepreneurial process (Baron, 1990; Baron et al., 2011; Lyubomirsky et al., 2005). In this way, we use Baron's framework to explain *how* positive affect is associated with entrepreneurial success of sole proprietors, viz. whether the entrepreneurial process plays a mediating role. By interpreting the entrepreneurial process as a mediator between positive affect and entrepreneurial success of sole proprietors, we are also able to identify whether positive affect has an additional direct link to entrepreneurial success of sole proprietors given the entrepreneurial process. Hence, we enrich the current affect-entrepreneurial success knowledge.

Our results show a positive association between positive affect and four of Baron's key aspects of the entrepreneurial process, viz. the entrepreneur's capacity to recognize opportunities, to develop broad social networks, to respond quickly and effectively to highly dynamic environments, and to tolerate intense levels of stress. Moreover, positive affect and entrepreneurial success of sole proprietors are

positively and indirectly associated through these four key aspects of the entrepreneurial process. Therefore, four of Baron's key aspects of the entrepreneurial process play a key role in explaining how positive affect and entrepreneurial success of sole proprietors are related.

The next section deals with the theoretical framework on which we base the hypotheses. Then, we describe the dataset of 851 Dutch sole proprietors and explain the method used. Finally, we report and interpret results before we conclude.

4.2. Supporting Literature

The aim of the present study is to investigate entrepreneurial success by associating it with positive affect and allowing for a mediation role of key aspects of the entrepreneurial process. This is done using Baron's framework (2008) and examining the role of entrepreneurial success in a new and extended version of this framework. The context of our investigation is sole proprietors and trait affect – the present study focuses on trait instead of state affect. We are not aware of any literature which deals with this specific context. Therefore, we termed the present section '*Supporting* literature': we extend our search dimensions from 'trait' affect to both 'state' and 'trait' affect and from 'sole proprietors' to 'entrepreneurs' and derive the hypotheses using the resulting literature. We first describe the hypotheses implied from Baron's framework. Second, we describe a novel and extended version of Baron's framework by including entrepreneurial success. Third, the direct and indirect associations between positive affect and entrepreneurial success are discussed. This setup is summarized in Figure 4.1.

It is tempting to follow Baron (2008) and its follow up studies (Baron et al., 2011; Hmieleski & Baron, 2009), and present correlations as 'effects' of positive affect. However, we prefer to refer to 'associations' since it is impossible to fully test for causality given our dataset. We will return to this issue in the section on 'Limitations and suggestions for future research' where we argue that a causality from positive affect toward process and success is the most likely interpretation.

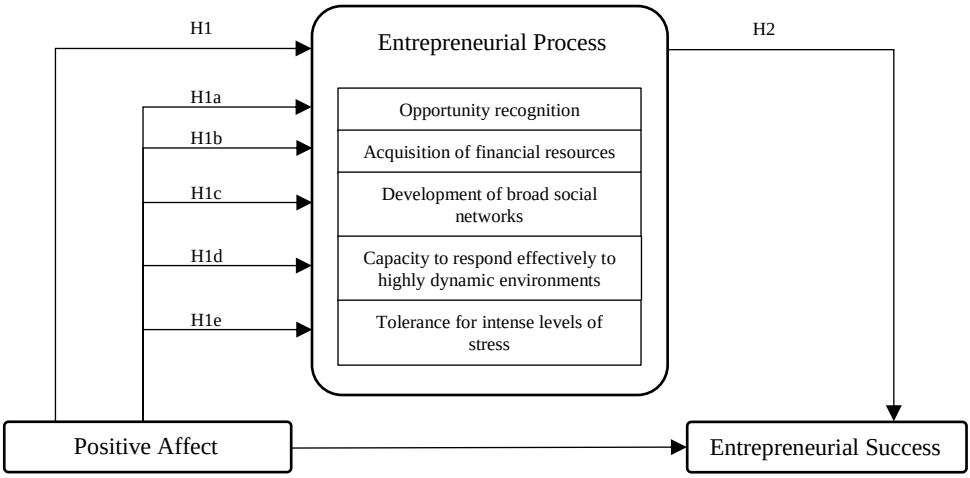

Figure 4.1. A mediation model of the influence of positive affect on entrepreneurial success (adapted from Baron, 2008, p. 335). Although we refer to 'associations' throughout our current study, we kept the arrows of Baron's original framework. Note that the key aspect 'acquisition of financial and human resources' is changed to 'acquisition of financial resources' due to the type of subjects we investigate (sole proprietors).

4.2.1 Positive Affect and Entrepreneurial Process

The concept of affect contains two independent dimensions: positive affect and negative affect. The present paper focuses on positive affect, without neglecting the negative dimension. Positive affect refers to stable tendencies to experience positive feelings and emotions often and across many situations (*i.e.*, trait or dispositional positive affect) as well as to positive feelings and emotions in response to specific events (*i.e.*, state or event-generated positive affect) (Baron, 2008, p.328; Baron et al., 2012, p. 311). Similar to Baron and Tang (2011) who suggest that innovation is a continuing process reflected better by trait positive affect than state positive affect, we assume that entrepreneurial outcomes (e.g., the entrepreneurial process and entrepreneurial success) are continuing processes. Therefore, it is likely that these outcomes are reflected by trait rather than state positive affect.[6] Hence, throughout the present paper, we use the term positive affect to refer to trait positive affect.

Across a considerable body of research conducted in the field of entrepreneurship, positive affect is associated with a wide range of positive

[6] While trait positive affect and state positive affect derive from distinct sources (such as biological processes and genetic influences on the one hand versus discrete external events on the other), research indicates that both produce parallel effects in many situations (Lyubomirsky et al., 2005; Baron, 2008).

outcomes such as enhanced focus and effort on future-oriented tasks, increased creativity, increased resilience in terms of bouncing back from failure, the adoption of more challenging goals, stronger goal commitment, and enhanced creative problem solving (Baron & Tang, 2011; Cardon, Wincent, Singh, & Drnovsek, 2009; Foo et al., 2009; Hayward, Forster, Sarasvathy, & Fredrickson, 2010). The possibility that high levels of positive affect be associated with detrimental effects has also been reported in the literature (Baron et al., 2012). For instance, high levels of positive affect can increase cognitive errors in decision making, reduce performance in critical thinking, hamper ideas generation and evaluation, and encourage impulsiveness, in particular the tendency to act without adequate thinking (DeYoung, 2010; Forgas & George, 2001; Melton, 1995; Zhou & George, 2007).

Baron (2008, p.335) makes an attempt to bring this all together and proposes a theoretical framework on the role of positive affect in the entrepreneurial process. This is a process that encompasses four main stages, namely, the discovery of an idea, the development of the business idea, the acquisition of the needed financial, human, and capital resources, and the operationalization of the business idea (Haber & Reichel, 2007). The performance on the entrepreneurial process is conditioned by certain capabilities that the entrepreneur should possess and that Baron (2008) in his conceptual framework names "key aspects of the entrepreneurial process", including the entrepreneur's capacity to recognize opportunities, to acquire financial and human resources, to develop broad social networks, to respond quickly and effectively to highly dynamic environments, and to tolerate intense levels of stress.

Indeed, Baron (2008) posits that positive affect may potentially impact these key aspects through basic cognitive processes such as decisions, memory, creativity, and cognitive strategies for coping with stress. In the present paper, the term 'entrepreneurial process' refers to all key aspects together. Baron's theoretical framework implies hypotheses on the association between affect and key aspects of the entrepreneurial process. These associations have received little empirical backup and only recently became a subject of interest (Baron & Tang, 2011) and, as far as we know, empirical evidence never refers to the complete framework with all five key aspects in one study or dataset. So, the first purpose of the present study is to empirically test the propositions resulting from Baron's framework using one dataset. These propositions are developed by leaving out the specific mediators of Baron's framework (Baron, 2008, p.335) so that only the associations between positive affect and the five key aspects of the entrepreneurial process remain. One of these key aspects, 'acquisition of financial and human resources' is replaced by 'acquisition of financial resources', because our research subjects are sole proprietors. Although this replacement does not allow for the perfect testing of Baron's framework, the use of sole proprietors is a big advantage because it bridges the gap between individual-specific concepts (i.e. positive affect) and firm-specific concepts (i.e. entrepreneurial success) as the latter concepts become individual- rather than firm-specific. Baron's framework, corrected for his specific mediators

and the sample used in the present study, results in five hypotheses. These hypotheses are similar to the five propositions of Baron's study, but we will update their justification with some recent investigations.

According to Baron's framework (2008), positive affect may influence five key aspects of the entrepreneurial process. First, positive affect triggers the entrepreneurial process as it represents a significant source of identifying and creating a new entrepreneurial opportunity (Grichnik et al., 2010; Foo, 2011; Hayton & Cholakova, 2012). For an entrepreneur seeking to create an entrepreneurial opportunity, initially there is an idea and significant uncertainty (Dimov, 2007). Over time, the idea may be developed and worked up into an opportunity to be exploited (Hayton & Cholakova, 2012). Opportunity recognition has been found to be related to creativity (Baron, 2008; Hills, Shrader, & Lumpkin, 1999). There is considerable empirical evidence suggesting that creativity is enhanced by positive affect (Baron, 2008; Baron & Tang, 2011, Isen, Daubman, & Nowicki, 1987). For example, positive affect is also found to generate increased levels of dopamine in the anterior cingulate cortex, which facilitates the cognitive flexibility to switch among alternative cognitive sets (Baas, De Dreu, & Nijstad, 2008) as positive affect may increase this number of cognitive sets (Isen & Daubman, 1984). Furthermore, positive affect may facilitate unusual associations useful to explore new opportunities (Isen, Johnson, Mertz, & Robinson, 1985). Hence, positive affect fosters the generation of new ideas. These considerations lead to the following hypothesis:

Hypothesis 1a. *Entrepreneurs' positive affect is positively associated with opportunity recognition.*

Second, positive affect may influence the entrepreneurial process through its effect on activities involved in the acquisition of essential financial and human resources (Baron, 2008). The ability of an entrepreneur to obtain such resources is often a crucial step in exploiting opportunities and succeeding ventures (Haber & Reichel, 2007). We follow Baron (2008) to explain why positive affect may play a role in the acquisition of such resources. First, positive affect is closely related to motivation, and a large body of findings indicate that motivation, in turn, is closely related to high effort levels (Foo et al., 2009). High effort levels often pay off for entrepreneurs and help them obtain the desired resources to succeed (Bitler, Moskowitz, & Vissing-Jorgensen, 2005). Second, positive affect is closely related to demonstrating enthusiasm which, in turn, is closely related to persuasiveness (Cardon, 2008). Entrepreneurs who are passionate and enthusiastic persist to persuade others, on the value of their potential ideas, in order to obtain the needed resources to succeed (Cardon, Zietsma, Saparito, Matherne, & Davis, 2005). Thus, entrepreneurs who have high levels of positive affect may be more effective in generating positive reactions in order to obtain essential financial and human resources. While this may be true for entrepreneurs owning a business with

considerable resources, it may not be true for sole proprietors since generally they do not need or want ample resources. Especially, *sole* proprietors do not employ others by definition. In other words, the acquisition of human resources is not embedded in the definition of *sole* proprietors Therefore, we will focus on the association between positive affect and acquisition of financial resources by investigating the following hypothesis:

Hypothesis 1b. *Entrepreneurs' positive affect is positively associated with acquisition of financial resources.*

Third, positive affect may contribute to the breadth and quality of entrepreneurs' social networks (Baron, 2008, p. 333). Indeed, their social competence plays a key role in determining whether they obtain financing and attract key employees (Baron & Markman, 2000) and entrepreneurs who show positive affect have better social networks than those who show negative affect (Baron, 2008). These considerations lead to the following hypothesis:

Hypothesis 1c. *Entrepreneurs' positive affect is positively associated with the development of broad social networks.*

Fourth, positive affect may play a role in increasing entrepreneurs' capacity to respond effectively to dynamic environments (Baron, 2008). Dynamic environments are environments that are subject to unpredictable and rapid change, and thus, to high levels of uncertainty (Baron & Tang, 2011; Miller, 2007). These environments require entrepreneurs to quickly generate alternatives and make effective decisions, which on their turn could be influenced by positive affect. For instance, positive affect encourages the use of a 'satisficing' strategy by which the first acceptable alternative is chosen, which allows entrepreneurs to make decisions both quickly and efficiently (Baron, 2008). Furthermore, positive affect tends to encourage flexibility in thinking and problem solving, which may help entrepreneurs to quickly generate useful alternatives that can be effectively applied to reduce uncertainties (Baron & Tang, 2011; Lyubomirsky et al., 2005). Finally, it should be noted that entrepreneurs who are passionate and enthusiastic (both hallmarks of positive affect) persist to cope with uncertainties, which may contribute to increase their capacity for responding effectively in dynamic environments (Hayton & Cholakova, 2012). These considerations lead to the following hypothesis:

Hypothesis 1d. *Entrepreneurs' positive affect is positively associated with the capacity to respond effectively to highly dynamic environments.*

Fifth, positive affect may play a role in increasing entrepreneurs' capacity to tolerate intense levels of stress (Baron, 2008). While the capacity to tolerate and

resist high levels of stress is important in many contexts, it may be crucial for entrepreneurs, who often work under high levels of stress (Cardon & Patel, 2013). Empirical studies indicate that positive affect facilitates successful adaptation to stress and is a starting point for enhanced well-being (Baron, Franklin, & Hmieleski, 2016; Fredrickson & Joiner, 2002; Ong, Bergeman, Bisconti, & Wallace, 2006). Ong et al. (2006) argue that adaptation to stress may be reflected in the capacity to maintain and preserve positive affective states. Moreover, Fredrickson and Joiner (2002) posit that positive emotions are important facilitators of adaptive recovery, quieting or undoing the autonomic arousal generated by negative emotions. These considerations lead to the following hypothesis:

Hypothesis 1e. *Entrepreneurs' positive affect is positively associated with tolerance for intense levels of stress.*

All above considerations are indicative of a broad range of cognitive and other behaviors of entrepreneurs that are hypothesized to be associated with positive affect. This enables us to investigate whether there is association between positive affect and an 'aggregated' cognition and behavior component: the key aspects of the entrepreneurial process. We do so formulating hypothesis 1.

Hypothesis 1. *Entrepreneurs' positive affect is positively associated with the performance on the key aspects of the entrepreneurial process.*

4.2.2 Entrepreneurial Process and Entrepreneurial Success

The relationship between the entrepreneurial process and entrepreneurial success has been widely dealt with in the field of entrepreneurship and small business research (Bosma, Van Praag, Thurik, & De Wit, 2004; Cassar, 2006; Haber & Reichel, 2007; Rauch et al., 2005; Wiklund & Shepherd, 2005; Wright, Liu, Buck, & Filatotchev, 2008). Entrepreneurial success is multidimensional in nature (Wiklund & Shepherd, 2005). Amongst others, growth in finance or firm size, survival, or happiness can be seen as indicators of entrepreneurial success. Although growth in firm size is often used as indicator for entrepreneurial success, *sole* proprietors do not necessarily intend to hire employees. As such, investigating sole proprietors' success naturally shifts towards evaluating finance, survival, or happiness. Because many others adopt financial performance as a success measure (Duchesneau & Gartner, 1990; McClelland, 1987), the present study does so too.

A few of the many determinants that are proposed to explain entrepreneurial success are opportunity recognition (Gielnik, Frese, Graf, & Kampschulte, 2012), human capital, in particular managerial skills (Haber & Reichel, 2007; Unger, Rauch, Frese, & Rosenbusch, 2011), social skills (Baron & Markman, 2000; 2003; Leung, Wong, & Foo, 2006), need for achievement (Ahmed, 1985), and stress (Cardon & Patel, 2013). Below we will briefly discuss the association between these

determinants (that are closely related to the key aspects of the entrepreneurial process) and entrepreneurial success.

First, opportunity recognition, is proposed as a determinant for entrepreneurial success (Gielnik et al., 2012; Shane & Venkataraman, 2000). According to Baron (2006), entrepreneurs 'connect the dots' between changes in different markets easier than others do. Properly and inventively connecting these changes, may result in identifying business opportunities and new ideas. Business idea generation, on its turn, is related to venture growth (Gielnik et al., 2012).

Second, entrepreneurs have to convince venture capitalists of the credibility of their startup (Busenitz & Barney, 1997). If one is able to acquire the required financial resources, thoughtful and proper investments can be made. These investments in, for instance, human and social capital eventually pay off in higher survival rates, profits, and employment growth (Bosma et al., 2004). Hence, the ability to acquire financial resources with ease and consideration can improve entrepreneurial success.

Third, when a broad social network is developed, entrepreneurs may acquire knowledge by using the diversity of its joint expertise. Broad social networks favor access to information, resources, and career sponsorship (Seibert, Kraimer, & Liden, 2001). Indeed, network support can be beneficial to business growth and success (Brüderl & Preisendörfer, 1998).

Fourth, entrepreneurs usually operate in dynamic environments in which they have to be quick and accurate. In such environments, entrepreneurs face the need to creatively adapt and anticipate market requirements (Baron & Tang, 2011). Indeed, in such environments, entrepreneurs' capacity to effectively respond to market needs is also related to their ability to seeking required advice (Dyer & Ross, 2008). Advice seeking, in turn, is found to be positively associated to business performance (Dyer & Ross, 2008).

Finally, as explained by Cardon and Patel (2013), although entrepreneurs experience more stress than employees, they do not experience this stress as a burden to their health but as a benefit to their personal success.

Accordingly, the next logical step is to extend Baron's framework with entrepreneurial success (Figure 4.1). We formulate the following hypothesis:

Hypothesis 2. *Entrepreneurs' performance on the key aspects of the entrepreneurial process is positively associated with entrepreneurial success.*

4.2.3 Positive Affect and Entrepreneurial Success: A Mediation Model

A research setup including a combination of Hypothesis 1a through 1e, or Hypothesis 1, on the one hand and Hypothesis 2 on the other does not clarify what role positive affect exactly plays in entrepreneurial success. The association

between positive affect and entrepreneurial success can be direct or indirect through a certain mediator for which we propose Baron's key aspects of the entrepreneurial process (2008). Hence, an indirect association would mean that positive affect is associated with the entrepreneurial process, which in turn would be associated with entrepreneurial success, or in other words, that the association between positive affect and entrepreneurial success is mediated by the key aspects of the entrepreneurial process. As Hypothesis 1 and 2 presume positive associations, the indirect effect is also expected to be positive. Hence, the third hypothesis is:

Hypothesis 3. *The association between positive affect and entrepreneurial success is positively and indirectly associated with the entrepreneurial process.*

We will investigate whether the association between positive affect and entrepreneurial success is fully, partially or not at all mediated by the key aspects of the entrepreneurial process and thereby address the suggestion of Cardon et al., (2012) and Delgado García et al., (2015) to investigate how positive affect is associated to entrepreneurial success.

4.3. Data and Method

4.3.1 Sample

Data were collected by Panteia[7], one of the largest market and policy research institutes in the Netherlands. One of its activities is maintaining a nationally representative panel of Dutch sole proprietors[8] using surveys twice a year on firm-specific aspects such as revenue and number of customers and individual-specific aspects such as physical and psychological health. We have been invited to contribute to the questionnaire used for the data collection between December 2014 and January 2015. As the space for our questions was limited, only some crucial questions, such as a measure of positive affect and measures of the key aspects of the entrepreneurial process, were inserted. Therefore, we have to rely on the measures of Panteia with regard to entrepreneurial success.

An e-mail with a link to this questionnaire[9] was sent to 2,498 registered e-mail addresses of the panel. In total three reminders were sent, ultimately resulting in responses of 851 sole proprietors. This results in a response rate of 34.1 percent. Among the respondents, 572 (67.2 percent) are men and the average age is 51 with a standard deviation of 9. To assess sample representativeness, these statistics are compared to those of the general population of Dutch entrepreneurs as described by

7 http://www.panteia.nl/

8 The terms 'sole proprietor' and 'entrepreneur' is used interchangeably in some parts of the present text.

9 Note that the questionnaire was in Dutch.

the Central Agency for Statistics (CBS)[10]. The CBS reports 64.1 percent men and an average age of 49 with a standard deviation of 13, so our sample and the population measured in the fourth quarter of 2014 are similar in at least these two dimensions.

4.3.2 Variables and Measures

***Entrepreneurial success*.** For the measurement of entrepreneurial success, we are constrained by the questions of Panteia, which primarily deal with revenue growth measures. Hence, only two dimensions of revenue growth are included (Hmieleski & Baron, 2009; Wiklund, Patzelt, & Shepherd, 2009): *expected revenue growth* and *observed revenue growth*. The question used to measure *expected revenue growth* follows upon a question about the actual expected revenue over 2014: "Is this revenue (i.e. the expected revenue over 2014) in agreement with the expected revenue in the beginning of 2014?" where answers indicate whether the revenue was much higher (more than 20%) than expected, higher, similar, lower, or much lower (less than 20%) than expected. To measure *observed revenue growth*, the question "Can you indicate whether the expected revenue in 2014 is more or less than in 2013?" was used, where answer opportunities are "higher than 2013", "equal", or "less than 2013". For both questions, we reversed scale such that the highest value represents an increase in revenue. Then, *entrepreneurial success* is calculated as the average of these (standardized) scales and its value of Cronbach's alpha is .73.

***Positive affect*.** To measure (positive) affect, a Dutch version of the Positive Affect and Negative Affect Schedule (PANAS: Watson et al., 1988) is used. The PANAS describes various feelings and emotions, of which ten are dealing with positive affect and ten with negative affect. Positive affect and negative affect are clearly separately defined and independent (Watson et al., 1988). The PANAS invites participants to rate the 20 items in the area of feelings and emotions. The items for positive affect are "interested", "excited", "strong", "enthusiastic", "proud", "alert", "inspired", "determined", "attentive", and "active". The items for negative affect are "distressed", "upset", "guilty", "scared", "hostile", "irritable", "ashamed", "nervous", "jittery", and "afraid". The PANAS can be framed with various temporal perspectives, such as "at this moment", "over the past few days", and "in general". As explained earlier, in our study positive affect refers to dispositional positive affect because we aim to investigate a long-term process, viz., entrepreneurial success. Therefore, we are interested in one's feelings and emotions "in general". Hence, we frame the instructions as "Indicate to what extent you generally feel this way, that is, how you feel on average". We will focus on positive affect, which shows a high Cronbach's alpha of .85, similar to the value of .88

10 http://www.ikwordzzper.nl/landelijk/zzp-kennisbank/cijfers-en-kengetallen/wat-zijn-de-zzp-kengetallen-volgens-het-cbs

reported in Watson et al. (1988). Cronbach's alpha for negative affect is .88, which is also similar to the value of .87 reported in Watson et al. (1988).

Key aspects of the entrepreneurial process. As Baron (2008) proposed, the entrepreneurial process can be described by five key aspects: opportunity recognition, acquisition of financial and human resources, development of broad social networks, capacity to respond effectively to highly dynamic environments, and tolerance for intense levels of stress.

The use of multiple item scales to measure psychological concepts is often preferred above single items because for multiple item scales reliability indices can be reported. Nevertheless, all five key aspects of the entrepreneurial process were measured with a single item due to limited questionnaire space. However, there are two reasons to be confident with our single item measures. First, the wording of the items is close to Baron's wording of the key aspects. Therefore, we think the items measure what the key aspects represent. Second, Wanous, Reichers, and Hudy (1997) show that single item measures (of job satisfaction) could be acceptable.

Items were rated on a 5-point Likert scale. The item for measuring *opportunity recognition* was "I'm good at recognizing new, profitable opportunities (new products, new services, new ways of marketing, etc.) for my firm". As explained earlier, sole proprietors by definition do not acquire human resources. Therefore, we operationalize Baron's key aspect acquisition of financial and human resources as "I have no trouble in acquiring the financial means I need (loans at a bank or other lenders)", which we name *acquisition of financial resources*. In this way, the item only measures the acquisition of financial resources (and not the acquisition of human resources). The item corresponding to *development of broad social networks* was "I developed a broad social network". The item corresponding to *capacity to respond effectively to highly dynamic environments* was "I have the capacity to respond effectively to highly dynamic environments', and the item corresponding to *tolerance for intense levels of stress* was 'I can tolerate intense levels of stress".

To test hypotheses 1a through 1e, the key aspects of the entrepreneurial process are dealt with separately, but for testing Hypothesis 1 and 2, a composite measure of these five aspects will be used. Since correlations between these five items are significant without any multicollinearity issues (Table 4.1), we view entrepreneurial process measured by these items as a reflective construct. Also, Baron (2008) treats the key aspects of the entrepreneurial process as equally important. Hence, we take a simple average over the five single items to obtain *entrepreneurial process*. The value of Cronbach's alpha for this composite measure is .69.

Control variables. Four entrepreneur-specific variables were used as controls: entrepreneur's age (years), gender (0=woman, 1=man), education, and experience (Baron & Tang, 2011). Education is measured as the highest finished type of education, for which there are six categories ranging from primary education to university. In education two clear peaks are observed. More than half of the people have university certificates and a large part (approximately 24 percent) finished

secondary vocational education. Finally, experience is measured as the number of years the entrepreneur have been a sole proprietor, including experience years with earlier ventures. We compensate the low amount of control variables with the considerable amount of robustness checks.

4.3.3 Analysis

For each hypothesis of Figure 4.1 a corresponding model was analyzed. To estimate the coefficients of these models, an ordinary least squares (OLS) estimator is used. Next to testing the hypotheses, we investigate whether an indirect association between positive affect and entrepreneurial success exists. The significance of this indirect association is calculated by applying a Sobel test (Sobel & Leinhardt, 1982). All non-dummy variables are standardized for ease of comparison.

Robustness Checks

We performed several robustness checks but discuss only a selection including those that show results that deviate from the main results. The first robustness check (RC1) deals with the items constituting *entrepreneurial success*, which, as mentioned before, are confined by Panteia's questions. To test robustness in the dependent variable, we repeat the original analysis with the two entrepreneurial success items separately and with several other measures dealing with entrepreneurial success. The first other item, *observed revenue growth (calculated)*, is similar to *observed revenue growth*, but growth is categorized based upon the reported revenue categories of 2014 and 2013 instead of directly asking about growth. Panteia also measures net monthly income in categories. We translate the categories to 'real' incomes to define *net income per worked hour*: the 'real' income divided by the number of worked hours per month, where we assume a month to consist of four weeks. Further, *weekly revenue* (multiplication of the number of charged hours and the price per hour) and the number of months one can provide in livelihood after a possible failure, which we call *number of months to provide in livelihood after failure*, are investigated.

Although the *observed revenue growth* and *observed revenue growth (calculated)* seem similar, there are quite some sole proprietors with incongruent answers (for instance stating that the expected revenue of 2014 is higher than the revenue in 2013 in *observed revenue growth*, while the difference in their self-reported revenues, i.e. *observed revenue growth (calculated)*, shows a decrease). This could indicate sloppy answering in the questionnaire. Therefore, the second robustness check (RC2) entails leaving out the sole proprietors with incongruent answers.

The third robustness check (RC3) is also based on sample selection. In our definition of *entrepreneurial success*, we implicitly assume that entrepreneurial

success can be measured with financial growth. However, some entrepreneurs may simply classify themselves as 'successful' if they are able to retain their desirable living standard and/or if they are happy. Hence, they do not necessarily prefer to grow financially. For these sole proprietors, the expected patterns between entrepreneurial process and success are not likely to apply. To check for this phenomenon, we exclude 179 sole proprietors that explicitly state that they do not want to grow.

The final variable related robustness check (RC4) aims to give additional information on the role of affect. In the present analysis, the focus is on positive affect (and we hypothesize positive associations), while we also measured negative affect. In this final 'robustness check', we repeat the original analysis where we replace positive affect with negative affect and test for negative associations.

4.4. Results

In this section, we first describe the main results, such as the results corresponding to the hypotheses and the mediation model. Subsequently, the results of the robustness checks are discussed.

4.4.1 Main Results

Table 4.1 shows the means, standard deviations (SDs), percentage of missing observations, variance inflation factors (VIFs), correlations, and Cronbach's alpha of the variables. With regard to the correlations, Table 4.1 shows significant and high correlations amongst the key aspects of the entrepreneurial process, which justifies its satisfactory reliability. Among all other independent variables, correlations range from -.18 to .38. Further, all variables show a missing data level less than 10 percent, which is acceptable (Hair, Anderson, Babin, & Black, 2010), except for the variable *acquisition of financial resources* (30 percent). The reason for this higher percentage of missing observations is probably that sole proprietors do not need ample financial resources and thus do not (aim to) acquire it, so that they were unable to rate the statement 'I have no trouble in acquiring the financial means I need (loans at a bank or other lenders)'.

We tested for multicollinearity by examining the variance inflation factors (VIFs). As we have single items and a composite measure for the entrepreneurial process, we considered two groups of VIFs: one group consisted of the single items and the other of the composite measure. The maximum value of the VIF for the single items group is 1.68 and that for the composite measure group is 1.23. Both are below 3.30, indicating no danger of multicollinearity (Diamantopoulos, Riefler & Roth, 2008; Hair et al., 2010). We also checked for common method bias by applying Harman's single factor test (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). The rule of thumb is that a single unrotated principal component should not

explain more than the threshold level of 50 percent of the variance for all of the indicators measured with the same method. Our first principal component has an explained variance of 25.2 percent, indicating no danger of common method bias.

Table 4.2 shows results of hypotheses 1a through 2. Hypotheses 1a (coefficient = .35, $p < .001$), 1c (coefficient = .29, $p < .001$), 1d (coefficient = .29, $p < .001$), 1e (coefficient = .30, $p < .001$), and 1 (coefficient = .39, $p < .001$) are confirmed because the p-values suggest strong evidence against a null hypothesis of no association. However, we found no evidence for the confirmation of Hypothesis 1b according to an attained significance level of .124. This may be due to the same reasons that hold for the low response rate on *acquisition of financial resources*[11]. We confirm Hypothesis 2 (coefficient = .11, p-value = .004) as the p-value suggests strong evidence against the null hypothesis of no association.

Additionally, we tested to what extent the association between positive affect and entrepreneurial success is direct (corrected for the key aspects of the entrepreneurial process) and to what extent it is indirect (through the key aspects of the entrepreneurial process). We cannot confirm a direct association as the corresponding p-value is .355. The indirect association is positive (coefficient = .043) with a p-value of .005 according to Sobel's test (Sobel & Leinhardt, 1982) and hence Hypothesis 3 is confirmed. To check the accuracy of these outcomes, we analyzed the mediation model using PROCESS[12] in SPSS, with the number of bootstrap samples for the bias corrected bootstrap confidence intervals equal to 5000. We found similar results.

11 Results on the other hypotheses do not noticeably change when we repeat the original analysis where acquisition of financial resources was disregarded.

12 http://afhayes.com/index.html

Table 4.1. The means, standard deviations (SDs), percentage of missing observations, variance inflation factors (VIFs), correlations, and values of Cronbach's alpha (on the diagonal). VIFs are based on the maximum VIF of the single items group and the composite measure group.

	Mean	SD	Missing Obs. (%)	VIF	1	2	3	4	5	6	7	8	9	10	11
1. Entrepreneurial success	2.93	0.89	3		0.73										
2. Opportunity recognition	3.31	0.85	5	1.56	0.07*	-									
3. Acquisition of financial resources	2.82	1.25	30	1.14	0.04	0.25***	-								
4. Development of broad social networks	3.63	0.94	2	1.35	0.08*	0.39***	0.25***	-							
5. Capacity to responde effectively to highly dynamic environments	3.71	0.86	3	1.68	0.11**	0.51***	0.25***	0.40***	-						
6. Tolerance for intense levels of stress	3.57	0.96	2	1.37	0.09*	0.34***	0.23***	0.26***	0.48***	-					
7. Entrepreneurial process	3.69	0.72	2	1.18	0.12***	0.71***	0.58***	0.68***	0.76***	0.66***	0.69				
8. Positive affect	3.56	0.52	0	1.24	0.08*	0.32***	0.07	0.28***	0.28***	0.27***	0.36***	0.85			
9. Entrepreneur's age	51.25	9.06	0	1.19	-0.11**	0.04	0.13**	0.01	0.03	0.03	0.06	-0.08*	-		
10. Gender	0.67	0.47	0	1.13	0.04	0.14***	0.04	-0.03	0.11**	0.15***	0.07*	-0.07*	0.00	-	
11. Education	4.91	1.36	0	1.15	0.01	0.04	0.06	0.09**	0.11**	-0.01	0.09**	0.19***	-0.01	-0.16***	-
12. Experience	13.32	9.34	2	1.26	-0.11**	-0.02	0.05	-0.10**	-0.06	0.01	-0.06	-0.13***	0.38***	0.14***	-0.18***

Note: *: p < .05, **: p < .01, ***: p < .001.

Table 4.2. Estimated coefficients for all models corresponding to the hypotheses (abbreviated with 'H'). Note that coefficients are presented with their corresponding SEs in brackets.

	Dependent variables						
Independent variables	Opportunity recognition (H1a)	Acquisition of financial resources (H1b)	Development of broad social networks (H1c)	Capacity to responde effectively to highly dynamic environments (H1d)	Tolerance for intense levels of stress (H1e)	Entrepreneurial process (H1)	Entrepreneurial success (H2)
Intercept	-0.232***	-0.063	-0.002	-0.205***	-0.245***	-0.207***	-0.037
	(0.059)	(0.080)	(0.059)	(0.059)	(0.059)	(0.057)	(0.063)
Positive affect	0.352***	0.066	0.291***	0.291***	0.303***	0.392***	0.037
	(0.036)	(0.043)	(0.036)	(0.036)	(0.036)	(0.035)	(0.040)
Entrepreneurial process							0.111**
							(0.038)
Entrepreneur's age	0.076*	0.124**	0.058	0.069	0.054	0.109**	-0.098*
	(0.036)	(0.044)	(0.037)	(0.036)	(0.036)	(0.035)	(0.038)
Gender (men = 1)	0.329***	0.089	0.003	0.290***	0.354***	0.302***	0.075
	(0.072)	(0.095)	(0.073)	(0.073)	(0.072)	(0.069)	(0.077)
Education	-0.001	0.057	0.024	0.076*	-0.038	0.023	-0.015
	(0.035)	(0.043)	(0.035)	(0.035)	(0.035)	(0.033)	(0.037)
Experience	-0.032	0.012	-0.083*	-0.061	-0.010	-0.056	-0.063
	(0.038)	(0.045)	(0.037)	(0.038)	(0.037)	(0.036)	(0.039)
F-statistic	23.290***	2.970*	15.900***	18.610***	18.520***	31.380***	4.870***
	(0.000)	(0.012)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Adjusted R squared	0.123	0.017	0.083	0.098	0.097	0.156	0.028
Number of observations	798	581	820	811	817	822	803

Note: *: $p < .05$, **: $p < .01$, ***: $p < .001$, F-statistic is accompanied with p-values in brackets.

4.4.2 Robustness Checks

Many of the performed robustness checks show results similar to the main results. In the present section, we focus on those of which the results deviate from the main results.

In RC1, *entrepreneurial success* is replaced by six different measures: the two items currently constituting to *entrepreneurial success* and four other earlier mentioned items. In Table 4.3 we present the results concerning Hypothesis 2 and the total, direct, and indirect (i.e. Hypothesis 3) associations (the coefficients corresponding to Hypothesis 1a through 1e and 1 do not change because entrepreneurial success is not included in the models to test these hypotheses).

Table 4.3. Estimated coefficients with their corresponding p-values for Hypothesis 2 and the mediation model (including Hypothesis 3) for different measures for entrepreneurial success.

	Hypothesis 2		Total association		Direct association		Hypothesis 3 (indirect association)		
Measure for entrepreneurial success	coef.	p-value	coef.	p-value	coef.	p-value	coef.	p-value	N
Expected revenue growth	0.129	0.001	0.048	0.219	-0.003	0.942	0.051	0.001	790
Observed revenue growth	0.067	0.083	0.095	0.013	0.069	0.093	0.026	0.082	782
Observed revenue growth (calculated)	-0.036	0.390	0.082	0.041	0.096	0.026	-0.014	0.381	731
Net income per worked hour	0.131	0.001	-0.015	0.701	-0.066	0.117	0.051	0.002	742
Weekly revenue	0.176	0.000	0.126	0.006	0.063	0.190	0.064	0.000	515
Number of months to provide in livelihood after failure	0.119	0.001	0.014	0.697	-0.033	0.398	0.047	0.002	812

Table 4.3 shows that there is strong evidence for hypotheses 2 and 3 when the focus is on *expected revenue growth, net income per worked hour*, *weekly revenue*, and *number of months to provide in livelihood after failure*. With regard to these variables a direct association is unlikely because coefficients have p-values higher than .10. We interpret the coefficients for *observed revenue growth* as clear signals for the expected association while we cannot do so for *observed revenue growth (calculated)* due to its high p-value. Note that the insignificant total associations between *positive affect* and the success measures *expected revenue growth, net income per worked hour*, and *number of months to provide in livelihood after failure* suggest inconsistent mediation, where the direct and indirect associations cancel out.

Leaving out sole proprietors (RC2) with incongruent responses in the variables *observed revenue growth* and *observed revenue growth (calculated)* results in a stronger indirect association for the congruent sole proprietors (coefficient = .054, p-value = .003, N = 656). We cannot confirm an indirect association for the incongruent sole proprietors as the p-value is high (coefficient = -.062, p-value = .321, N = 56).

We see distinct results when separating the sole proprietors who want to grow from those who do not want to grow (RC3). The analysis on the group of sole proprietors that want to grow (N = 637) results in an association between entrepreneurial process and entrepreneurial success (Hypothesis 2) of .122 (p-value

= .004), a direct association of .043 (p-value = .337), and an indirect association (Hypothesis 3) of .049 (p-value = .005). These results differ from the coefficients of the group that does not want to grow (N = 162), where the association between entrepreneurial process and entrepreneurial success (Hypothesis 2) is .043 (p-value = .645), the direct association is .013 (p-value = .893), and the indirect association (Hypothesis 3) is .015 (p-value = .642). The results of the group that does not want to grow financially does not provide strong evidence for Hypothesis 2 or 3. There is a difference between sole proprietors that aim for financial growth and those who do not, but the results of the group that does not want to grow hardly influences the main results.

The fourth robustness check (RC4), which is not a robustness check *sensu stricto*, deals with the associations between negative affect and entrepreneurial process and between negative affect and entrepreneurial success. For all results that involve positive affect, similar but negative coefficients arise. We see a negative association between negative affect and the entrepreneurial process (as well for separate key aspects as the composite measure), but the coefficients are somewhat smaller than those of positive affect. For instance, the association between negative affect and the entrepreneurial process is -.320 (p-value < .001). Also, the direct association (coefficient = -.047, p-value = .223) cannot be confirmed due to a high p-value but there is a negative indirect association (coefficient = -.035, p-value = .005, N = 803).

4.5. Discussion

Baron (2008, p. 337) concludes that "careful attention to the potential influence of affect may assist scholars in the field of entrepreneurship in addressing several important questions (e.g., the nature of entrepreneurial cognition, how microlevel variables can influence macrolevel measures of new venture success)." The present study builds upon this recommendation by testing an extended version of Baron's conceptual framework (2008) using data of some 800 sole proprietors to investigate the role of positive affect in the entrepreneurial process and for success. By and large our results are consistent with the findings of previous studies (Baron & Tang, 2011; Delgado García et al., 2015; Foo, 2011; Foo et al., 2009), which provides additional confidence in Baron's approach connecting positive affect to the entrepreneurial process.

Our results provide support for the positive association between positive affect and the key aspects of the entrepreneurial process as defined by Baron (2008) except for the key aspect 'acquisition of financial resources'. Hence, the results provide an empirical test of the propositions implied by Baron's framework. Indeed, four out of five hypotheses implied by Baron's framework are supported by results of more than 800 Dutch sole proprietors.

Further, the results *explain* the positive association between positive affect and entrepreneurial success of sole proprietors as they show that this association is mediated by the entrepreneurial process through four key aspects out of the five suggested by Baron (2008). Indeed, sole proprietors who express general positive feelings and emotions are more likely to succeed due to their increased capacity to recognize opportunities, to develop broad social networks, to respond effectively to rapid change in highly dynamic environments, and to tolerate intense levels of stress. Hence, four of Baron's key aspects of the entrepreneurial process play an important role in explaining *how* positive affect and entrepreneurial success of sole proprietors are related.

Moreover, it is important to note that, next to the indirect association between positive affect and entrepreneurial success of sole proprietors through the entrepreneurial process, there is no direct association between positive affect and entrepreneurial success of sole proprietors. The relationship between positive affect and entrepreneurial success of sole proprietors seems to be entirely based on the mediation by the entrepreneurial process which hints at the important role of the entrepreneurial process and the way it is defined.

Further, replacing revenue growth with several other indicators of entrepreneurial success of sole proprietors yields the same results and provides clear evidence of an indirect and positive association between positive affect and entrepreneurial success of sole proprietors through the entrepreneurial process.

In short, sole proprietors who experience more positive feelings and emotions recognize opportunities easier, develop broader networks of possible clients or useful others, respond more effective in high incentive situations, and handle stress better. These processes, in turn, result in success for sole proprietors in terms of higher expected growth in revenue, higher net monthly income per worked hour, higher weekly revenues, and higher number of months one can provide for livelihood after failure.

4.5.1 Implications for Theory and Practice

The present study serves several theoretical implications. *First*, Baron's original model (2008) contains five key aspects of the entrepreneurial process. Some of these have been associated with positive affect (Baron & Tang, 2011; Foo, 2011; Foo et al., 2009), but to our knowledge, we are the first analyzing all key aspects using one single sample.

Second, although many studies relate positive affect and successful outcomes in various life domains (Lyubomirsky et al., 2005), little attention has been devoted to empirical studies addressing the link between positive affect and *entrepreneurial* success (Baron & Tang, 2011; Hayton & Cholakova, 2012). The present study extends Baron's model (2008) with entrepreneurial success, a focal concept in the field of entrepreneurship research. This results in a new model in which

entrepreneurial success plays a prominent role. Analysis of this new model shows that there is an association between positive affect and entrepreneurial success of sole proprietors, even for a variety of success indicators. And maybe even more importantly, we address *how* positive affect is associated with entrepreneurial success of sole proprietors (Delgado García et al., 2015). In fact, mediation plays a role such that positive affect is not directly, but indirectly associated to entrepreneurial success of sole proprietors through four of the five key aspects of the entrepreneurial process (Baron, 2008).

Third, for testing purposes the advantage of using sole proprietors instead of, for instance, (small) business owners is that the complexities arising from the discrepancy between micro-level (individual) and macro-level (firm) variables are partly solved. Positive affect and key aspects of the entrepreneurial process are micro-level variables. To draw proper conclusions, micro-level variables should be compared to other micro-level variables. Usually, entrepreneurial success is classified as a macro-level variable, but with sole proprietors being the subject of study we can argue that entrepreneurial success is 'individual' – as sole proprietors are personally and emotionally responsible for their business success (Duchesneau & Gartner, 1990) – and can thus be classified as a micro-level variable.

Fourth, our model supplements the literature on affect (often connected to terms such as 'effective events theory', 'psychological capital', 'positive emotions' and 'positive organizations') and employee performance (Ashkanasy & Daus, 2002; Avey, Reichard, Luthans, & Mhatre, 2011; Avey, Wernsing, & Luthans, 2008; Luthnas & Youssef, 2007) by contributing to emerging theoretical frameworks for understanding how entrepreneurs – and more specifically, how characteristics pertaining to their skills, motives, and emotions – ultimately relate to the entrepreneurial success (e.g., firm growth in sales and profits). Several researchers have suggested that understanding such links is useful for the field of entrepreneurship (Baron, 2008), and a small, but growing body of evidence pertaining to these suggestions has recently begun to emerge (Baron & Tang, 2011; Baron et al., 2012). Such research suggests that to fully understand key aspects of entrepreneurship, it is necessary to deal with the effects of variables operating at many levels of analysis – individual-level factors relating to characteristics of entrepreneurs as well as firm-level factors relating to the entrepreneurial success (Baron et al., 2012). The present model helps to resolve this complex issue by suggesting that positive affect should be included as relevant factor, and that its association with entrepreneurial success is mediated through several key aspects of the entrepreneurial process. A lack of attention to these complexities may, in fact, partly explain prior failures to identify associations between the individual characteristics of entrepreneurs and the success of their firms (Gartner, 1988).

Furthermore, and from a practical perspective, we help sole proprietors giving insights in their possibilities on financial growth. Of the five key aspects proposed by Baron (2008), four are relevant to the (financial) success of sole proprietors, viz.,

being able to recognize opportunities, having a broad social network, being able to respond effectively in highly dynamic situations, and being able to handle stress. To reach a better performance on those key aspects, positive feelings and emotions seem helpful, although positive feelings and emotions do not directly influence success. We also found that, contrary to positive affect, negative affect has a negative impact on the performance on these key aspects and thus, via the key aspects, on success. Aspiring sole proprietors may use this information to classify themselves as eligible for starting a new venture or not, while established sole proprietors can reflect on their success and obtain new insights in their evaluation. Financers of entrepreneurs, often bearing considerable part of the risk, may want to know more about the role of affect in entrepreneurial success to estimate their chances for success.

4.5.2 Limitations and Suggestions for Future Research

The results of the present study are subject to some limitations that should be dealt with in future research. *First*, the key aspects of the entrepreneurial process were measured using single items due to the limited room Panteia granted us to ask additional questions. Although the lower bounds of internal reliability of entrepreneurial process and entrepreneurial success of sole proprietors are .69 and .66, respectively, a replication of the present study with other (validated) measures would be desirable to increase the validity of the present results. Related to this limitation is the measurement of the single items for *entrepreneurial process*. The item corresponding to *development of broad social networks* was "I developed a broad social network". Of the five *entrepreneurial process* items, this is the only one that states a fact while the others state potentials, i.e. "I *can* tolerate … stress" or "I *have no trouble in* acquiring … lenders)". Future research should create and use valid and reliable multiple item scales to operationalize *entrepreneurial process*. For instance, our stress item could be accompanied with a 14-item scale of perceived stress (Perceived Stress Scale; Cohen, Kamarck, & Mermelstein, 1983). Another future research direction could investigate whether single items actually suffer from the presumed low reliability. As Wanous et al. (1997) show, multiple items to measure job satisfaction are not always significantly better than single measures. Further, although *entrepreneurial success* is measured as a growth indicator over a time span, it is measured at one point in time. We suggest future studies to measure *entrepreneurial success* over time for a longer period such that a more objective and reliable measure of success is obtained and such that failure could be captured.

Second, analyzing negative instead of positive affect may be worthwhile (Delgado García et al., 2015). Some first results using our sample data shows that, scoring high on negative affect is associated with a poor performance on the entrepreneurial process. In the same way, negative affect negatively influences entrepreneurial success of sole proprietors through the key aspects of the

entrepreneurial process. Further research is needed on whether, while positive feelings and emotions contribute to success, negative feelings and emotions deteriorate success. This relates to the fact that although the PANAS has been validated in many studies (Watson et al., 1988), there is some critique on its scale: it measures affect using two separate dimensions, viz. positive and negative. Feldman Barrett and Russell (1998) propose that affect should be measured by four dimensions, which arise from the components pleasantness and activation. The PANAS deals with pleasantness (i.e. positive and negative), but it only captures high activation and not low activation. Future research could widen our knowledge about the role of feelings and emotions in entrepreneurship by investigating these four different dimensions of affect.

Third, while in many aspects a strength of the present paper, investigating sole proprietors has at least one small drawback. Sole proprietors do not, by definition, need human resources and often they do not need much financial help. Therefore, Baron's item about the acquisition of financial and human resources is not appropriate for sole proprietors, while the relation between positive affect and acquisition of financial and human resources in other types of entrepreneurs can be relevant. Therefore, retesting this association in other types of entrepreneurs, such as small and medium sized business owners, is desirable.

Fourth, in the present study we have been careful to talk about associations instead of causalities. As Baron (2008) implies with his work, a causality from positive affect towards entrepreneurial success is not unlikely. Reversed causality may occur if entrepreneurial success leads to positive affect. However, we have confidence in the first option for two reasons. First, we measured trait positive affect, which is the affect one feels in *general*, i.e. throughout one's complete earlier life. As our sample shows a difference between the company's age and the entrepreneur's age, positive affect partly measures a period before eventual entrepreneurial success of sole proprietors. Second, as the indirect association between positive affect and entrepreneurial success of sole proprietors through key aspects of the entrepreneurial process is evident, the 'effect' of positive affect on entrepreneurial success of sole proprietors is more likely than the reversed case. It is not likely that one's success influences the performance on key aspects of the entrepreneurial process. For instance, opportunity recognition comes before the business idea, which comes before starting a firm, which eventually is necessary to succeed.

Fifth, a low adjusted R squared is found in our model for entrepreneurial success of sole proprietors (corresponding to Hypothesis 2). Hence, although positive affect and the entrepreneurial process are associated with entrepreneurial success of sole proprietors, they only explain little of its variation. In other words, although findings of the present paper indicate a clear association between positive affect and entrepreneurial success, and although Lyubomirsky et al. (2005) shows many beneficial outcomes related to positive affect, we want to stress that 'just'

positive affect does not per definition lead to entrepreneurial success and that one has to be careful with adopting positive affect and the entrepreneurial process as *the* essentials for entrepreneurial success. Some even argue that a trait approach (i.e. investigating the role of traits) for entrepreneurship unfruitful and that one should consider a behavioral approach (i.e. investigating the role of behavior) when it comes to defining entrepreneurship (Gartner, 1990). Suggestions for future research include the investigation of other drivers of entrepreneurial success.

Sixth, in the present research, we make the assumption that positive affect is linearly associated with entrepreneurial process and success (Baron, 2008). Nevertheless, high levels of positive affect have been found to also be associated with detrimental outcomes such as reduced task performance (Baron et al., 2012). Hmieleski and Baron (2009) found a negative association between optimism and venture performance. Therefore, future research should address this issue by separating low and high positive affect levels to examine their association with entrepreneurial process and success or by testing for nonlinear models.

Seventh, the reason for a positive association between positive affect and the key aspects of the entrepreneurial process could be the nature of positive affect itself. It may be suggested that scoring high on positive affect evaluating more positively when assessing the key aspects of the entrepreneurial process. Or, a third variable such as optimism could plays a role in both concepts and hence drive the found association. However, positive affect is associated with cognitive errors such as optimistic bias and planning fallacy (Baron, 2008). These negative associations could lead to undesirable outcomes for entrepreneurs and thus lead to negative associations between positive affect and entrepreneurial outcomes. Such negative associations would not exist if positive affect would positively bias measures of other concepts. Therefore, we believe that we can rely on our associations (accounted for other limitations). Nevertheless, future research should address this issue by replicating the present study while controlling for at least third variables such as optimism.

Eighth, as in most entrepreneurship studies a discrimination between necessity and opportunity driven would have been worthwhile. It would be interesting to perform robustness checks on necessity or opportunity driven sole proprietors. Unfortunately, we did not have the means to do so.

Finally, as set out in Angrist and Pischke (2008), mediation models suffer from the bad control problem. A bad control arises when an independent variable could have been the dependent variable too, which is evident in the mediation model. Bad controls lead to selection bias. Unfortunately, to our knowledge, there is no remedy for this problem, so finding one is important for future studies.

4.6. Conclusion

The interplay between wellbeing and entrepreneurship (Hessels, Rietveld, Thurik, & Van der Zwan, 2018; Shepherd, 2015; Uy, Foo, & Song, 2013) does not receive the scholarly attention it deserves. After all, people who feel better are likely to produce better while those who produce better probably feel better (Rietveld, Van Kippersluis, & Thurik, 2015). One reason for this lack of attention may be the dual causality itself, another the multidimensional concept of both wellbeing (with cognitive, affective, physiologic and psychologic dimensions) and entrepreneurship (with its many manifestations such as preference, intention, orientation, process, choice and success). The present study tests this interplay between wellbeing and entrepreneurship by proposing an extended version of Baron's conceptual framework (2008) to investigate whether and how positive affect associates to entrepreneurial success of sole proprietors. Our findings provide empirical evidence for a positive indirect association between positive affect and entrepreneurial success of sole proprietors. Interestingly, we find that this positive association is fully mediated by the entrepreneurial process. The association between positive affect and success in many different life domains has been predicted (Lyubomirsky et al., 2005), but to date, little attention has been devoted to entrepreneurial success. Moreover, our study is the first to fully cover the assumed benefits of positive affect for entrepreneurial success using the Baron's framework (2008), and shows that sole proprietors who in general express positive feelings and emotions, are more likely to succeed.

Part II

Biology and Entrepreneurship

5. The Role of Behavioral and Electrophysiological Measures in Entrepreneurship

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Abstract. The present study examines the functional significance of impulsivity-related behavioral and electrophysiological measures in predicting several entrepreneurial constructs. In specific, we employ regression analyses to investigate whether behavioral and electrophysiological measures can serve as substitutes for or complements to self-report measures of entrepreneurship. The findings, based on three relatively large datasets (n = 133, n = 142, and n = 119), indicate neither a subsituting nor complementing role of behavior and electrophysiology. Though disappointing at first sight, our findings and their interpretation pave the way for future research on the relevance of behavioral and electrophysiological measures for entrepreneurship.

5.1. Introduction

Attempts to explain the differences between entrepreneurs and non-entrepreneurs have traditionally focused on self-reported personal characteristics, business characteristics, and environmental factors (Parker, 2018). In more recent years, entrepreneurship researchers have expanded the scope of their studies to measures that originate in other fields, such as psychology (Brandstätter, 1997, 2011; Gorgievski & Stephan, 2016). Some of these studies have focused on the personality dimensions that are postulated in the five-factor taxonomy. Meta-analyses on these studies demonstrate that compared to managers, entrepreneurs score higher on conscientiousness and openness to experiences, and lower on neuroticism and agreeableness (Frese & Gielnik, 2014; Zhao & Seibert, 2006). Furthermore, studies have examined risk-taking, showing that entrepreneurs exhibit higher levels of risk propensity than managers, especially when the entrepreneur's main purpose is profit and growth (Stewart & Roth, 2001). Other psychological constructs that have been examined include achievement motivation, self-efficacy, innovativeness, and need for autonomy, which have all consistently been related to both business creation and performance (Frese & Gielnik, 2014; Rauch & Frese, 2007). A final construct that has been examined in relation to entrepreneurship concerns impulsivity. Wiklund, Yu, and Patzelt (2017a) have argued that uncertain contexts such as entrepreneurship attract impulsive individuals, and that impulsivity may in fact be an asset in an entrepreneurial career. In line with this, impulsivity and related constructs such as sensation seeking (Wiklund, Yu, & Patzelt, 2017a), the behavioral activation system (Geenen, Urbig, Muehlfeld, Van Witteloostuijn, & Gargalianou, 2016), and symptoms of Attention Deficit/Hyperactivity Disorder (ADHD, Antshel, 2017; Thurik, Khedhaouria, Torrès, & Verheul, 2016; Verheul et al., 2015; Wiklund, Yu, Tucker, & Marino, 2017b) have been associated with entrepreneurial intention (Antshel, 2017; Geenen et al., 2016; Verheul et al., 2015), preference/startup (Wiklund et al., 2017b), action (Antshel, 2017; Wiklund et al., 2017a), and orientation (Thurik et al., 2016).

A common denominator in these studies is the use of self-report scales to operationalize the targeted constructs. Many of these self-report scales are constructed to have convergent and discriminant validity as well as high reliability. Nevertheless, these scales could contain biases (Fairburn & Beglin, 1994; Zimmerman & Coryell, 1990). As explained by Podsakoff and Organ (1986), such biases may stem from social desirability, i.e. replying in a way that society expects; consistency motif, i.e. responding consistently following some underlying logic or theory; and common method variance, i.e. a situation in which variance can be explained by the overlap in used measurement methods instead of the underlying constructs these methods are supposed to measure. Suggestions to avoid these problems include using alternative measures such as behavior and electrophysiology (Krueger & Welpe, 2014). Indeed, the advantage of behavioral and

electrophysiological measures above self-reports is that the former are of an implicit nature, which means that they intent to measure preconscious processes. At the present time, however, there is little research on the associations between behavioral and especially electrophysiological measures and entrepreneurial constructs.

To address this gap in the literature, the present study explores the functional significance of these alternative measures for entrepreneurial constructs such as intention (to become an entrepreneur), orientation (strategic posture), and choice (becoming an entrepreneur or not), as well as related concepts such as personal attitude, subjective norm, and locus of control. The significance of behavioral and electrophysiological measures could unfold in two ways: they may explain variance in these entrepreneurial constructs (1) *above* the variance explained by the conventional self-report measures (which would make them complements), or (2) *instead of* the variance explained by these measures (which would make them substitutes). The aim of the present study is to investigate whether behavior and electrophysiology can serve as complements to or substitutes for self-reports in explaining entrepreneurship.

The present study contributes to the entrepreneurship literature in three ways. *First*, we are, to our knowledge, the first to empirically introduce electrophysiology in entrepreneurship. Krueger and Welpe (2014, p. 2) mention that 'the entrepreneurial mindset is decidedly not a set of facts to be learned or even a set of skills to be taught, it is a way of thinking and feeling', and suggest to 'look deeper', for instance at the neuroscience behind entrepreneurship (Pérez-Centeno, 2017). The present study follows this advice and focuses on new measurement levels as to avoid the biases inherent to self-reports (Podsakoff & Organ, 1986).

Second, the present approach is multidimensional in several ways: we focus on *multiple* constructs using *multiple* levels of measurement. That is, in total we investigate nine self-reported entrepreneurial outcomes which we relate to four impulsivity-related self-report measures, nine behavioral measures, and nine electrophysiological measures. The use of multiple self-report measures is not new: Antshel (2017) discussed entrepreneurial orientation, intention, and action, and Wiklund et al., (2017b) examined multiple dimensions of impulsivity. However, previous studies investigating associations between behavior and electrophysiology on the one hand and (self-reported) psychological concepts on the other hand generally report results for single behavioral/electrophysiological measures (Du et al., 2006; Ruchsow, Spitzer, Grön, Grothe, & Kiefer, 2005). When multiple measures are analyzed, these are either purely behavioral or purely electrophysiological (Groen et al., 2008).

Third, we use *three* relatively *large* datasets. Many studies involving electrophysiology analyze small samples with sizes between 20 and 40 participants. However, small samples decrease the change that discovered findings are genuinely true (Button et al., 2013; Forstmeier, Wagenmakers, & Parker, 2017; Ioannidis, 2005). Therefore, the use of larger electrophysiology samples to determine

reliability of the current body of literature is recommended (Moser, Durbin, Patrick, & Schmidt, 2015). The present paper follows this recommendation by analyzing three large datasets of $n = 133$, $n = 142$, and $n = 119$.

Our findings show that self-reported impulsivity(-related) measures are associated with several entrepreneurial constructs. However, the variance in these entrepreneurial constructs could not significantly be explained by the behavioral and electrophysiological measures that were associated with the same impulsivity(-related) measures. Thus, we did not find evidence for behavior and/or electrophysiology complementing or substituting self-report measures in predicting entrepreneurial constructs. These findings have important consequences for future research on the role of behavioral and electrophysiological measures in entrepreneurship.

The present paper is organized as follows. Section 5.2 explains our reasoning and the exploratory focus of this paper. In Section 5.3 both datasets are described together with the analysis method. The resulting findings are presented in Section 5.4. Finally, Section 5.5 provides a conclusion of the results, and discusses these results together with the limitations of our study and future research directions.

5.2. Literature and Exploratory Purpose

The answer to the question "what is entrepreneurship?" depends on what literature one consults (Gartner, 1990). Some, among which Kirzner (1973), argue that the key component in entrepreneurship is opportunity recognition, whereas others, such as Schumpeter (1934), argue for innovation to be the key characteristic (Hébert & Link, 1989). Despite or perhaps as a result of these definitional disagreements, several measures exist that all probe different constructs, such as entrepreneurial intention, orientation, and choice, some of which are again subject to discussion (Krueger, 2017). An example of such a debate concerns whether intention indeed leads to action, as proposed by the Theory of Planned Behavior (Ajzen, 1991). In order to attenuate the impact asserted by a specific definition/measure of entrepreneurship, the present study focuses on several constructs of entrepreneurship: personal attitude, subjective norm, locus of control, self-efficacy, fit, orientation, intention, and choice.

Instead of confining ourselves to the customs of conventional literature by associating entrepreneurial self-report measures to psychological self-report measures, the present study will investigate these measures by also associating them to behavior and electrophysiology. The added value of doing so is twofold: (1) attempting to prevent biases resulting from self-report, and (2) identifying the relevance of behavioral and electrophysiological measures for entrepreneurship. To define our behavioral and electrophysiological measures, we rely on recent literature showing that entrepreneurship is associated with impulsivity and impulsivity-related constructs (Antshel, 2017; Geenen et al., 2016; Thurik et al., 2016; Verheul

et al., 2015; Wiklund et al., 2017a; 2017b). This literature can serve as proof of concept for the general link between psychological self-report measures and entrepreneurial constructs (Lerner, Verheul, & Thurik, 2018). In order to test this link, we selected behavioral and electrophysiological measures that have previously been related to self-report measures of impulsivity and associated constructs such as sensation seeking, reward responsiveness, and ADHD. This design allows all measures to 'compete' for a link with entrepreneurship.

A considerable number of studies have already successfully taken a first step in relating self-report measures of impulsivity on the one hand to behavioral and/or electrophysiological measures on the other. As an extensive report of studies would distract from the main purpose of our study, we will only discuss a few for illustrative purposes. With regard to the relationship between self-reports and behavior, impulsivity has been associated with lower behavioral inhibition in a Go/No-Go task (Littel et al., 2012), riskier behavior in a decision-making task (Lejuez, Aklin, Zvolensky, & Pedulla, 2003), and slower reaction times in a stop-signal task (Logan, Schachar, & Tannock, 1997). With regard to the relationship between self-report and electrophysiology, impulsivity has for example been related to reduced error-related signals in a Go/No-Go task (Littel et al., 2012), an Eriksen Flanker task (Potts, George, Martin, & Barratt, 2006), and a decision-making task (Martin & Potts, 2009). A set of additional studies has examined constructs that are related to impulsivity. For example, sensation seeking has been associated with riskier behavior in a decision-making task (Lejuez et al., 2003), and with reduced error-related signals in an Eriksen Flanker task (Zheng, Sheng, Xu, & Zhang, 2014). Furthermore, reward responsiveness has been related to shorter reaction times in a Go/No-Go task (De Pascalis, Varriale, & D'Antuono, 2010). Finally, people scoring high on ADHD symptoms make more mistakes and have attenuated error signals in the Erisken Flanker and Go/No-Go task (Geburek, Rist, Gediga, Stroux, & Pedersen, 2013).

Given that the behavioral and electrophysiological measures described above have been associated with impulsivity, sensation seeking, reward responsiveness, and ADHD symptoms, and that these constructs are in turn associated with entrepreneurship, the present study combines these measures in one design in order to examine the relationship between self-report measures of entrepreneurial constructs and behavioral/electrophysiological measures of impulsivity. Specifically, we examine whether behavioral and electrophysiological measures can either substitute or complement self-report measures of impulsivity in predicting entrepreneurial constructs. As we are not aware of any previous empirical studies that relate behavior and electrophysiology to self-reported entrepreneurial constructs, we will not propose hypotheses, thereby emphasizing the exploratory nature of the present study.

5.3. Method

The present section describes the three samples (Sample 1, Sample 2, and Sample 3) and the methods that were used to analyze these samples. The data reported for Samples 1 and 2 are also reported in a study on the associations between self-report measures, behavioral measures, and electrophysiological measures for impulsivity and related constructs (Bernoster, De Groot, Wieser, Thurik, & Franken, 2018). Therefore, some parts of the method section are also overlapping. Part of the data reported for Sample 1 is reported in a previous study (Rietdijk, Franken, & Thurik, 2014) that addresses the internal consistency of the electrophysiological measures. Also, part of the data reported for Sample 3 is also used as comparison data in a study examining the applicability of a new behavioral task (the Columbia Card Task) in electroencephalography (EEG; De Groot, Van Strien, & Thurik, 2018).

5.3.1 Sample 1

Sample

Sample 1 consists of third- and fourth-year university students (N = 169) and was collected between September 2013 and May 2014. To enable comparisons across different models, incomplete observations were excluded[13] resulting in a final sample of n = 133 (average age of 22.23 (SD = 2.46) and 39 percent female).

Session Design

At least two days before the lab session, participants received an email asking them to not drink coffee or smoke cigarettes in the 90 minutes before the lab session to prevent acute caffeine/nicotine effects. This email also contained a link to the web-based questionnaire including the self-report measures. Further, it was communicated that the six best-performing (highest accuracy in both lab tasks) participants would receive a financial reward of 100 euros.

Upon arrival in the lab, the participant was informed about the procedure and provided written informed consent. Then, the participant was seated in a comfortable chair in a light- and sound-attenuated EEG room. Participants were wired to the EEG and performed two behavioral tasks, a Go/No-Go task (Donders,

13 None of the participants reported head surgeries, pregnancy, or any history of psychiatric illness (these exclusion criteria were checked the day before data recording). Nine participants were excluded because of errors during data recording, and one participant was excluded for reporting an age of 0. A number of 12 participants were removed due to too many artefacts (e.g. movement, noise) or too few (< 20) correct No-Go trials on the Go/No-Go task. A number of 16 participants were removed due to too many artefacts (e.g., movement, noise) or too few (< 5) error trials on the Eriksen Flanker task. Two participants fit two exclusion criteria, resulting in a total sample of 133 (169 – 9 – 1 – 12 – 16 + 2).

1969; Littel et al., 2012) and an Eriksen Flanker task (Eriksen & Eriksen, 1974; Marhe, Van de Wetering, & Franken, 2013), during which EEG was recorded. The total lab session lasted approximately two hours. All tasks were programmed using E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). Session design was approved by the local institutional review board.

Measures

Self-report measures. In addition to *Age* and *Gender* (1 = female), the online questionnaire included self-reported impulsivity(-related) measures and self-reported entrepreneurial measures. The former consisted of questionnaires on *Impulsivity*, *Sensation Seeking*, and *ADHD symptoms. Impulsivity* and *Sensation Seeking* were measured using the ImpSS-8 scale (Webster & Crysel, 2012), which incorporates the best items from the larger ImpSS-19 scale (Zuckerman, Kuhlman, Joireman, Teta, & Kraft, 1993). *Impulsivity* was measured by four items ("I usually think about what I am doing before doing it" (reverse-scored), "I often do things on impulse", "I very seldom spend much time on the details of planning ahead", "I often get so carried away by new and exciting things and ideas that I never think of possible complications") and *Sensation Seeking* by another four ("I enjoy getting into new situations where you cannot predict how things will turn out", "I like doing things just for the thrill of it", "I sometimes do 'crazy' things just of fun", "I like to explore a strange city or section of town by myself, even if it means getting lost"). Items were rated on a 7-point scale ranging from completely disagree to completely agree. Cronbach's alpha was .50 for *Impulsivity* and .71 for *Sensation Seeking*. *ADHD symptoms* were measured using the ASRS-6 (Kessler et al., 2005), which includes the following items: "How often do you have trouble wrapping up the fine details of a project, once the challenging parts have been done?", "How often do you have difficulty getting things in order when you have to do a task that requires organization?", "When you have a task that requires a lot of thought, how often do you avoid or delay getting started?", "How often do you have problems remembering appointments or obligations?", "How often do you fidget or squirm with your hands or your feet when you have to sit down for a long time?", and "How often do you feel overly active and compelled to do things, like you were driven by a motor?". Response options included "never", "rarely", "sometimes", "often", and "very often". Cronbach's alpha equaled .52.

The self-reported entrepreneurial measures included *Entrepreneurial Personal Attitude*, *Entrepreneurial Subjective Norm*, *Entrepreneurial Internal Locus of Control*, *Entrepreneurial Self-Efficacy*, *Entrepreneurial Fit*, *Entrepreneurial Intention Percentage*, and *Entrepreneurial Choice*. *Entrepreneurial Personal Attitude* was measured using four items (Liñán & Chen, 2009): "Being an entrepreneur implies more advantages than disadvantages to me", "A career as entrepreneur is attractive for me", "If I had the opportunity and resources, I would become an entrepreneur", and "Being an entrepreneur would entail great

satisfactions for me", which were rated on a 5-point scale and which yielded a Cronbach's alpha of .91. Liñán and Chen (2009) also provide a subjective norm scale, which was used to measure *Entrepreneurial Subjective Norm*. Participants were asked to answer the following question separately for close family, friends, and colleagues: "If you would pursue a career as an entrepreneur, how would people in your environment react?". Answering options varied from 1 (total disapproval) to 7 (total approval), and Cronbach's alpha equaled .81. For *Entrepreneurial Internal Locus of Control*, we employed three out of seven items by Levenson (1973): "I am usually able to protect my personal interests", "When I make plans, I am almost certain to make them work", and "I can pretty much determine what will happen in my life". Items were answered on a 7-point scale, and Cronbach's alpha was .49. *Entrepreneurial Self-Efficacy* was measured by the participant's degree of certainty (ranging from 1 = completely unsure to 5 = completely sure) in performing on the following tasks: "establish and achieve goals and objects", "generate new ideas", "develop new products and services", "perform financial analysis", "reduce risk and uncertainty", "take calculated risks", "make decisions under uncertainty and risk", "manage time by setting goals", and "take responsibility for ideas and decisions". These items were selected from Chen, Greene, and Crick (1998) in order to reduce total survey length. Two additional items ("start my own firm" and "lead my own firm to success") were added to obtain information on entrepreneurial self-efficacy in terms of a new firm. These two items strongly loaded on one factor, indicating that they indeed provide additional information. Cronbach's alpha including all self-efficacy items equaled .74. Finally, *Entrepreneurial Fit*, *Entrepreneurial Intention Percentage*, and *Entrepreneurial Choice* were based on single items, respectively "When you think of the word 'entrepreneur', how closely do you fit that image (1 = 0%, 7 = 100%)?", "How likely is it (in %) that in 5 years you will have your own company?", and "Currently, do you have your own company (1 = yes, 0 = no)?".

Behavioral measures. Participants completed two behavioral tasks: the Go/No-Go task and the Eriksen Flanker task. The Go/No-Go task (Donders, 1969; Littel et al., 2012) consisted of 500 trials (of which 125 were No-Go trials), including 30 practice trials. In each trial, a vowel (A, E, I, O, or U) was shown. When the vowel differed from the previously shown vowel, participants had to indicate a 'Go' by pressing a button with their right index finger as fast as possible. In case of the vowel being equal, participants had to indicate a 'No-Go' by withholding a response. Vowels were visible for 200 ms, and between consecutive vowels the screen was empty for a randomly varying duration between 1020 and 1220 ms. Vowels were presented in white on a black background. Four behavioral measures were obtained from the Go/No-Go task: (1) the number of incorrect No-Go trials (*GNG Number Incorrect No Go*), indicating impulsive pressing; (2) the number of incorrect Go trials (*GNG Number Incorrect Go*), which can be used as a benchmark measure; (3) the number of times individuals had two incorrect trials in

a row (*post-incorrect incorrect trials; GNG Number Post-Incorrect Incorrect*), which is an indicator of extreme impulsiveness; and (4) the average response time on the correct Go trials and incorrect No-Go trials (*GNG Average Response Time*), for which lower response times indicate impulsivity (note that response times for incorrect Go trials and correct No-Go trials do not exist since by definition participants do not press in these instances).

The Eriksen Flanker Task (Eriksen & Eriksen, 1974; Marhe et al., 2013) consisted of 400 trials, including eight practice trials. In each trial, participants saw one out of four letter strings ('SSSSS', 'SSHSS', 'HHSHH', or 'HHHHH'). Letter strings appeared 100 times each in a completely random order. Participants were instructed to press a predefined button with their right index finger if the central letter was an 'H' and another button with their left index finger if the central letter was an 'S'. Half of the trials were congruent (i.e. 'SSSSS' or 'HHHHH') and the other half were incongruent (i.e. 'SSHSS' or 'HHSHH'). Trials started with a 150 ms cue ('^') pointing at the location of the central letter in the letter string. Then, the string appeared for 52 ms followed by a black screen for 648 ms, so that the total response time was 700 ms. Finally, a feedback symbol appeared for 500 ms indicating whether a response was correct ('ooo'), incorrect ('xxx'), or too late ('!'). Between trials there was a 100 ms break. Three behavioral measures were obtained from the Eriksen Flanker task: (1) the number of incorrect trials (*EF Number Incorrect*), indicating quick and imprecise responding; (2) the average response time for incongruent trials (*EF Average Response Time Incongruent*), which might indicate impulsivity as these trials require participants to 'take a step back' before responding; and (3) the difference between the average response time after incorrect trials and the average response time after correct trials (*EF Difference Average Response Time Post-Incorrect - Post-Correct*).

Electrophysiological measures. EEG was recorded during both the Go/No-Go task and Eriksen Flanker task using a Biosemi Active-Two amplifier system (Biosemi, Amsterdam, the Netherlands). A number of 32 active Ag/AgCl electrodes mounted in an elastic cap were placed on the scalp according to the 10–20 International System, with two extra electrodes at FCz and CPz. Additional electrodes were attached to the left and right mastoids (for referencing), the two outer canthi of both eyes (for recording a horizontal electrooculogram), and the infraorbital and supraorbital region of the left eye (for recording a vertical electrooculogram). Signals were digitalized with a sample rate of 512 Hz and a 24-bit A/D conversion with a band pass of 0-134 Hz.

The recorded raw EEG signals were transformed offline using Brain Vision Analyzer 2.0 (Brain Products, Munich, Germany). Data were re-referenced to the computed mastoids. In addition, all signals were filtered with a band pass of 0.10-30 Hz (phase shift free Butterworth filters; 24 dB/octave slope). Ocular corrections were performed using the Gratton, Coles, and Donchin (1983) algorithm. Topographical interpolation (Soong, Lind, Shaw, & Koles, 1993) was employed to

calculate new values for bad channels, with a maximum of three channels per participant (data were excluded if more than three bad channels had to be interpolated). The data from the Go/No-Go task were segmented into epochs of 1000 ms (200 ms before to 800 ms after stimulus presentation); data from the Eriksen Flanker task were segmented into epochs of 700 ms (100 ms before to 600 ms after the response). The pre-stimulus period (respectively 200 ms and 100 ms) served as a baseline. Epochs including a signal that exceeded ± 100 μV were excluded. Ultimately, the average number of artefact-free segments on the Go/No-Go task was 70.95 for No-Go and 298.16 for Go trials. The average number of artefact-free segments on the Eriksen Flanker task was 22.17 for incorrect and 315.92 for correct trials.

The electrophysiological measures of interest in the Go/No-Go task are the N2 (representing mismatch detection) and the P3 (representing more elaborate appraisal of the stimuli). We opted for analyzing difference scores, which has the advantage of eradicating exogenous components, i.e. elements that are elicited in response to all stimuli and hence across all conditions (Miltner, Braun, & Coles, 1997). The N2 difference wave for the Go/No-Go task (*GNG N2*) was defined as the difference between the mean amplitude on No-Go trials vs. Go trials within the 175-250 ms time interval, averaged across midline electrodes (Fz, FCz, Cz, CPz, Pz). The P3 difference wave for the Go/No-Go task (*GNG P3*) was defined as the difference between the mean amplitude on No-Go trials vs. Go trials within the 300-500 ms time interval, again averaged across midline electrodes. The decision to only include midline electrodes was based on studies showing that these electrodes have the lowest beta and gamma spectral power, indicating that they are least contaminated by myogenic artefact (Orekhova et al., 2007).

The electrophysiological measures of interest in the Eriksen Flanker task are the Event-Related Negativity (ERN; representing early error processing) and the Pe (representing conscious error processing). Again, the analyses focused on difference scores and used the averaged activity across the midline electrodes. The ERN difference wave for the Eriksen Flanker task (*EF ERN*) was defined as the difference between the mean amplitude on incorrect vs. correct trials within the 25-75 ms time interval. The Pe difference wave for the Eriksen Flanker task (*EF Pe*) was defined as the difference between the mean amplitude on incorrect vs. correct trials within the 200-400 ms time interval.

All time windows chosen for calculating the average amplitudes were consistent with both previous studies (Littel et al., 2012; Marhe et al., 2013; Rietdijk et al., 2014) and with visual inspection of the present grand averaged waveforms (see Figure 5.1).

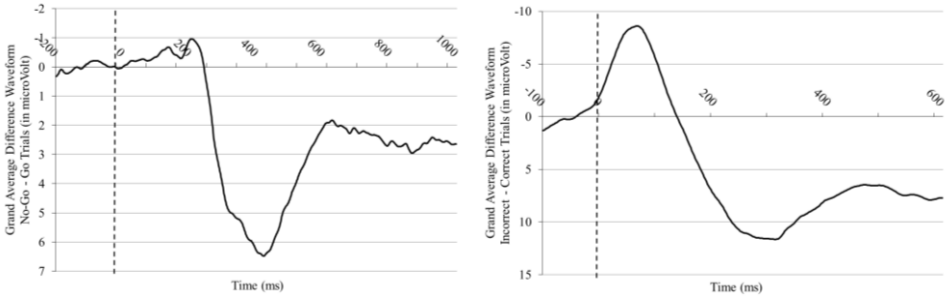

Figure 5.1. Grand average difference waveforms for the Go/No-Go task (left) and the Eriksen Flanker task (right), averaged over all midline electrodes. Note that y-axes are upside down. This is the conventional for presenting EEG difference waveforms in psychology.

5.3.2 Sample 2

Sample

Sample 2 also consists of university students (N = 181) and was collected between May 2015 and April 2016. As for sample 1, incomplete observations[14] were deleted, enabling comparisons across different models. This resulted in a final sample of n = 142 students (average age of 20.63 (SD = 2.04) and 54 percent female).

Session Design

After signing up for the study, participants received an e-mail asking them to not drink coffee and/or energy drinks on the day of the experiment. The email also contained a link to the web-based questionnaire including the self-report measures, and explained the procedure and the reward system: participants received a show-up fee of five euros[15] and could earn an additional 7.50 euros by performing well on the tasks. One day before the lab session, participants received a reminder e-mail with a summary of the most important information.

Upon arrival in the lab, the participant was informed about the procedure and provided written informed consent. Then, the participant was seated in a

14 Incomplete observations included 16 no-shows for the lab session, 6 participants with incorrect electrophysiological measurements on only the BART, 10 participants with incorrect electrophysiological measurements on only the Reward task, and 7 participants who had incorrect electrophysiological measurements on both the BART and the Reward task. Here, incorrect refers to not having enough trials to obtain a reliable electrophysiological measurement. These exclusions resulted in a final sample of 142 (181 – 16 – 6 – 10 – 7).

15 Psychology students received a start-up fee of two participant hours (i.e. hours contributing to the mandatory number of hours they need to fulfil as a research participant).

comfortable chair in a light- and sound-attenuated EEG room. Participants were wired to the EEG and performed two behavioral tasks, a Reward task (Franken, Van den Berg, & Van Strien, 2010; Potts, Martin, Burton, & Montague, 2006) and an automatic Balloon Analogue Risk Task (BART; Euser, Van Meel, Snelleman, & Franken, 2011; Lejuez et al., 2002; Pleskac, Wallsten, Wang, & Lejuez, 2008), during which EEG was recorded. The total lab session lasted approximately two hours. All tasks were programmed using E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). Session design was approved by the local institutional review board.

Measures

Self-report measures. In addition to *Age* and *Gender* (1 = female), the online questionnaire included self-reported impulsivity(-related) measures and self-reported entrepreneurial measures. The former consisted of *Reward Responsiveness*, *Sensation Seeking*, and *ADHD symptoms. Reward Responsiveness* was measured using the 8-item RR scale (Van den Berg, Franken, & Muris, 2010). Four items of this scale are original: "I am someone who goes all-out", "If I discover something new I like, I usually continue doing it for a while", "I would do anything to achieve my goals", and "When I am successful at something, I continue doing it". The remaining four items are revised BAS scale (Carver & White, 1994) items: "When I go after something I use a 'no holds barred' approach", "When I see an opportunity of something I like, I get excited right away", "When I'm doing well at something, I love to keep at it", and "If I see a chance of something I want, I move on it right away". Items were rated on a 4-point scale. Response options included "strong disagreement", "mild disagreement", "mild agreement", and "strong agreement". Cronbach's alpha equaled .78. *Sensation Seeking* was measured using the Brief Sensation Seeking Scale (BSSS; Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002), which consists of eight items: "I would like to explore strange places", "I get restless when I spend too much time at home", "I like to do frightening things", "I like wild parties", "I would like to take off on a trip with no pre-planned routes or timetables", "I prefer friends who are excitingly unpredictable", "I would like to try bungee jumping", "I would love to have new and exciting experiences, even if they are illegal". The items were rated on a 5-point scale ranging from strongly disagree to strongly agree. Cronbach's alpha was .78. *ADHD symptoms* were measured using the ASRS-6 (Kessler et al., 2005), which is explained in more detail in the description of Sample 1. For Sample 2, Cronbach's alpha was .50.

The self-reported entrepreneurial measures included *Entrepreneurial Personal Attitude*, *Entrepreneurial Subjective Norm*, *Entrepreneurial Internal Locus of Control*, *Entrepreneurial Intention*, *Entrepreneurial Intention Percentage*, *Entrepreneurial Orientation*, and *Entrepreneurial Choice*. The instruments used to measure *Entrepreneurial Personal Attitude*, *Entrepreneurial Subjective Norm*,

Entrepreneurial Internal Locus of Control, and *Entrepreneurial Intention Percentage* were equal to those used in Sample 1. The Cronbach's alphas of these measures for Sample 2 were respectively .95, .79, and .75 (*Entrepreneurial Intention Percentage* was measured by a single question and thus no reliability was calculated). *Entrepreneurial Intention* was measured using a 6-item scale by Liñán and Chen (2009), which includes: "I am ready to do anything to be an entrepreneur", "My professional goal is to become an entrepreneur", "I will make every effort to start and run my own firm", "I am determined to create a firm in the future", "I have very seriously thought of starting a firm", and "I have the firm intention to start a firm some day". Items were answered on a 7-point scale ranging from "totally disagree" to "totally agree". Cronbach's alpha was .95. *Entrepreneurial Orientation* was measured by the Individual Entrepreneurial Orientation scale (Langkamp Bolton & Lane, 2012), which consists of ten items ("I like to take bold action by venturing into the unknown", "I am willing to invest a lot of time and/or money on something that might yield a high return", "I tend to act 'boldly' in situations where risk is involved", "I often like to try new and unusual activities that are not typical but not necessarily risky", "In general, I prefer a strong emphasis in projects on unique, one-of-a-kind approaches rather than revisiting tried and true approaches used before", "I prefer to try my own unique way when learning new things rather than doing it like everyone else does", "I favor experimentation and original approaches to problem solving rather than using methods others generally use for solving their problems", "I usually act in anticipation of future problems, needs, or changes", "I tend to plan ahead on projects", and "I prefer to 'step-up' and get things going on projects rather than sit and wait for someone else to do it"). Items were answered on a 5-point Likert scale, and yielded a Cronbach's alpha of .75. Finally, *Entrepreneurial Choice* was coded as 1 when participants answered "yes" to either "Are you currently starting a venture?" or "Do you currently have your own venture?".

Behavioral measures. Participants completed two behavioral tasks: the Reward task and the automatic BART. The Reward task (Franken et al., 2010; Potts, Martin, et al., 2006) consisted of 240 trials and eight additional practice trials. On each trial, participants were shown two consecutive stimuli that could be a picture of a lemon or a picture of a golden bar. Stimulus one predicted similarity of stimulus two in 80 percent of the trials. For example, if the first picture of a given trial was a lemon, there was an 80 percent chance that the second picture was a lemon as well and a 20 percent chance that the second picture was a golden bar. The second picture indicated a gain or a no gain. The task started with a white fixation cross ('+') on a black screen for 300 ms. Then, the first stimulus was shown for a period of 500 ms, after which the black screen with a fixation cross appeared again (300 ms) followed by the second stimulus (500 ms). A final black screen with a fixation mark (300 ms) was shown before the score screen (600 ms), which indicated a gain ('+1') or a no-gain ('+0'). For counter-balancing purposes, half of the participants were shown the

golden bar as gain picture, whereas for the other half the lemon was indicative of a gain.[16] In case of a gain, the total number of points increased, which translated linearly to receiving more money. Since the Reward task is passive, no behavioral measures were obtained.

The automatic BART (Euser et al., 2011; Lejuez et al., 2002; Pleskac et al., 2008) consisted of 60 trials. On each trial, a picture of a balloon was shown. Participants had to inflate the balloon by selecting a number of pumps (between 1 and 128) and then clicking on a predefined button labeled 'P' to start pumping. If the number of pumps was too high, the balloon could burst after pumping, which was indicated by a picture of a burst balloon accompanied by a red cross. In these cases, participants did not earn points. If the balloon did not burst, participants were shown a green dollar sign, and received points equal to the number of pumps. For each trial, the balloon had a predefined bursting point, determined by a random draw of 60 (trials) from an interval distribution between 1 and 128. The bursting points were the same for each participant, but unknown to them. Hence, decisions were made under conditions of uncertainty (De Groot & Thurik, 2018). As for the Reward task, earned points were linearly translated to the amount of money participants received. Two behavioral measures were obtained from the BART: (1) the average number of pumps (*BART Average Pumps*), indicating a riskier choice; and (2) the average response time (*BART Average Response Time*), i.e. the time it took participants to choose a number between 1 and 128 and to press the 'P'.

Electrophysiological measures. EEG was recorded using the same settings as reported for Sample 1. The recorded raw EEG signals were again transformed offline using Brain Vision Analyzer 2.1 (Brain Products, Munich, Germany). Data were re-referenced to the computed mastoids. In addition, all signals were filtered with a band pass of 0.10-30 Hz for the N2, P2, and P3 of the Reward task and for the P3 of the BART, and 2-12 Hz for the Feedback-Related Negativity (FRN) of the BART (phase shift free Butterworth filters; 24 dB/octave slope). Topographical interpolation (Soong et al., 1993) was employed to calculate new values for bad channels, with a maximum of three channels per participant (data were excluded if more than three bad channels had to be interpolated). Data were segmented into epochs of 1000 ms (200 ms before to 800 ms after stimulus presentation for the Reward task; and 200 ms before to 800 ms after feedback, i.e. the actual burst or gain, in the BART). Then, ocular corrections were performed using the Gratton et al. (1983) algorithm. The pre-stimulus period (200 ms for both tasks) served as a baseline. Epochs including a signal that exceeded ± 75 μV were excluded. Ultimately, the average number of artefact-free segments on the Reward task was 22.43 for unexpected loss and 22.56 for unexpected gain trials. The average number of artefact-free segments on the BART was, with regard to the FRN, 27.71 for loss

16 It was examined whether condition influenced our results. Although average brain potentials differed between conditions, the findings for the correlation and associations remained similar.

and 32.15 for the gain trails, and, with regard to the P3, 25.70 for the loss and 29.41 for the gain trials.

The electrophysiological measures of interest in the Reward task are the N2 (representing mismatch detection), the P2 (representing attention to (deviating) stimuli), and the P3 (representing elaborate stimulus appraisal). The analyses employed difference scores obtained from midline electrodes (justifications for these choices can be found in the description of Sample 1). The Reward task difference scores were defined as the difference between the mean amplitude on the unexpected loss trials vs. unexpected gain trials within the 200-300 ms time interval (for the N2; *REWARD N2*), the 150-230 ms time interval (for the P2; *REWARD P2*), and the 300-400 ms time interval (for the P3; *REWARD P3*).

The electrophysiological measures of interest in the BART are the FRN (representing error processing), and the P3 (representing elaborate stimulus appraisal). The BART difference scores were defined as the difference between the mean amplitude on the loss trials vs. gain trails within the 200-275 ms time interval (for the FRN; *BART FRN*) and within the 250-400 ms time interval (for the P3; *BART P3*).

As for Sample 1, the chosen time windows for calculating the average amplitudes were consistent with previous literature (Euser et al., 2011; Franken et al., 2010) and with visual inspection of the present grand averaged waveforms (see Figure 5.2).

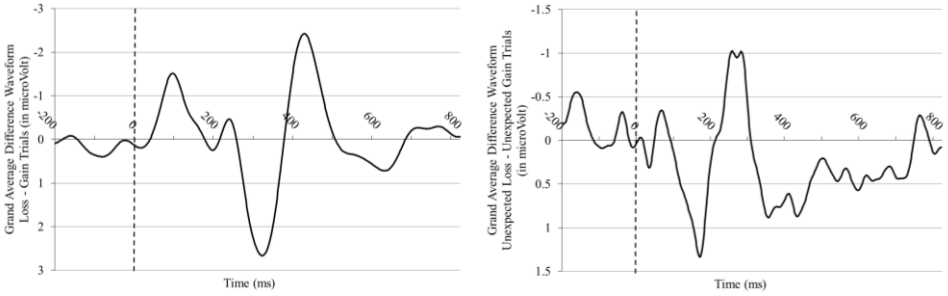

Figure 5.2. Grand average difference waveforms for the BART (left) and the Reward Task (right), averaged over all midline electrodes. Note that y-axes are upside down. This is the conventional for presenting EEG difference waveforms in psychology.

5.3.3 Sample 3

Sample

Sample 3 again consisted of university students (N = 126) and was collected between April and December 2017. Participants who already showed clear abnormalities during the lab-session were not merely excluded but replaced; later

data analysis led to exclusion of additional participants.[17] This resulted in a final sample of n = 119 students (average age of 20.94 (SD = 2.48) and 54 percent female).

Session Design

Participants signed up online, after which they received an email with in-depth information about the measurements and the request to not drink alcohol, coffee, or energy drinks on the day of the appointment to prevent these substances from impacting the measures. The experimental session lasted 90 minutes and included signing informed consent forms, having the electrodes placed, performing the tasks, having the electrodes removed, and debriefing. During the session, participants were seated in a light- and sound-attenuated EEG room. In exchange for participation, students received either course credit or a standard fee of 25 euros. They were informed that they could earn extra money (up to 7.50 euros) based on their task performance. The nature of the measurements (EEG) was communicated to participants beforehand, and all participants provided informed consent. The study was approved by the institutional review board.

Measures

Self-report measures. In addition to *Age* and *Gender* (1 = female), the online questionnaire included self-reported impulsivity(-related) measures and self-reported entrepreneurial measures. The former consisted of *Reward Responsiveness, Sensation Seeking,* and *ADHD symptoms. Reward Responsiveness* was measured using the five items of the BAS Reward Responsiveness scale (Carver & White, 1994): "When I get something I want, I feel excited and energized", "When I'm doing well at something, I love to keep at it", "When good things happen to me, it affects me strongly", "It would excite me to win a contest", and "When I see an opportunity for something I like, I get excited right away". Items were rated on a 4-point scale, where response options included "strong disagreement", "mild disagreement", "mild agreement", and "strong agreement". Cronbach's alpha equaled .68. *Sensation Seeking* was measured using the Brief Sensation Seeking

17 Three participants showed abnormalities during the lab-session. One was enrolled in a Dutch language program for immigrants and had difficulty understanding the task instructions, which resulted in atypical responses on control tasks. Two were enrolled in a so-called 'hovo' (higher education for the elderly) course, and reported problems related to eyesight (reading the instructions) and the use of technology (quickly operating the keyboard and mouse). Therefore, these participants were replaced shortly after their session. Data of these participants is still available upon request. Five other participants reported a current psychiatric or neurological disorder in the questionnaire, but since confidential data were only examined after anonymising all files (which occurred after the study had ended), these participants could not be replaced and were hence merely excluded. Further, two participants were excluded because they did not report on several of the self-report measures. The final sample therefore included 119 (126 – 3 + 3 – 5 – 2) participants.

Scale (BSSS; Hoyle et al., 2002), as described for Sample 2. Cronbach's alpha was .78. *ADHD symptoms* were measured using the ASRS-6 (Kessler et al., 2005), which is explained in more detail in the description of Sample 1. Cronbach's alpha was .63.

The self-reported entrepreneurial measures included *Entrepreneurial Personal Attitude*, *Entrepreneurial Subjective Norm*, *Entrepreneurial Perceived Behavioral Control*, *Entrepreneurial Intention*, and *Entrepreneurial Orientation*. The first four scales consisted of items from Liñán, Urbano, and Guerrero (2011). Specifically, *Entrepreneurial Personal Attitude*, was measured using the four items "A career as entrepreneur is totally *unattractive* to me", "Amongst various options, I would rather be *anything but* an entrepreneur", "Being an entrepreneur would give me great satisfaction", and "Being an entrepreneur implies more advantages than disadvantages to me", of which the first two were reversed scored. Items were rated on a scale ranging from 1 (total disagreement) to 7 (total agreement). Cronbach's alpha was .88. *Entrepreneurial Subjective Norm* was measured using the items: "My friends would approve of my decision to start a business", "My immediate family would approve of my decision to start a business", and "My colleagues would approve of my decision to start a business". Items were rated on a scale ranging from 1 (total disagreement) to 7 (total agreement). Cronbach's alpha was .85. *Entrepreneurial Perceived Behavioral Control* was measured with five items: "Start a firm and keeping it viable would be easy for me", "I am able to control the creation process of a new business", "If I tried to start a business, I would have a high chance of being successful", "It would be *very difficult* for me to develop a business idea", and "I know all about the practical details needed to start a business". The fourth item was reversed. Answer options ranged from 1 (total disagreement) to 7 (total agreement) and Cronbach's alpha was .79. Finally, *Entrepreneurial Intention* was measured with five items: "I am ready to do anything to be an entrepreneur", "I will make every effort to start and run my own business", "I am determined to create a business venture in the future", "My professional goal is to be an entrepreneur", and "I have a *very low* intention of ever starting a business", of which the last item was reversed. Items were again rated on a scale ranging from 1 (total disagreement) to 7 (total agreement) and Cronbach's alpha was .91. The scale for *Entrepreneurial Orientation* was based on the same scale as described for Sample 2. Cronbach's alpha for this measure was .70.

Behavioral measures. Participants completed the automatic BART (Euser et al., 2011; Lejuez et al., 2002; Pleskac et al., 2008), which consisted of 60 trials. This behavioral task is described in Sample 2. Two behavioral measures were obtained from the BART: (1) the average number of pumps (*BART Average Pumps*), indicating a riskier choice; and (2) the total earnings (*BART Total Earnings*), i.e. the total earnings participants obtained with their gains.

Electrophysiological measures. EEG was recorded using the same settings as reported for Sample 1, but without the FCz and CPz electrodes. The recorded raw

EEG signals were again transformed offline with Brain Vision Analyzer 2.1 (Brain Products, Munich, Germany). Data were re-referenced to the computed mastoids. In addition, all signals were filtered with a band pass of 0.10-30 Hz and a notch filter of 50 Hz (phase shift free Butterworth filters; 24 dB/octave slope). Data were segmented into epochs of 1100 ms (100 ms before to 1000 ms after feedback presentation). Then, ocular corrections were performed using the Gratton et al. (1983) algorithm. The pre-stimulus period (100 ms) served as a baseline. Epochs including a signal that exceeded ± 75 µV were excluded. Ultimately, the average number of artefact-free segments was 22.88 for loss and 30.17 for the gain trails.

The electrophysiological measures of interest in the BART are the FRN (representing error processing) and the P3 (representing elaborate stimulus appraisal). The analyses employed difference scores, this time obtained from the Fz, Cz, and Pz electrodes (justifications for using the midline electrodes can be found in the description of Sample 1). Visual inspection of the grand averaged data showed no clear FRN, which was hence not exported and not further analyzed. The BART difference scores for the P3 (*BART P3*) were defined as the difference between the mean amplitude on the loss trials vs. gain trails within the 250-400 ms time interval.

Figure 5.3 shows the grand average different waveforms for the BART. As for Sample 1, the chosen time windows for calculating the average amplitudes for the P3 were consistent with previous literature (Euser et al., 2011; Franken et al., 2010) and with visual inspection of the present grand averaged waveforms (see Figure 5.3).

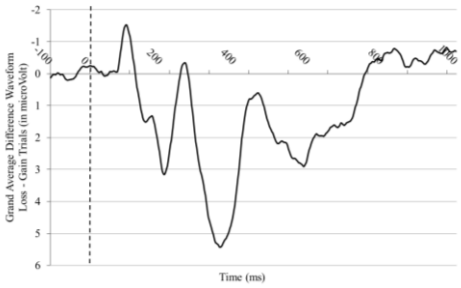

Figure 5.3. Grand average difference waveforms for the BART. Note that y-axes are upside down. This is the conventional for presenting EEG difference waveforms in psychology.

5.3.4 Analysis

To investigate whether behavior and electrophysiology associated with impulsivity can serve as substitutes for or complements to self-reports of impulsivity(-related) constructs when investigating entrepreneurship, we analyzed descriptive statistics and correlation matrices and we performed several multiple regressions. Amongst descriptive statistics, we reported Variance Inflation Factors

(VIFs) with the aim to detect multicollinearity. As the threshold for a low VIF may be perceived as arbitrary, we controlled for potential multicollinearity with the correlation matrices. These provided uncontrolled associations such that there is no bias – that could arise in the regression analyses – due to potential multicollinearity. For each entrepreneurial construct, four regression models were analyzed. In the first model (Model 1), the entrepreneurial construct was regressed on the control variables and on the impulsivity(-related) self-report measures. This first model served as a baseline model. If associations in the first model were prominent, our hypothesis that behavioral and electrophysiological measures associated with impulsivity could act as complements for or substitutes to self-reports of impulsivity(-related) constructs was justified. In the second and third model, the self-report measures were replaced by respectively behavioral and electrophysiological measures. Therefore, Models 2 and 3 provided results on the substituting role of behavior and electrophysiology: they investigated whether behavioral and electrophysiological measures associated to impulsivity are predicting entrepreneurial constructs *instead of* self-reported measures of impulsivity(-related) constructs. The fourth model (Model 4) included all measures: controls, self-report, behavior, and electrophysiology. Hence, it tested whether behavior and electrophysiology could play a complementing role to self-reported impulsivity(-related) constructs in explaining entrepreneurial constructs. In other words, it tested whether behavioral and electrophysiological measures associated to impulsivity are predicting entrepreneurial constructs *above* self-reported measures of impulsivity(-related) constructs. The coefficients of the regression models were estimated using Ordinary Least Squares (OLS), except for *Entrepreneurial Choice*, which was analyzed using logistic regression as it is binary. To allow comparison between the OLS regression models, coefficients were standardized.

5.4. Results

Table 5.1 shows the descriptive statistics for the variables in Sample 1: the mean, standard deviation (SD), minimum (Min), maximum (Max), variance inflation factor (VIF), correlations, and Cronbach's alphas (on the diagonal). The highest VIF was 3.34 for *GNG Number Post-Incorrect Incorrect* and thus lower than the threshold of 10.00 (Diamantopoulos, Riefler, & Roth, 2008; Hair, Anderson, Babin, & Black, 2010). Hence, there is no danger of multicollinearity. Nevertheless, we inspected correlation matrices. Many correlations within self-report measures of entrepreneurship were high and significant (71.43 percent), as were the correlations within self-report impulsivity(-related) measures (100.00 percent). For the behavioral and electrophysiological measures, these percentages were lower but still substantial (respectively 57.14 and 50.00 percent). Further, 42.86 percent of the correlations between self-report impulsivity(-related) measures and self-reported entrepreneurship measures, were significant. However, only 6.12

percent of the correlations between behavior and self-reported entrepreneurship measures and 7.14 percent of the correlations between electrophysiology and self-reported entrepreneurship measures were significant.

Table 5.2 shows the descriptive statistics for the variables in Sample 2: the mean, standard deviation (SD), minimum (Min), maximum (Max), variance inflation factor (VIF), correlations, and Cronbach's alphas (on the diagonal). The highest VIF was 4.55 for *REWARD N2*, which is considerably lower than 10.00, and thus indicates no serious danger of multicollinearity (Diamantopoulos et al., 2008; Hair et al., 2010). As for Sample 1, many correlations within self-report measures of entrepreneurship and within self-report measures of impulsivity were high and significant (respectively 90.48 and 66.67 percent). The percentage of significant correlations within behavioral (100.00 percent) and electrophysiological measures (30.00 percent) was also substantial. Further, 66.67 percent of the correlations between self-report impulsivity(-related) measures and self-report entrepreneurship measures were significant. However, none of the correlations between behavior and self-reported entrepreneurship measures and none of the correlations between electrophysiology and self-reported entrepreneurship measures were significant.

Table 5.3 shows the descriptive statistics for the variables in Sample 1: the mean, standard deviation (SD), minimum (Min), maximum (Max), variance inflation factor (VIF), correlations, and Cronbach's alphas (on the diagonal). The highest VIF was 1.40 for *BART Average Pumps* and thus lower than the threshold of 10.00 (Diamantopoulos, Riefler, & Roth, 2008; Hair, Anderson, Babin, & Black, 2010) indicating no danger of multicollinearity. Nevertheless, we inspected correlation matrices. Many correlations within self-report measures of entrepreneurship and behavioral measures were high and significant (100.00 percent), opposed to the correlations within self-report impulsivity(-related) measures (33.33 percent). Further, 46.67 percent of the correlations between self-report impulsivity(-related) measures and self-reported entrepreneurship measures, were significant. However, only 10.00 percent of the correlations between behavior and self-reported entrepreneurship measures and none of the correlations between electrophysiology and self-reported entrepreneurship measures were significant.

Further, there is a risk of common method bias in our data, which could lead to inflated or deflated correlations and hence type I or II errors (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Therefore, we examined common method bias using Harman's single factor test. The first principal component explained 12.17, 17.23, and 17.20 percent of the variance in respectively Sample 1, 2 and 3, which is below the 50.00 percent threshold and therefore indicates no danger of common method bias.

The results of the multiple regressions are presented in Table 5.4 (Sample 1), Table 5.5 (Sample 2), and Table 5.6 (Sample 3). With regard to the first model, the tables show significant associations between self-reported impulsivity(-related) measures and self-reported entrepreneurial measures. Hence, these results justify

our hypothesis that behavioral and electrophysiological measures associated with impulsivity may act as complements for or substitutes to self-reports.

For investigating the substituting role of behavior and electrophysiology, we investigated Models 2 and 3. For Sample 1 (Table 5.4), there are 77 relevant coefficients (i.e. those including behavioral/electrophysiological measures in Model 2 and 3). Allowing a five percent significance level, we may expect 6.49 coefficients to be significant. However, there is only one significant coefficient. As this coefficients represented only 1.30 percent, it cannot be interpreted. Similarly, for Sample 2 (Table 5.5), there are 49 relevant coefficients and thus we may expect 2.45 coefficients to be significant based on a five percent level. Hence, the two significant coefficients, representing 4.08 percent, cannot be interpreted. For Sample 3 (Table 5.6), there were 15 relevant coefficients. A five percent significance level would mean that 0.75 coefficients are significant. In fact, three are significant, representing 20.00 percent. This means that the associations (between *BART P3* and *Entrepreneurial Subjective Norm*, *BART P3* and *Entrepreneurial Perceived Behavioral Control*, and *BART P3* and *Entrepreneurial Intention*) may be interpreted. However, the correlations corresponding to these three significant associations were insignificant. Together, Models 1, 2, and 3 in Tables 5.4, 5.5, and 5.6 show that many of the coefficients between self-reported impulsivity(-related) measures and entrepreneurship are significant while the majority of coefficients between behavior/electrophysiology and entrepreneurship are not. Therefore, we conclude that the data show no functional significance of behavioral and electrophysiological measures *instead of* self-reported impulsivity(-related) measures in explaining entrepreneurship. In other words, our behavioral and electrophysiological measures did not act as substitutes to self-reports in explaining entrepreneurial constructs.

Models 4 in Tables 5.4, 5.5, and 5.6 test a complementing role of behavioral and electrophysiological measures. The tables show that the coefficients of the self-reported impulsivity(-related) measures in Models 4 are slightly less prominent than the coefficients of these measures in Models 1. However, this 'loss' in coefficients is not compensated by the joint addition of our behavioral and electrophysiological measures: none of the coefficients for behavior/electrophysiology in Models 4 of Sample 1 are significant; only one of the coefficients for behavior/electrophysiology in Models 4 of Sample 2 is significant; and none of the coefficients for behavior/electrophysiology in Models 4 of Sample 3 is significant. Together, these results show that there is no functional significance of behavioral and electrophysiological measures *above* self-reported impulsivity(-related) measures in explaining entrepreneurship. In other words, our behavioral and electrophysiological measures did not act as complements for self-reports in explaining entrepreneurial constructs.[18]

18 Nevertheless, there is a possibility that associations are detectable only in the (upper) tails of the distributions as entrepreneurs could be seen as 'outsiders'. We checked this thought for the

electrophysiological measures. We categorized self-report and electrophysiological measures in low (lower than 30 percent of the total scale of values), medium (between 30 to 60 percent of the total scale of values), high (between 60 and 90 percent of the total scale of values), and very high (higher than 90 percent of the total scale of values). Then, we cross tabulated each electrophysiological measure with each self-reported measure and tested independence via Chi Square test of independence. For Sample 1, we find that two of the forty Chi Square statistics are significant. For Sample 2, we find 3 of the 55 Chi Square statistics to be significant. Both results are expected when adopting a five percent significance level. When focusing on enlargement factors (observed frequency/expected frequency) in the highest categories of both the self-report measures and the electrophysiological measures, we find 22.50 percent enlargement factors higher than 2 in Sample 1 and 18.00 percent enlargement factors higher than 2 in Sample 2. These higher percentages could hint to existing relationships within the upper tail comparison between electrophysiology and self-reports.

Table 5.1. Descriptive statistics for the variables in Sample 1 (*n* = 133): mean, standard deviation (SD), minimum (Min), maximum (Max), variance inflation factor (VIF), correlations, and Cronbach's alpha (on the diagonal).

						Correlations and Cronbach's alpha																				
	Mean	SD	Min	Max	VIF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. Entrepreneurial Personal Attitude (self-report)	3.98	0.92	1.00	5.00		0.91																					
2. Entrepreneurial Subjective Norm (self-report)	5.81	1.01	2.00	7.00		0.45***	0.81																				
3. Entrepreneurial Internal Locus of Control (self-report)	5.40	0.81	3.33	7.00		0.09	0.08	0.49																			
4. Entrepreneurial Self-Efficacy (self-report)	3.70	0.48	2.09	4.73		0.47***	0.49***	0.38***	0.74																		
5. Entrepreneurial Fit (self-report)	3.51	0.94	1.00	5.00		0.65***	0.46***	0.18*	0.61***	-																	
6. Entrepreneurial Intention Percentage (self-report)	56.04	26.33	0.00	100.00		0.59***	0.45***	0.17	0.47***	0.68***	-																
7. Entrepreneurial Choice (self-report)	0.08	0.26	0.00	1.00		0.03	0.11	0.10	0.22*	0.24**	0.27**	-															
8. Age	22.23	2.46	17.00	32.00		0.10	-0.01	0.10	0.06	-0.02	0.18*	0.08	-														
9. Gender	0.39	0.49	0.00	1.00		-0.25**	-0.06	0.06	-0.13	-0.24**	-0.08	-0.05	-0.11	-													
10. Impulsivity (self-report)	3.55	0.91	1.25	5.50	1.53	0.14	0.26**	-0.16	0.08	0.18*	0.19*	-0.03	-0.05	0.04	0.50												
11. Sensation Seeking (self-report)	5.12	1.03	2.00	7.00	1.29	0.33***	0.31***	0.16	0.30***	0.22*	0.27**	-0.07	0.08	-0.11	0.39***	0.71											
12. ADHD symptoms (self-report)	2.79	0.52	1.67	5.00	1.32	0.04	0.02	-0.15	-0.17	0.03	0.00	-0.08	0.03	-0.19*	0.39***	0.18*	0.52										
13. GNG Number Incorrect NoGo (behavior)	40.81	17.69	9.00	97.00	1.62	-0.07	0.00	-0.04	-0.15	-0.06	0.03	0.07	0.03	0.04	0.07	-0.06	0.00	-									
14. GNG Number Incorrect Go (behavior)	8.74	17.33	0.00	186.00	2.75	0.06	-0.10	-0.02	-0.10	-0.12	-0.12	-0.06	0.15	0.01	-0.17*	-0.13	-0.19*	0.08	-								
15. GNG Number Post-Incorrect Incorrect (behavior)	4.35	5.59	0.00	39.00	3.34	-0.03	-0.12	-0.08	-0.22*	-0.16	-0.09	-0.09	0.08	0.07	-0.09	-0.19*	-0.12	0.34***	0.76***	-							
16. GNG Average Response Time (behavior)	348.91	50.13	230.69	489.65	1.55	-0.14	-0.13	-0.11	-0.13	-0.10	-0.13	-0.04	0.01	0.11	-0.08	-0.18*	-0.14	-0.17*	0.26**	0.25**	-						
17. EF Number Incorrect (behavior)	35.86	25.43	2.00	148.00	1.59	-0.20*	-0.08	-0.11	-0.13	-0.05	0.00	-0.05	-0.09	0.13	0.08	-0.12	-0.10	0.34***	0.13	0.31***	0.11	-					
18. EF Average Response Time Incongruent (behavior)	429.81	41.26	320.14	543.44	1.37	0.09	0.14	-0.02	0.11	0.02	0.05	0.09	0.05	0.18*	-0.04	0.05	-0.12	-0.10	-0.03	-0.13	0.22*	-0.22*	-				
19. EF Difference Average Response Time Post-Incorrect - Post-Correct (behavior)	19.05	28.53	-60.46	131.24	1.37	0.14	0.20*	-0.04	0.14	0.06	0.09	0.06	0.17	-0.02	0.05	0.16	0.08	-0.17*	0.12	0.03	0.06	-0.32***	0.36***	-			
20. GNG N2 (electrophysiology)	-0.70	2.18	-5.13	5.20	1.65	0.11	-0.05	0.03	0.07	0.01	0.09	-0.05	0.14	0.08	0.13	0.03	-0.07	-0.27**	0.15	0.05	0.13	0.06	0.06	0.09	-		
21. GNG P3 (electrophysiology)	5.00	4.37	-5.70	19.40	1.90	0.21*	0.16	0.12	0.15	0.15	0.18*	0.00	-0.02	-0.03	0.19*	0.16	0.12	0.01	-0.13	-0.21*	-0.40***	-0.03	-0.07	0.03	0.38***	-	
22. EF ERN (electrophysiology)	-7.74	5.19	-20.62	5.00	1.32	-0.11	-0.15	-0.02	-0.08	-0.05	-0.06	0.06	-0.07	0.11	-0.09	-0.14	0.02	0.08	0.09	0.11	0.12	0.25**	0.10	-0.08	0.13	-0.07	-
23. EF Pe (electrophysiology)	10.17	6.18	-3.82	30.52	1.35	0.09	0.10	0.06	0.00	0.09	0.09	0.01	-0.23**	0.12	-0.09	0.05	0.08	-0.08	-0.04	-0.10	-0.12	-0.24**	0.06	0.11	0.01	0.29***	0.20*

Note: *: p < .05, **: p < .01, ***: p < .001.

Table 5.2. Descriptive statistics for the variables in Sample 2 (n = 142): mean, standard deviation (SD), minimum (Min), maximum (Max), variance inflation factor (VIF), correlations, and Cronbach's alpha (on the diagonal).

						Correlations and Cronbach's alpha																
	Mean	SD	Min	Max	VIF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Entrepreneurial Personal Attitude (self-report)	3.56	1.58	1.00	7.00		0.95																	
2. Entrepreneurial Subjective Norm (self-report)	5.47	0.88	3.00	7.00		0.37***	0.79																
3. Entrepreneurial Internal Locus of Control (self-report)	4.99	0.98	1.00	7.00		0.19*	0.42***	0.75															
4. Entrepreneurial Intention (self-report)	3.22	1.60	1.00	7.00		0.91***	0.39***	0.23**	0.95														
5. Entrepreneurial Intention Percentage (self-report)	20.33	22.20	0.00	100.00		0.73***	0.35***	0.20*	0.76***	-													
6. Entrepreneurial Choice (self-report)	0.07	0.26	0.00	1.00		0.29***	0.15	-0.01	0.34***	0.58***	-												
7. Entrepreneurial Orientation (self-report)	3.53	0.50	2.30	5.00		0.50***	0.38***	0.35***	0.53***	0.52***	0.26**	0.75											
8. Age	20.63	2.04	18.00	30.00		0.20*	0.18*	0.04	0.19*	0.23**	0.13	0.09	-										
9. Gender	0.54	0.50	0.00	1.00		-0.08	0.03	-0.07	-0.01	-0.08	-0.02	-0.03	-0.02	-									
10. Reward Responsiveness (large) (self-report)	3.24	0.38	2.25	4.00	1.14	0.22**	0.30***	0.38***	0.30***	0.33***	0.19*	0.43***	0.09	0.13	0.78								
11. Sensation Seeking (self-report)	3.20	0.71	1.25	4.75	1.20	0.35***	0.17*	0.14	0.39***	0.41***	0.19*	0.45***	0.20*	-0.07	0.19*	0.78							
12. ADHD symptoms (self-report)	2.75	0.54	1.67	4.00	1.14	0.13	-0.12	-0.20*	0.10	0.00	0.04	-0.01	0.25**	0.09	-0.06	0.27**	0.50						
13. BART Average Pumps (behavior)	61.86	10.09	24.87	90.83	1.18	-0.11	-0.10	-0.02	-0.15	-0.04	-0.01	-0.03	0.14	-0.22**	-0.09	0.03	0.14	-					
14. BART Average Response Time (behavior)	6457.59	29574.15	1853.38	355985.00	1.18	-0.04	0.04	0.01	0.02	-0.07	-0.02	0.08	-0.11	0.07	0.11	-0.08	-0.15	-0.31***	-				
15. REWARD N2 (electrophysiology)	-0.27	4.94	-16.32	13.21	4.55	-0.07	-0.06	0.05	-0.10	-0.11	-0.04	-0.01	-0.01	-0.05	-0.17*	-0.01	0.05	0.05	0.02	-			
16. REWARD P2 (electrophysiology)	0.68	4.47	-10.06	13.12	3.50	-0.03	-0.02	0.05	-0.09	-0.06	-0.09	-0.05	-0.05	0.03	-0.11	-0.05	0.08	0.03	-0.04	0.83***	-		
17. REWARD P3 (electrophysiology)	0.90	5.93	-14.87	14.51	2.81	-0.04	0.00	0.12	-0.06	-0.11	-0.14	0.04	-0.01	-0.05	-0.09	0.04	0.04	0.04	0.03	0.79***	0.71***	-	
18. BART FRN (electrophysiology)	0.26	2.46	-7.32	5.56	1.04	0.06	0.12	0.07	0.07	0.07	0.02	0.15	0.08	-0.03	-0.04	0.13	0.01	0.01	-0.06	-0.01	0.00	-0.05	-
19. BART P3 (electrophysiology)	4.09	4.58	-8.39	21.15	1.09	0.03	0.00	-0.08	0.12	0.03	0.01	-0.04	0.03	0.09	-0.15	0.01	0.01	-0.17*	-0.06	0.07	0.01	0.08	0.08

Note: *: p < .05, **: p < .01, ***: p < .001.

Table 5.3. Descriptive statistics for the variables in Sample 3 (*n* = 119): mean, standard deviation (SD), minimum (Min), maximum (Max), variance inflation factor (VIF), correlations, and Cronbach's alpha (on the diagonal).

						Correlations and Cronbach's alpha											
	Mean	SD	Min	Max	VIF	1	2	3	4	5	6	7	8	9	10	11	12
1. Entrepreneurial Personal Attitude (self-report)	4.37	1.41	1.00	7.00		0.88											
2. Entrepreneurial Subjective Norm (self-report)	4.64	1.16	1.00	7.00		0.52***	0.85										
3. Entrepreneurial Perceived Behavioral Control (self-report)	3.58	1.06	1.00	5.80		0.61***	0.54***	0.79									
4. Entrepreneurial Intention (self-report)	2.98	1.46	1.00	6.50		0.74***	0.51***	0.68***	0.91								
5. Entrepreneurial Orientation (self-report)	3.44	0.50	1.70	4.50		0.39***	0.38***	0.45***	0.39***	0.70							
6. Age	20.94	2.48	17.00	30.00		0.02	0.06	0.06	0.07	0.10	-						
7. Gender	0.54	0.50	0.00	1.00		-0.23*	-0.18	-0.30***	-0.33***	-0.14	0.12	-					
8. Reward Responsiveness (large) (self-report)	3.33	0.43	1.80	4.00	1.04	0.30***	0.13	-0.09	0.04	0.28**	0.02	0.21*	0.68				
9. Sensation Seeking (self-report)	3.18	0.71	1.38	4.62	1.14	0.31***	0.23*	0.23*	0.36***	0.44***	0.01	-0.07	0.13	0.78			
10. ADHD symptoms (self-report)	1.90	0.61	0.33	3.83	1.07	0.02	-0.10	-0.06	0.06	0.14	-0.14	-0.05	0.07	0.18*	0.63		
11. BART Average Pumps (behavior)	58.48	11.98	13.42	85.25	1.40	0.17	0.13	0.14	0.11	0.13	0.21*	-0.24**	0.13	0.19*	0.01	-	
12. BART Total Earnings (behavior)	1732.05	293.29	585.00	2304.00	1.32	0.13	0.20*	0.15	0.11	0.11	0.17	-0.24**	0.11	0.06	-0.11	0.48***	-
13. BART P3 (electrophysiology)	0.62	32.11	-99.67	78.00	1.09	0.10	0.16	0.10	0.12	0.08	-0.02	0.22*	0.06	0.17	-0.07	-0.15	-0.03

Note: *: p < .05, **: p < .01, ***: p < .001.

Table 5.4. Regression results (standard errors in brackets) for Sample 1 (*n* = 133).

	Entrepreneurial Personal Attitude (self-report)				Entrepreneurial Subjective Norm (self-report)				Entrepreneurial Internal Locus of Control (self-report)				Entrepreneurial Self-Efficacy (self-report)				Entrepreneurial Fit (self-report)				Entrepreneurial Intention Percentage (self-report)				Entrepreneurial Choice (self-report)			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Intercept	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2.65***	-2.89***	-2.63***	-3.22***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.09)	(0.09)	(0.08)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.08)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.08)	(0.37)	(0.47)	(0.37)	(0.59)
Age	0.06	0.03	0.08	0.04	-0.03	-0.05	0.01	0.00	0.08	0.12	0.13	0.10	0.04	0.04	0.04	0.04	-0.04	-0.04	-0.02	0.01	0.16	0.18*	0.19*	0.22*	0.31	0.20	0.35	0.40
	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)	(0.32)	(0.34)	(0.34)	(0.38)
Gender	-0.23**	-0.23**	-0.24**	-0.25**	-0.07	-0.07	-0.05	-0.10	0.09	0.11	0.08	0.12	-0.16	-0.12	-0.12	-0.15	-0.26**	-0.24**	-0.25**	-0.28**	-0.07	-0.08	-0.07	-0.12	-0.32	-0.21	-0.20	-0.35
	(0.08)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.38)	(0.37)	(0.36)	(0.42)
Impulsivity (self-report)	0.08			0.11	0.21*			0.24*	-0.22*			-0.22*	0.08			0.09	0.17			0.20	0.16			0.16	0.23			0.29
	(0.10)			(0.10)	(0.10)			(0.10)	(0.10)			(0.11)	(0.10)			(0.10)	(0.10)			(0.11)	(0.10)			(0.11)	(0.41)			(0.45)
Sensation Seeking (self-report)	0.28**			0.23*	0.25**			0.17	0.27**			0.26*	0.30***			0.23*	0.15			0.10	0.21*			0.18	-0.35			-0.57
	(0.09)			(0.09)	(0.09)			(0.09)	(0.09)			(0.10)	(0.09)			(0.09)	(0.09)			(0.10)	(0.09)			(0.10)	(0.38)			(0.46)
ADHD (self-report)	-0.09			-0.09	-0.12			-0.16	-0.10			-0.13	-0.28**			-0.31***	-0.11			-0.15	-0.12			-0.16	-0.40			-0.59
	(0.09)			(0.10)	(0.09)			(0.10)	(0.09)			(0.10)	(0.09)			(0.10)	(0.09)			(0.10)	(0.09)			(0.10)	(0.40)			(0.46)
GNG Number Incorrect No-Go (behavior)		-0.05		-0.05		0.05		-0.01		-0.03		-0.02		-0.09		-0.10		-0.03		-0.05		-0.01		-0.01		0.51		0.51
		(0.10)		(0.10)		(0.10)		(0.11)		(0.11)		(0.11)		(0.10)		(0.11)		(0.10)		(0.11)		(0.10)		(0.11)		(0.39)		(0.46)
GNG Number Incorrect Go (behavior)		0.12		0.09		-0.04		-0.03		0.08		-0.01		0.08		0.00		-0.03		-0.04		-0.17		-0.22		0.19		-0.18
		(0.14)		(0.14)		(0.14)		(0.14)		(0.14)		(0.14)		(0.14)		(0.14)		(0.14)		(0.14)		(0.14)		(0.14)		(2.13)		(2.58)
GNG Number Post-Incorrect Incorrect (behavior)		0.01		0.09		-0.07		0.00		-0.09		-0.02		-0.21		-0.13		-0.11		-0.05		0.05		0.13		-1.25		-1.27
		(0.15)		(0.15)		(0.16)		(0.15)		(0.16)		(0.16)		(0.15)		(0.15)		(0.16)		(0.16)		(0.16)		(0.15)		(1.43)		(1.66)
GNG Average Response Time (behavior)		-0.18		-0.09		-0.12		-0.04		-0.11		-0.03		-0.13		-0.08		-0.07		-0.02		-0.12		-0.06		0.01		-0.12
		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.11)		(0.10)		(0.10)		(0.10)		(0.11)		(0.10)		(0.10)		(0.42)		(0.53)
EF Number Incorrect (behavior)		-0.10		-0.11		0.03		0.06		-0.11		-0.12		0.04		-0.01		0.06		0.06		0.09		0.10		-0.22		-0.28
		(0.10)		(0.10)		(0.10)		(0.11)		(0.10)		(0.11)		(0.10)		(0.10)		(0.10)		(0.11)		(0.10)		(0.11)		(0.50)		(0.58)
EF Average Response Time Incongruent (behavior)		0.14		0.14		0.12		0.13		-0.02		-0.07		0.09		0.05		0.05		0.05		0.07		0.07		0.30		0.16
		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.40)		(0.44)
EF Difference Average Response Time Post-Incorrect - Post-Correct (behavior)		0.04		-0.03		0.20*		0.14		-0.09		-0.08		0.10		0.09		0.07		0.03		0.09		0.03		0.18		0.45
		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.37)		(0.42)
GNG N2 (electrophysiobgy)			0.08	0.04			-0.10	-0.14			-0.04	-0.02			0.03	-0.03			-0.01	-0.04			0.02	0.03			-0.32	-0.36
			(0.09)	(0.11)			(0.10)	(0.11)			(0.10)	(0.11)			(0.10)	(0.11)			(0.10)	(0.11)			(0.10)	(0.11)			(0.40)	(0.54)
GNG P3 (electrophysiology)			0.13	0.12			0.16	0.11			0.12	0.13			0.13	0.10			0.12	0.07			0.14	0.06			0.14	-0.02
			(0.10)	(0.11)			(0.10)	(0.11)			(0.10)	(0.12)			(0.10)	(0.11)			(0.10)	(0.12)			(0.10)	(0.12)			(0.39)	(0.53)
EF ERN (electrophysiology)			-0.10	-0.04			-0.14	-0.09			-0.01	0.05			-0.05	0.04			-0.03	-0.00			-0.05	-0.04			0.33	0.30
			(0.09)	(0.09)			(0.09)	(0.09)			(0.09)	(0.10)			(0.09)	(0.09)			(0.09)	(0.10)			(0.09)	(0.10)			(0.36)	(0.39)
EF Pe (electrophysiology)			0.12	0.08			0.09	0.11			0.05	-0.02			-0.01	-0.04			0.09	0.13			0.11	0.17			0.06	0.09
			(0.09)	(0.10)			(0.10)	(0.10)			(0.10)	(0.11)			(0.10)	(0.10)			(0.10)	(0.11)			(0.10)	(0.10)			(0.37)	(0.45)
F-value	4.92	2.13	3.02	2.36	3.93	1.32	1.42	2.04	3.11	0.76	0.73	1.28	5.04	1.59	0.98	2.17	3.54	1.34	1.98	1.38	3.57	1.23	1.81	1.67	2.93*	6.27[b]	2.54[b]	10.76[b]
p-value	0.00	0.03	0.01	0.01	0.00	0.24	0.21	0.02	0.01	0.65	0.63	0.22	0.00	0.13	0.44	0.01	0.01	0.22	0.07	0.17	0.01	0.28	0.10	0.06	0.70	0.71	0.86	0.82
R-squared (adj.)	0.13	0.07	0.08	0.14	0.10	0.02	0.02	0.11	0.07	-0.02	-0.01	0.03	0.13	0.04	-0.00	0.12	0.09	0.02	0.04	0.04	0.09	0.02	0.04	0.08	-	-	-	-
n	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133

Note: *: p < .05, **: p < .01, ***: p < .001.

[a]: Instead of the results of an F-test, we present the results of the more appropriate LR-test for logistic regressions.

Table 5.5. Regression results (standard errors in brackets) for Sample 2 (*n* = 142).

	Entrepreneurial Personal Attitude (self-report)				Entrepreneurial Subjective Norm (self-report)				Entrepreneurial Internal Locus of Control (self-report)				Entrepreneurial Intention (self-report)				Entrepreneurial Intention Percentage (self-report)				Entrepreneurial Choice (self-report)				Entrepreneurial Orientation (self-report)			
	Model 1	Model 2	Model 3	Model 4	Model1	Model 2	Model 3	Model 4	Model1	Model 2	Model 3	Model 4	Model1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model1	Model 2	Model 3	Model4	Model 1	Model2	Model 3	Model 4
Intercept	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-3.13***	-2.68***	-3.06***	-3.59***	0.00	0.00	0.00	0.00
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.09)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.07)	(0.08)	(0.08)	(0.07)	(0.49)	(0.36)	(0.48)	(0.63)	(0.07)	(0.08)	(0.08)	(0.07)
Age	0.11	0.21*	0.19*	0.13	0.18*	0.20*	0.17*	0.19*	0.03	0.04	0.03	0.03	0.11	0.22*	0.19*	0.12	0.16*	0.23**	0.23**	0.17*	0.24	0.44	0.50	0.25	0.00	0.11	0.08	-0.00
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.09)	(0.08)	(0.09)	(0.09)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.31)	(0.29)	(0.30)	(0.34)	(0.07)	(0.09)	(0.09)	(0.08)
Gender	-0.09	-0.12	-0.10	-0.14	0.03	0.00	0.03	0.00	-0.09	-0.08	-0.05	-0.08	-0.02	-0.05	-0.03	-0.08	-0.08	-0.10	-0.10	-0.11	-0.12	-0.09	-0.06	-0.19	-0.04	-0.04	-0.01	-0.04
	(0.08)	(0.08)	(0.09)	(0.08)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.08)	(0.08)	(0.08)	(0.09)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.36)	(0.34)	(0.35)	(0.41)	(0.07)	(0.09)	(0.09)	(0.08)
Reward Responsiveness (self-report)	0.17*			0.16	0.25**			0.25**	0.35***			0.37***	0.23**			0.23**	0.25***			0.26**	0.78			0.87	0.35***			0.36***
	(0.08)			(0.09)	(0.08)			(0.09)	(0.08)			(0.08)	(0.08)			(0.08)	(0.08)			(0.08)	(0.42)			(0.47)	(0.07)			(0.08)
Sensation Seeking (self-report)	0.28***			0.28***	0.14			0.13	0.12			0.10	0.32***			0.32***	0.36***			0.37***	0.69			0.87	0.41***			0.39***
	(0.08)			(0.09)	(0.09)			(0.09)	(0.08)			(0.09)	(0.08)			(0.08)	(0.08)			(0.08)	(0.41)			(0.50)	(0.08)			(0.08)
ADHD (self-report)	0.04			0.05	-0.19*			-0.18*	-0.22*			-0.22**	0.00			0.03	-0.12			-0.13	-0.04			-0.07	-0.09			-0.08
	(0.08)			(0.09)	(0.09)			(0.09)	(0.08)			(0.09)	(0.08)			(0.08)	(0.08)			(0.08)	(0.39)			(0.46)	(0.08)			(0.08)
BART Average Pumps (behavior)		-0.18*		-0.16		-0.11		-0.07		-0.05		-0.02		-0.20*		-0.15		-0.11		-0.06		-0.17		-0.09		-0.03		0.01
		(0.09)		(0.09)		(0.09)		(0.09)		(0.09)		(0.09)		(0.09)		(0.08)		(0.09)		(0.08)		(0.37)		(0.47)		(0.09)		(0.08)
BART Average Response Time (behavior)		-0.06		-0.04		0.03		0.01		0.00		-0.06		-0.01		0.02		-0.08		-0.06		-0.21		-0.20		0.09		0.06
		(0.09)		(0.09)		(0.09)		(0.09)		(0.09)		(0.08)		(0.09)		(0.08)		(0.09)		(0.08)		(1.12)		(1.52)		(0.09)		(0.08)
BART FRN (electrophysiology)			0.04	0.01			0.12	0.11			0.08	0.08			0.04	0.01			0.04	-0.00			-0.02	-0.17			0.15	0.12
			(0.09)	(0.08)			(0.09)	(0.08)			(0.09)	(0.08)			(0.08)	(0.08)			(0.08)	(0.08)			(0.35)	(0.39)			(0.09)	(0.07)
BART P3 (electrophysiology)			0.04	0.04			-0.02	0.01			-0.09	-0.04			0.12	0.14			0.05	0.08			-0.08	0.15			-0.06	0.01
			(0.09)	(0.08)			(0.09)	(0.08)			(0.09)	(0.08)			(0.09)	(0.08)			(0.08)	(0.08)			(0.35)	(0.40)			(0.09)	(0.07)
REWARD N2 (electrophysiology)			-0.22	-0.15			-0.22	-0.15			-0.13	-0.03			-0.18	-0.11			-0.17	-0.09			1.35	1.47			0.01	0.10
			(0.18)	(0.17)			(0.18)	(0.17)			(0.18)	(0.17)			(0.18)	(0.16)			(0.17)	(0.16)			(0.82)	(0.86)			(0.18)	(0.15)
REWARD P2 (electrophysiology)			0.15	0.17			0.08	0.12			-0.01	0.02			0.04	0.08			0.16	0.21			-0.50	-0.32			-0.16	-0.09
			(0.16)	(0.15)			(0.16)	(0.15)			(0.16)	(0.15)			(0.16)	(0.14)			(0.15)	(0.14)			(0.65)	(0.74)			(0.16)	(0.13)
REWARD P3 (electrophysiology)			0.02	-0.04			0.13	0.07			0.24	0.18			0.04	-0.04			-0.10	-0.19			-1.47*	-1.60*			0.16	0.05
			(0.14)	(0.13)			(0.14)	(0.13)			(0.14)	(0.13)			(0.14)	(0.13)			(0.14)	(0.12)			(0.71)	(0.69)			(0.14)	(0.12)
F-value	5.65	2.69	1.23	2.81	4.99	1.72	1.15	2.34	6.89	0.27	0.81	3.33	7.44	2.70	1.34	3.89	10.16	2.61	1.73	4.81	10.37[a]	2.43[a]	8.60[a]	17.92[a]	13.72	0.66	0.92	6.00
p-value	0.00	0.03	0.29	0.00	0.00	0.15	0.34	0.01	0.00	0.90	0.58	0.00	0.00	0.03	0.24	0.00	0.00	0.04	0.11	0.00	0.07	0.66	0.28	0.12	0.00	0.62	0.49	0.00
R-squared (adj.)	0.14	0.05	0.01	0.13	0.12	0.02	0.01	0.10	0.17	-0.02	-0.01	0.17	0.19	0.05	0.02	0.20	0.25	0.04	0.04	0.25	-	-	-	-	0.31	-0.01	-0.00	0.30
n	142	142	142	142	142	142	142	142	142	142	142	142	142	142	142	142	142	142	142	142	142	142	142	142	142	142	142	142

Note: *: p < .05, **: p < .01, ***: p < .001.

[a]: Instead of the results of an F-test, we present the results of the more appropriate LR-test for logistic regressions.

Table 5.6. Regression results (standard errors in brackets) for Sample 3 (*n* = 119).

	Entrepreneurial Personal Attitude (self-report)				Entrepreneurial Subjective Norm (self-report)				Entrepreneurial Perceived Behavioral Control (self-report)				Entrepreneurial Intention (self-report)				Entrepreneurial Orientation (self-report)			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Intercept	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.08)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.08)	(0.08)	(0.09)	(0.09)	(0.08)
Age	0.04	0.02	0.06	0.05	0.06	0.04	0.09	0.05	0.08	0.08	0.11	0.08	0.10	0.11	0.12	0.13	0.13	0.10	0.13	0.14
	(0.08)	(0.10)	(0.09)	(0.09)	(0.09)	(0.10)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.10)	(0.09)	(0.09)
Gender	-0.29***	-0.20*	-0.27**	-0.32***	-0.21*	-0.15	-0.24*	-0.22*	-0.29**	-0.29**	-0.35***	-0.30**	-0.34***	-0.35***	-0.40***	-0.39***	-0.18*	-0.13	-0.19	-0.20*
	(0.09)	(0.10)	(0.09)	(0.09)	(0.09)	(0.10)	(0.09)	(0.10)	(0.09)	(0.09)	(0.09)	(0.10)	(0.09)	(0.09)	(0.09)	(0.09)	(0.08)	(0.10)	(0.09)	(0.09)
Reward Responsiveness (self-report)	0.34***			0.34***	0.16			0.15	-0.05			-0.06	0.06			0.08	0.26**			0.27**
	(0.09)			(0.09)	(0.09)			(0.09)	(0.09)			(0.09)	(0.09)			(0.09)	(0.08)			(0.09)
Sensation Seeking (self-report)	0.26**			0.23*	0.22*			0.18	0.24**			0.21*	0.33***			0.31***	0.38***			0.38***
	(0.08)			(0.09)	(0.09)			(0.09)	(0.09)			(0.09)	(0.08)			(0.09)	(0.08)			(0.09)
ADHD symptoms (self-report)	-0.05			-0.05	-0.15			-0.12	-0.11			-0.09	-0.01			0.01	0.06			0.07
	(0.08)			(0.09)	(0.09)			(0.09)	(0.09)			(0.09)	(0.08)			(0.09)	(0.08)			(0.08)
BART Average Pumps (behavior)		0.10		0.02		0.02		-0.01		0.03		0.02		-0.00		-0.06		0.06		-0.06
		(0.11)		(0.10)		(0.11)		(0.11)		(0.10)		(0.11)		(0.10)		(0.10)		(0.11)		(0.10)
BART Total Earnings (behavior)		0.03		-0.02		0.15		0.11		0.06		0.05		0.01		0.01		0.04		0.03
		(0.11)		(0.10)		(0.11)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.11)		(0.10)
BART P3 (electrophysiology)			0.16	0.11			0.21*	0.16			0.18*	0.14			0.21*	0.14			0.12	0.04
			(0.09)	(0.09)			(0.09)	(0.09)			(0.09)	(0.09)			(0.09)	(0.09)			(0.09)	(0.09)
F-value	7.47	2.06	3.35	4.81	3.27	1.82	3.40	2.62	4.27	3.37	5.83	2.97	7.18	4.03	7.56	4.92	9.24	1.21	1.98	5.76
p-value	0.00	0.09	0.02	0.00	0.01	0.13	0.02	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.31	0.12	0.00
R-squared (adj.)	0.22	0.04	0.06	0.21	0.09	0.03	0.06	0.10	0.12	0.07	0.11	0.12	0.21	0.09	0.14	0.21	0.26	0.01	0.02	0.24
n	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119

Note: *: p < .05, **: p < .01, ***: p < .001.

5.5. Conclusion

The present study examined whether behavioral and electrophysiological measures can complement or substitute impulsivity(-related) self-report measures in their association with entrepreneurial constructs. This functional significance was investigated in three relatively large samples by means of regression analyses. The results showed no functional significance for behavioral and electrophysiological measures in explaining self-reported entrepreneurial constructs *above* or *instead of* self-reported impulsivity. The remainder of this paper discusses these results in more depth, identifies some of the limitations that characterize our study, and considers possible avenues for future research given our negative and seemingly disappointing results.

5.5.1 Discussion

The questions addressed in the present study are based on two sets of previous literature: (1) studies relating behavioral and electrophysiological measures to self-report measures of impulsivity(-related) constructs, and (2) the association between such impulsivity self-reports and entrepreneurship. To our knowledge, the present study is the first to relate all these constructs in a single empirical design. Therefore, we did not postulate explicit hypotheses, even though these sets of previous studies suggest that behavioral and electrophysiological measures may add predictive value to self-reports, or even substitute them. Our present findings were not in line with this, however, as we did not find significant associations between behavioral/electrophysiological measures and several self-report measures of constructs related to impulsivity and to entrepreneurship.

Several factors may help explain why our behavioral and electrophysiological measures did not show functional significance for our self-reported entrepreneurial constructs or even for our self-reported impulsivity. One possible explanation is that some of the previous positive results on the relationship between self-reported impulsivity and behavior/electrophysiology are not genuine positives but the results of small samples (Button et al., 2013; Forstmeier et al., 2017; Ioannidis, 2005), which are particularly common in studies using electrophysiology. As we used three relatively large samples, we are in a better position to address this problem. Findings from other studies employing large samples have so far been equivocal: some have difficulty finding substantial associations between self-report, behavior, and electrophysiology (see e.g. Brenner, Beauchaine, & Sylvers, 2005; Dittmar, Krehl, Lautenbacher, 2011; Moser et al., 2015), whereas others do report significant associations between these measurement levels (see e.g. Ait Oumeziane & Foti, 2016). Hence, the available literature can neither confirm nor reject the possibility that previous positive findings have arisen as a result of small samples.

A second possible explanation for not finding significant results between self-report measures and behavioral/electrophysiological measures concerns the difference between implicit and explicit measures. It has been argued that behavior and electrophysiology are implicit measures because they represent preconscious processes, and that self-reports represent the conscious result of these preconscious processes and are therefore explicit (Dittmar et al., 2011; Eysenck, 1992). This could in theory explain the lack of significant associations between self-reports on the one hand and behavioral/electrophysiology on the other. However, our present data do not support this explanation as the associations between behavior and electrophysiology (which are both implicit) do not clearly outperform the associations between these implicit measures and the (explicit) self-reports. A similar counterargument can be used against the claim that behavioral/electrophysiological impulsivity and self-reported impulsivity/entrepreneurship are too distant because the former are in the range of milliseconds (thereby measuring state impulsivity), whereas the latter are 'in general' (therefore measuring trait impulsivity).

Focusing solely on the non-significant association between self-reports and behavioral measures, a final possible explanation of our non-significant findings concerns the general predictive value of our behavioral tasks. According to Hedge, Powell, and Summer (2017), several well-known behavioral tasks cannot properly predict self-reported individual differences as a result of low between-subject variability in their outcomes. While this could explain a subset of our non-significant findings, it cannot account for the lack of significant associations between self-reports and electrophysiological measures.

5.5.2 Limitations

The present study suffers from several limitations. *First*, although our samples are large in terms of general sample size, they are concise when it comes to other dimensions such as participant type and geographical spread because they were collected using the same participant databases from the same university. This can have contributed to our null-findings. For example, the possibility exists that our samples were unable to capture all actual entrepreneurial aspects given that our subjects were not actual entrepreneurs. Therefore, future studies could investigate differences in behavior and electrophysiology for entrepreneurs versus non-entrepreneurs, or examine specific groups of entrepreneurs, such as entrepreneurs who were trained to become an entrepreneur versus internally driven entrepreneurs. We are therefore eager to see our study be replicated in other research labs without the limitation of selecting students only.

Second, raw electrophysiological data require much pre-processing, which makes the outcomes partly dependent on analytical choices that are sometimes relatively arbitrary (i.e. have no one right answer). For example, in the present study

we opted for using the subtraction method to calculate the electrophysiological measures, resulting in difference scores. The upside of doing so is eliminating baseline differences in the signals (Miltner et al., 1997), but the downside includes interpretation issues and lower between-subject variance (Meyer, Lerner, De Los Reves, Laird, & Hajcak, 2017). Future studies should therefore for example try to replicate our findings using an approach different from subtraction.

Third, the measures in our three samples are overlapping, but are not entirely similar. Especially when it comes to the self-report measures, using the exact same constructs could lead to more consistent results. For example, we adopted reward responsiveness as an impulsivity-related construct, whereas Franken and Muris (2006) explain that the original reward responsiveness dimension by Gray (1987) in fact consists of reward sensitivity and rash impulsivity, two separate dimensions that are differentially related to impulsivity. Future research could benefit from using well-defined models for deciding what constructs to use. An example concerns the UPPS model (Whiteside & Lynam, 2001), which states that impulsivity is a multidimensional construct composed of urgency, perseverance, premediation, and sensation seeking.

5.5.3 The Way Forward

The present findings indicate that behavioral and electrophysiological measures lack functional significance in predicting entrepreneurial concepts. An obvious reason for this null-finding is a true lack of associations between behavior/electrophysiology and self-reported entrepreneurial constructs. However, the discussed alternative explanations and limitations indicate that it is far too early to draw this conclusion as our null findings could have multiple underlying reasons that do not necessarily eliminate the possibility of true associations. In addition, the link between behavioral/electrophysiological measures and entrepreneurship has been postulated in theoretical scholarly work (see e.g. Krueger & Welpe, 2014). Based on our present findings and our examination of available literature, we provide some valuable considerations for studying the intersection of psychological measures and entrepreneurship.

First, a vast number of studies did report associations between self-reports and behavioral/electrophysiological measures (e.g. De Pascalis et al., 2010; Geburek et al., 2013; Lansbergen, Böcker, Bekker, & Kenemans, 2007; Littel et al., 2012; Potts, George, et al., 2006; Van den Berg, Franken, & Muris, 2011; Zheng et al., 2010; Zheng et al., 2014). Given that the present study reported null-finding, it is important to identify differences between these studies and our present study. As discussed before, one key difference concerns sample size, which is often low in studies that include time- and money-consuming physiology. For example, a recent systematic review on EEGs in relation to risk-taking reported an average sample size of only 29.01 (SD = 18.54) across 81 samples (Chandrakumar, Feuerriegel, Bode, Grech, &

Keage, 2018). The use of such small samples decreases the chance that research findings are genuinely true. In contrast, the findings from our three large samples are more likely to reflect true results. If this factor indeed contributed to the lack of significant associations in the present study, the implication is that previous findings on electrophysiology should be interpreted very carefully, and that electrophysiological research should shift towards using larger samples to examine whether or not true associations exist.

Second, the fact that we did not find evidence for an association between behavior/electrophysiology and entrepreneurship constructs does not mean that there is no future in using these types of measures to explain economic phenomena. The use of these measures in entrepreneurship is relatively new, and hence requires some exploration. It is for example possible that the particular tasks used in the present study are not optimally suited for this purpose. Even though we made a head start by examining not one but four computerized tasks, there are several other tasks that can provide behavioral and electrophysiological data, such as the Columbia Card Task (CCT). An advantage of the CCT is that it can systematically vary all parameters in a full-factorial design, thereby providing separate data on how the win amount, loss amount, and loss probability impacted participants' decisions. Hence, future research should extend the present design to other experimental tasks.

Third, we are aware that the present study examined student samples, measuring entrepreneurship via intention, attitude, and so on. Examining entrepreneurial behavior in students may result in relatively weak responses, and has indeed been criticized (Krueger, 2017). Future studies should therefore examine actual entrepreneurs and matched controls.

Fourth, we recommend investigating the use of real-time EEG equipment. Most studies, including the present one, use computerized tasks that elicit time- and environment-specific behavior and electrophysiology as participants perform the task once in a non-naturalistic setting. Because it is plausible that behavioral and electrophysiological responses vary across times and environments, it could be worthwhile to investigate such measures in real-life. Although there are still technological challenges that need to be addressed, devices that measure EEG anywhere in real-time are already entering the market and form a viable future research avenue.

Finally, although behavior and electrophysiology are among the most commonly used measures in psychology, many other measures exist, including other types of physiology (such as electrodermal activity, heartbeat, and blood pressure), hormones (see e.g. Van der Loos, Haring, et al., 2013a), and genetic information (Koellinger et al., 2010; Van der Loos, Rietveld, et al., 2013b), but also more ethnographic measures such as language analysis, peer-reports, and social media analysis (Kosinski et al., 2015). Future research should explore which (combination of) measurement levels offers little bias and high predictive value

against a low investment of time and money, and combine these measurement levels in examining the drivers of entrepreneurship.

5.5.4 Final Conclusion

The present study investigated whether behavioral and electrophysiological measures can serve as substitutes for or complements to self-reported impulsivity when investigating entrepreneurship. The findings show that there is no evidence of a relationship between our behavioral and electrophysiological measures and several entrepreneurial constructs. Although seemingly disappointing, our findings and their interpretation provide a valuable starting point for studies at the intersection of electrophysiology and entrepreneurship.

6. Electrophysiological, Behavioral, and Self-Reported Measures of Impulsivity: Different Sides of the Same Coin?

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Abstract. Despite many studies examining a combination of self-report, behavioral, and neurophysiological measures, only few address whether these different levels of measurement indeed reflect one construct. The present study aids in filling this gap by exploring the association between self-report, behavioral, and electrophysiological measures of impulsivity and related constructs such as sensation seeking, reward responsiveness, and ADHD symptoms. Individuals across two large samples (n = 133 and n = 142) completed questionnaires and performed behavioral tasks (the Eriksen Flanker task, the Go/No-Go task, the Reward task, and the Balloon Analogue Risk Task) during which brain activity was measured using electroencephalography (EEG). The resulting data showed that even though the correlations within each level of measurement were prominent, there was no evidence of significant correlations across the three measurement levels. These findings contradict the outcomes of some previous smaller studies, which did report significant associations between self-reported impulsivity(-related) measures and behavior and/or electrophysiology. Therefore, these findings suggest to use sufficient large samples to investigate the association between different levels of measurement tapping an apparent single construct.

6.1. Introduction

Impulsivity is defined as "a predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions to the impulsive individual or to others" (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001, p. 1784). It is a normal aspect of behavior which is often functional but can also be dysfunctional. Impulsivity is a multidimensional construct (Gerbring, Ahadi, & Patton, 1987; Khadka et al., 2017) and is closely related to other constructs such as the Behavioral Activation System (BAS; Carver & White, 1994). BAS is in turn associated with reward responsiveness (Carver & White, 1994), which consists of reward sensitivity and rash impulsiveness (Dawe, Gullo & Loxton, 2004), of which particularly the latter is closely associated with impulsivity (Franken & Muris, 2006). Impulsivity is also closely related to sensation seeking (Whiteside & Lynam, 2001; Zuckerman & Neeb, 1979), "the seeking of varied, novel, complex, and intense sensations and experiences, and the willingness to take physical, social, legal, and financial risks for sake of such experience" (Zuckerman, 1994, p. 27). Both sensation seeking and impulsivity are related to risk taking (Jones & Lejuez, 2005; Lejuez et al., 2002; Romer, 2010; Steinberg, 2008), although they may differ in timing and neural underpinnings (Steinberg et al., 2008). Furthermore, impulsivity is a hallmark symptom of several mental disorders (Chamberlain, Stochl, Redden, & Grant, 2018): various facets of impulsivity such as urgency and a lack of both premediation and perseverance characterize for example Attention Deficit/Hyperactivity Disorder (ADHD; Lopez, Dauvilliers, Jaussent, Billieux, & Bayard, 2015).

Impulsivity and related constructs such as sensation seeking, reward responsiveness, and ADHD symptoms can be investigated using self-report measures (e.g. Lopez et al., 2015), behavioral measures (e.g. Sharma, Markon, & Clark, 2014), and neurophysiological measures such as electroencephalography (EEG; e.g. Taylor, Visser, Fueggle, Bellgrove, & Fox, 2018). However, only few studies address whether these different levels of measurement (i.e. self-report, behavior, and neurophysiology) indeed reflect one construct. Research in other areas has already demonstrated that this is not necessarily the case by showing that single constructs measured on different levels are only weakly connected. For instance, Dittmar, Krehl, and Lautenbacher (2011) investigated the association between these three levels of measurement for pain-related information processing. After correcting for multiple testing, they found no significant associations between the electrophysiological measures (recorded during processing pain-related words) and the behavioral measures (acquired from the dot-probe task), nor between electrophysiology and self-reports (obtained from the Pain Catastrophizing Scale, Pain Anxiety Symptoms Scale, and Pain Hypervigilance and Awareness Questionnaire). With respect to behavior and self-report, only one (out of nine) associations was significant. Another study examining different levels of

measurement focused on anxiety and depression, in specific defensive reactivity and cognitive control in young children (Moser, Durbin, Patrick, & Schmidt, 2015). Self-report measures consisted of two parental reports: the Child Behavior Questionnaire and Child Behavior Checklist. Further, children performed 15 behavioral tasks designed to probe defensive reactivity and cognitive control. Neurophysiological measures included the Fear-Potentiated Startle, resting-state EEG asymmetry, and EEG Event-Related Potentials (ERPs). The findings showed that only 2 out of the 11 correlations between different measurement levels were significant: the combined behavioral score correlated with the ERP, and one of the questionnaire scores correlated with EEG asymmetry. None of the questionnaire scores was significantly related to the behavioral measures. These findings again indicate that single constructs measured on different levels are only weakly related.

The present study contributes to this small body of literature on the associations between different measurement levels by providing a comprehensive overview of the associations between self-reports, behavior, and electrophysiology in the broad domain of impulsivity. Subsets of these associations have already been examined by previous studies. For example, self-reported impulsivity has been related to several behavioral outcomes, such as decreased behavioral inhibition in a Go/No-Go task (Littel et al., 2012), increased risky behavior in the Balloon Analogue Risk Task (BART; Lejuez et al., 2002), and slower stopping reaction times in a stop-signal task (Logan, Schachar, & Tannock, 1997). Self-reports have also been related to electrophysiology: individuals who score high on impulsivity were shown to have reduced error-related negativity (ERN) amplitudes in response to incorrect trials on the Go/No-Go task (Littel et al., 2012), punishment trials on the Eriksen Flanker task (Potts, George, Martin, & Barratt, 2006), and high-risk choices in a decision task (Martin & Potts, 2009), all implying poor error processing. Results concerning other ERPs are more equivocal. For example, some report that people scoring high on impulsivity have smaller P3 amplitudes on the stop-signal task (Shen, Lee, & Chen, 2014), whereas others report increased amplitudes for high-impulsive individuals using the same task (Lansbergen, Böcker, Bekker, & Kenemans, 2007).

In addition to studies examining impulsivity, some studies employed self-report measures of related constructs, such as sensation seeking, reward responsiveness, and ADHD symptoms. For example, self-reported sensation seeking has been associated with riskier behavior in the BART (Lejuez, Aklin, Zvolensky, & Pedulla, 2003), reduced ERN amplitudes in the Eriksen Flanker task (Zheng, Sheng, Xu, & Zhang, 2014), and reduced P3 amplitudes in a passive oddball paradigm (Wang & Wang, 2001). Furthermore, self-reported reward responsiveness has been related to shorter reaction times in a Go/No-Go task (De Pascalis, Varriale, & D'Antuono, 2010) and to P3 amplitudes, although literature is inconsistent as to whether this latter relationship is negative (De Pascalis et al., 2010) or positive (Van den Berg, Franken, & Muris, 2011). Finally, a meta-analysis by Geburek, Rist, Gediga, Stroux, and Pedersen (2013) reported that ADHD – a disorder with

impulsivity as one of the hallmark symptoms – is associated with more errors and an attenuated ERN in the Eriksen Flanker and Go/No-Go task.

Although these studies have revealed important insights and are excellent starting points for further inquiries, they have some limitations with regard to the consistency of the findings, the number of investigated measurement levels and constructs, and sample size. The present study is a first attempt to overcome these limitations. *First*, the present study adds value to the current body of literature by extending the knowledge on the role of behavioral and electrophysiological measures of impulsivity. The studies described above provide much insight but are far from conclusive. For example, some studies found negative associations between ADHD and the ERN (Liotti, Pliszka, Perez, Kothmann, & Woldorff, 2005; Geburek et al., 2013; Groen et al., 2008), whereas others did not find an association (Herrmann et al., 2009; Jonkman, Van Melis, Kemner, & Markus, 2007; Wiersema, Van der Meere, & Roeyers, 2005, 2009). Similar observations hold for behavioral measures such as reaction times (Ridderinkhof et al., 2004; Wiersema et al., 2005, 2009) and number of errors (Van Meel, Heslenfeld, Oosterlaan, & Sergeant, 2007; Wiersema et al., 2009). Another example concerns the discussed inconsistencies regarding the relationship between impulsivity(-related) self-report measures and the P3.

Second, the present study deals with *multiple* constructs (i.e. impulsivity, sensation seeking, reward responsiveness, and ADHD) and *multiple* levels of measurement (i.e. self-report, behavior, and electrophysiology). Most studies investigate the association between a *single* self-reported construct and *either* behavioral *or* electrophysiological measures (e.g. Du et al., 2006; Lansbergen et al., 2007; Ruchsow, Spitzer, Grön, Grothe, & Kiefer, 2005; Van den Berg et al., 2011). A small number of studies employs *multiple* self-reported constructs, but still focuses on *either* behavior *or* electrophysiology (e.g. Groen et al., 2008). This fits with the primary aim of these studies, but makes that they do not fully take the complexity of associations between multiple constructs and multiple levels of measurement into account.

Third, we use *two* relatively *large* samples. Most papers cited in the present study that involve electrophysiology use relatively small samples typically consisting of 20 to 40 participants. This is consistent with the broader field of EEG research: the average size of the 81 samples discussed in a recent systematic review on ERPs in relation to risk-taking (Chandrakumar, Feuerriegel, Bode, Grech, & Keage, 2018) was a mere 29.01 (SD = 18.54). The key problem regarding small samples is that they lead to low statistical power and thus have a lower chance that discovered effects are genuinely true (Button et al., 2013; Forstmeier, Wagenmakers, & Parker, 2017; Ioannidis, 2005). Moser et al. (2015) also recommend future studies to employ larger samples, specifically in EEG research, to establish reliability. Therefore, the present study explores two large nonclinical samples, with sample sizes of 133 and 142 participants.

In sum, the present study aims to investigate the association between self-report measures, behavioral measures, and electrophysiological measures for impulsivity and related constructs such as sensation seeking, reward responsiveness, and ADHD symptoms. Self-report measures include the ImpSS-8 scale (Webster & Crysel, 2012), the Brief Sensation Seeking Scale (BSSS; Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002), the Reward Responsiveness (RR) scale (Van den Berg, Franken, & Muris, 2010), and ADHD Self-Report Scale (ASRS-6; Kessler et al., 2005). To obtain behavioral and electrophysiological measures, participants performed the Eriksen Flanker task (Eriksen & Eriksen, 1974), the Go/No-Go task (Donders, 1969; Littel et al., 2012), the Reward task (Franken, Van den Berg, & Van Strien, 2010; Potts, Martin, Burton, & Montague, 2006), and the BART (Euser, Van Meel, Snelleman, & Franken, 2011; Lejuez et al., 2002; Pleskac, Wallsten, Wang, & Lejuez, 2008). Given the positive findings in previous research, we expect self-report measures, behavioral measures, and electrophysiological measures to significantly correlate with each other. Given the fact that these impulsivity-related constructs do not fully overlap, we only can expect small correlations.

6.2. Data and Method

The present section describes the two samples (Sample 1 and Sample 2) and the methods used to analyze these samples. Note that parts of the text in this section may overlap with text about the samples in Chapter 5, as results were based on the same samples.

6.2.1 Sample 1

Participants

The first sample consists of third- and fourth-year university students (N = 169) and was collected between September 2013 and May 2014. Incomplete observations were excluded[19] resulting in a final sample of n = 133 (average age of 22.23 (SD = 2.46) and 39 percent women).

19 None of the participants reported head surgeries, pregnancy, or any history of psychiatric illness (these exclusion criteria were checked the day before data recording). Nine participants were excluded because of errors during data recording, and one participant was excluded for reporting an age of 0. A number of 12 participants were removed due to too many artefacts (e.g. movement, noise) or too few (< 20) correct No-Go trials on the Go/No-Go task. A number of 16 participants were removed due to too many artefacts (e.g., movement, noise) or too few (< 5) error trials on the Eriksen Flanker task. Two participants fit two exclusion criteria, resulting in a total sample of 133 (169 – 9 – 1 – 12 – 16 + 2).

Procedure

At least two days before the lab session, participants received an email asking them to not drink coffee or smoke cigarettes in the 90 minutes before the lab session to prevent acute caffeine/nicotine effects. This email also contained a link to the web-based questionnaire including the self-report measures. Further, it was communicated that the six best-performing (highest accuracy in both lab tasks) participants would receive a financial reward of 100 euros.

Upon arrival in the lab, the participant was informed about the procedure and provided written informed consent. Then, the participant was seated in a comfortable chair in a light- and sound-attenuated EEG room. Participants were wired to the EEG and performed two behavioral tasks, a Go/No-Go task (Donders, 1969; Littel et al., 2012) and an Eriksen Flanker task (Eriksen & Eriksen, 1974; Marhe, Van de Wetering, & Franken, 2013), during which EEG was recorded. The total lab session lasted approximately two hours. All tasks were programmed using E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). Session design was approved by the local institutional review board. Part of the data is reported in a previous study (Rietdijk, Franken, & Thurik, 2014) that addresses the internal consistency of the electrophysiological measures.

Measures

Self-report measures. The online questionnaire included self-report measures on *Impulsivity*, *Sensation Seeking*, and *ADHD symptoms*, as well as two control variables: age and gender (1 = female). *Impulsivity* and *Sensation Seeking* were measured using the ImpSS-8 scale (Webster & Crysel, 2012), which incorporates the best items from the larger ImpSS-19 scale (Zuckerman, Kuhlman, Joireman, Teta, & Kraft, 1993). *Impulsivity* was measured by four items ("I usually think about what I am doing before doing it" (reverse-scored), "I often do things on impulse", "I very seldom spend much time on the details of planning ahead", "I often get so carried away by new and exciting things and ideas that I never think of possible complications"), and *Sensation Seeking* by another four ("I enjoy getting into new situations where you cannot predict how things will turn out", "I like doing things just for the thrill of it", "I sometimes do 'crazy' things just of fun", "I like to explore a strange city or section of town by myself, even if it means getting lost"). Items were rated on a 7-point scale ranging from completely disagree to completely agree. Cronbach's alpha was .50 for *Impulsivity* and .71 for *Sensation Seeking*.

ADHD symptoms were measured using the ASRS-6 (Kessler et al., 2005), which includes the following items: "How often do you have trouble wrapping up the fine details of a project, once the challenging parts have been done?", "How often do you have difficulty getting things in order when you have to do a task that requires organization?", "When you have a task that requires a lot of thought, how often do you avoid or delay getting started?", "How often do you have problems remembering appointments or obligations?", "How often do you fidget or squirm

with your hands or your feet when you have to sit down for a long time?", and "How often do you feel overly active and compelled to do things, like you were driven by a motor?". Response options included "never", "rarely", "sometimes", "often", and "very often". Cronbach's alpha equaled .52.

Behavioral measures. Participants completed two behavioral tasks: the Go/No-Go task and the Eriksen Flanker task. The Go/No-Go task (Donders, 1969; Littel et al., 2012) consisted of 500 trials (of which 125 were No-Go trials), including 30 practice trials. In each trial, a vowel (A, E, I, O, or U) was shown. When the vowel differed from the previously shown vowel, participants had to indicate a 'Go' by pressing a button with their right index finger as fast as possible. In case of the vowel being equal, participants had to indicate a 'No-Go' by withholding a response. Vowels were visible for 200 ms, and between consecutive vowels the screen was empty for a randomly varying duration between 1020 and 1220 ms. Vowels were presented in white on a black background. Four behavioral measures were obtained from the Go/No-Go task: (1) the number of incorrect No-Go trials (*GNG Number Incorrect No Go*), indicating impulsive pressing; (2) the number of incorrect Go trials (*GNG Number Incorrect Go*), which can be used as a benchmark measure; (3) the number of times individuals had two incorrect trials in a row (post-incorrect incorrect trials; *GNG Number Post-Incorrect Incorrect*), which is an indicator of extreme impulsiveness; and (4) the average response time on the correct Go trials and incorrect No-Go trials (*GNG Average Response Time*), for which lower response times indicate impulsivity (note that response times for incorrect Go trials and correct No-Go trials do not exist since by definition participants do not press in these instances).

The Eriksen Flanker Task (Eriksen & Eriksen, 1974; Marhe et al., 2013) consisted of 400 trials, including eight practice trials. In each trial, participants saw one out of four letter strings ('SSSSS', 'SSHSS', 'HHSHH', or 'HHHHH'). Letter strings appeared 100 times each in a completely random order. Participants were instructed to press a predefined button with their right index finger if the central letter was an 'H' and another button with their left index finger if the central letter was an 'S'. Half of the trials were congruent (i.e. 'SSSSS' or 'HHHHH') and the other half were incongruent (i.e. 'SSHSS' or 'HHSHH'). Trials started with a 150 ms cue ('^') pointing at the location of the central letter in the letter string. Then, the string appeared for 52 ms followed by a black screen for 648 ms, so that the total response time was 700 ms. Finally, a feedback symbol appeared for 500 ms indicating whether a response was correct ('ooo'), incorrect ('xxx'), or too late ('!'). Between trials there was a 100 ms break. Three behavioral measures were obtained from the Eriksen Flanker task: (1) the number of incorrect trials (*EF Number Incorrect*), indicating quick and imprecise responding; (2) the average response time for incongruent trials (*EF Average Response Time Incongruent*), which might indicate impulsivity as these trials require participants to 'take a step back' before responding; and (3) the difference between the average response time after incorrect

trials and the average response time after correct trials (*EF Difference Average Response Time Post-Incorrect - Post-Correct*).

Electrophysiological measures. EEG was recorded during both the Go/No-Go task and Eriksen Flanker task using a Biosemi Active-Two amplifier system (Biosemi, Amsterdam, the Netherlands). A number of 32 active Ag/AgCl electrodes mounted in an elastic cap were placed on the scalp according to the 10–20 International System, with two extra electrodes at FCz and CPz. Additional electrodes were attached to the left and right mastoids (for referencing), the two outer canthi of both eyes (for recording a horizontal electrooculogram), and the infraorbital and supraorbital region of the left eye (for recording a vertical electrooculogram). Signals were digitalized with a sample rate of 512 Hz and a 24-bit A/D conversion with a band pass of 0-134 Hz.

The recorded raw EEG signals were transformed offline using Brain Vision Analyzer 2.0 (Brain Products, Munich, Germany). Data were re-referenced to the computed mastoids. In addition, all signals were filtered with a band pass of 0.10-30 Hz (phase shift free Butterworth filters; 24 dB/octave slope). Ocular corrections were performed using the Gratton, Coles, and Donchin (1983) algorithm. Topographical interpolation (Soong, Lind, Shaw, & Koles, 1993) was employed to calculate new values for bad channels, with a maximum of three channels per participant (data were excluded if more than three bad channels had to be interpolated). The data from the Go/No-Go task were segmented into epochs of 1000 ms (200 ms before to 800 ms after stimulus presentation); data from the Eriksen Flanker task were segmented into epochs of 700 ms (100 ms before to 600 ms after the response). The pre-stimulus period (respectively 200 ms and 100 ms) served as a baseline. Epochs including a signal that exceeded ± 100 μV were excluded. Ultimately, the average number of artefact-free segments on the Go/No-Go task was 70.95 for No-Go and 298.16 for Go trials. The average number of artefact-free segments on the Eriksen Flanker task was 22.17 for incorrect and 315.92 for correct trials.

The electrophysiological measures of interest in the Go/No-Go task are the N2 (representing mismatch detection) and the P3 (representing more elaborate appraisal of the stimuli). We opted for analyzing difference scores, which has the advantage of eradicating exogenous components, i.e. elements that are elicited in response to all stimuli and hence across all conditions (Miltner, Braun, & Coles, 1997). The N2 difference wave for the Go/No-Go task (*GNG N2*) was defined as the difference between the mean amplitude on No-Go trials vs. Go trials within the 175-250 ms time interval, averaged across midline electrodes (Fz, FCz, Cz, CPz, Pz). The P3 difference wave for the Go/No-Go task (*GNG P3*) was defined as the difference between the mean amplitude on No-Go trials vs. Go trials within the 300-500 ms time interval, again averaged across midline electrodes. The decision to only include midline electrodes was based on studies showing that these electrodes have the

lowest beta and gamma spectral power, indicating that they are least contaminated by myogenic artefact (Orekhova et al., 2007).

The electrophysiological measures of interest in the Eriksen Flanker task are the ERN (representing early error processing) and the Pe (representing conscious error processing). Again, the analyses focused on difference scores and used the averaged activity across the midline electrodes. The ERN difference wave for the Eriksen Flanker task (*EF ERN*) was defined as the difference between the mean amplitude on incorrect vs. correct trials within the 25-75 ms time interval. The Pe difference wave for the Eriksen Flanker task (*EF Pe*) was defined as the difference between the mean amplitude on incorrect vs. correct trials within the 200-400 ms time interval.

All time windows chosen for calculating the average amplitudes were consistent with both previous studies (Littel et al., 2012; Marhe et al., 2013; Rietdijk et al., 2014) and with visual inspection of the present grand averaged waveforms (see Figure 6.1 and 6.2).

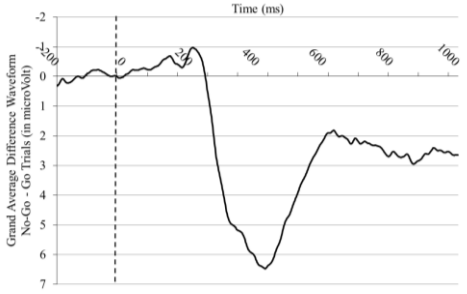

Figure 6.1. Grand average difference waveforms for the Go/No-Go task, averaged over all midline electrodes. Similar to Rietdijk et al. (2014), where the figure was used for a different purpose.

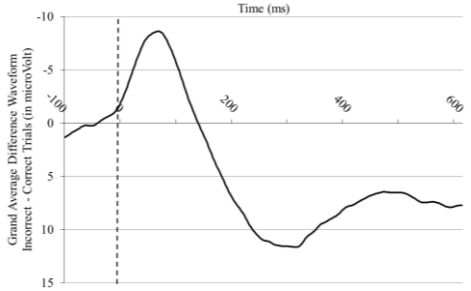

Figure 6.2. Grand average difference waveforms for the Eriksen Flanker task, averaged over all midline electrodes. Similar to Rietdijk et al. (2014), where the figure was used for a different purpose.

6.2.2 Sample 2

Sample

The second sample again consists of university students (N = 181) and was collected between May 2015 and April 2016. Incomplete observations were excluded[20] resulting in a final sample of n = 142 (average age of 20.63 (SD = 2.04) and 54 percent women).

Procedure

After signing up for the study, participants received an e-mail asking them to not drink coffee and/or energy drinks on the day of the experiment. The email also contained a link to the web-based questionnaire including the self-report measures, and explained the procedure and the reward system: participants received a show-up fee of five euros[21] and could earn an additional 7.50 euros by performing well on the tasks. One day before the lab session, participants received a reminder e-mail with a summary of the most important information.

Upon arrival in the lab, the participant was informed about the procedure and provided written informed consent. Then, the participant was seated in a comfortable chair in a light- and sound-attenuated EEG room. Participants were wired to the EEG and performed two behavioral tasks, a Reward task (Franken et al., 2010; Potts, Martin, et al., 2006) and an automatic BART (Euser et al., 2011; Lejuez et al., 2002; Pleskac et al., 2008), during which EEG was recorded. The total lab session lasted approximately two hours. All tasks were programmed using E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). Session design was approved by the local institutional review board.

Measures

Self-report measures. The online questionnaire included self-report measures on *Sensation Seeking*, *Reward Responsiveness*, and *ADHD symptoms*, as well as two control variables: age and gender (1 = female). *Sensation Seeking* was measured using the Brief Sensation Seeking Scale (BSSS; Hoyle et al., 2002), which consists of eight items: "I would like to explore strange places", "I get restless when I spend too much time at home", "I like to do frightening things", "I like wild parties", "I

20 Incomplete observations included 16 no-shows for the lab session, 6 participants with incorrect electrophysiological measurements on only the BART, 10 participants with incorrect electrophysiological measurements on only the Reward task, and 7 participants who had incorrect electrophysiological measurements on both the BART and the Reward task. Here, incorrect refers to not having enough trials to obtain a reliable electrophysiological measurement. These exclusions resulted in a final sample of 142 (181 – 16 – 6 – 10 – 7).

21 Psychology students received a start-up fee of two participant hours (i.e. hours contributing to the mandatory number of hours they need to fulfil as a research participant).

would like to take off on a trip with no pre-planned routes or timetables", "I prefer friends who are excitingly unpredictable", "I would like to try bungee jumping", "I would love to have new and exciting experiences, even if they are illegal". The items were rated on a 5-point scale ranging from strongly disagree to strongly agree. Cronbach's alpha was .78.

Reward Responsiveness was measured using the 8-item RR scale (Van den Berg et al., 2010). Four items of this scale are original: "I am someone who goes all-out", "If I discover something new I like, I usually continue doing it for a while", "I would do anything to achieve my goals", and "When I am successful at something, I continue doing it". The remaining four items are revised BAS scale (Carver & White, 1994) items: "When I go after something I use a 'no holds barred' approach", "When I see an opportunity of something I like, I get excited right away", "When I'm doing well at something, I love to keep at it", and "If I see a chance of something I want, I move on it right away". Items were rated on a 4-point scale. Response options included "strong disagreement", "mild disagreement", "mild agreement", and "strong agreement". Cronbach's alpha equaled .78.

ADHD symptoms were measured using the ASRS-6 (Kessler et al., 2005), which is explained in more detail in the description of Sample 1. For Sample 2, Cronbach's alpha was .50.

Behavioral measures. Participants completed two behavioral tasks: the passive Reward task and the automatic BART. The Reward task (Franken et al., 2010; Potts, Martin, et al., 2006) consisted of 240 trials and eight additional practice trials. On each trial, participants were shown two consecutive stimuli that could be a picture of a lemon or a picture of a golden bar. Stimulus one predicted similarity of stimulus two in 80 percent of the trials. For example, if the first picture of a given trial was a lemon, there was an 80 percent chance that the second picture was a lemon as well and a 20 percent chance that the second picture was a golden bar. The second picture indicated a gain or a no gain. The task started with a white fixation cross ('+') on a black screen for 300 ms. Then, the first stimulus was shown for a period of 500 ms, after which the black screen with a fixation cross appeared again (300 ms) followed by the second stimulus (500 ms). A final black screen with a fixation mark (300 ms) was shown before the score screen (600 ms), which indicated a gain ('+1') or a no-gain ('+0'). For counter-balancing purposes, half of the participants were shown the golden bar as gain picture, whereas for the other half the lemon was indicative of a gain.[22] In case of a gain, the total number of points increased, which translated linearly to receiving more money. Since the Reward task is passive, no behavioral measures were obtained.

The automatic BART (Euser et al., 2011; Lejuez et al., 2002; Pleskac et al., 2008) consisted of 60 trials. On each trial, a picture of a balloon was shown. Participants had to inflate the balloon by selecting a number of pumps (between 1

22 It was examined whether condition influenced our results. Although average brain potentials differed between conditions, the findings for the correlation and associations remained similar.

and 128) and then clicking on a predefined button labeled 'P' to start pumping. If the number of pumps was too high, the balloon could burst after pumping, which was indicated by a picture of a burst balloon accompanied by a red cross. In these cases, participants did not earn points. If the balloon did not burst, participants were shown a green dollar sign, and received points equal to the number of pumps. For each trial, the balloon had a predefined bursting point, determined by a random draw of 60 (trials) from an interval distribution between 1 and 128. The bursting points were the same for each participant, but unknown to them. Hence, decisions were made under conditions of uncertainty (De Groot & Thurik, 2018). As for the Reward task, earned points were linearly translated to the amount of money participants received.

Two behavioral measures were obtained from the BART: (1) the average number of pumps (*BART Average Pumps*), indicating a riskier choice; and (2) the average response time (*BART Average Response Time*), i.e. the time it took participants to choose a number between 1 and 128 and to press the 'P'.

Electrophysiological measures. EEG was recorded using the same settings as reported for Sample 1. The recorded raw EEG signals were transformed offline using Brain Vision Analyzer 2.1 (Brain Products, Munich, Germany). Data were re-referenced to the computed mastoids. In addition, all signals were filtered with a band pass of 0.10-30 Hz for the N2, P2, and P3 of the Reward task and for the P3 of the BART, and 2-12 Hz for the Feedback-Related Negativity (FRN) of the BART (phase shift free Butterworth filters; 24 dB/octave slope). Topographical interpolation (Soong et al., 1993) was employed to calculate new values for bad channels, with a maximum of three channels per participant (data were excluded if more than three bad channels had to be interpolated). Data were segmented into epochs of 1000 ms (200 ms before to 800 ms after stimulus presentation for the Reward task; and 200 ms before to 800 ms after feedback, i.e. the actual burst or gain, in the BART). Then, ocular corrections were performed using the Gratton et al. (1983) algorithm. The pre-stimulus period (200 ms for both tasks) served as a baseline. Epochs including a signal that exceeded ± 75 μV were excluded. Ultimately, the average number of artefact-free segments on the Reward task was 22.56 for unexpected gain and 22.43 for unexpected loss trials. The average number of artefact-free segments on the BART was, with regard to the FRN, 27.71 for loss and 32.15 for the gain trails, and, with regard to the P3, 25.70 for the loss and 29.41 for the gain trials.

The electrophysiological measures of interest in the Reward task are the N2 (representing mismatch detection), the P2 (representing attention to (deviating) stimuli), and the P3 (representing elaborate stimulus appraisal). The analyses employed difference scores obtained from midline electrodes (justifications for these choices can be found in the description of Sample 1). The Reward task difference scores were defined as the difference between the mean amplitude on the unexpected gain trials vs. unexpected loss trials within the 200-300 ms time interval

(for the N2; *REWARD N2*), the 150-230 ms time interval (for the P2; *REWARD P2*), and the 300-400 ms time interval (for the P3; *REWARD P3*).

The electrophysiological measures of interest in the BART are the FRN (representing error processing), and the P3 (representing elaborate stimulus appraisal). The BART difference scores were defined as the difference between the mean amplitude on the loss trials vs. gain trails within the 200-275 ms time interval (for the FRN; *BART FRN*) and within the 250-400 ms time interval (for the P3; *BART P3*).

As for Sample 1, the chosen time windows for calculating the average amplitudes were consistent with previous literature (Euser et al., 2011; Franken et al., 2010) and with visual inspection of the present grand averaged waveforms (see Figure 6.3 and 6.4).

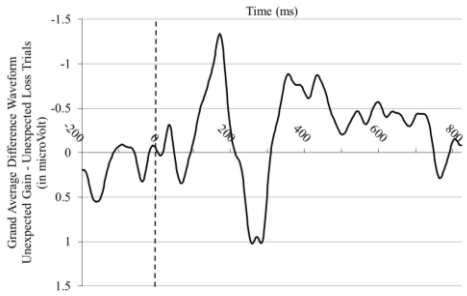

Figure 6.3. Grand average difference waveforms for the Reward Task, averaged over all midline electrodes.

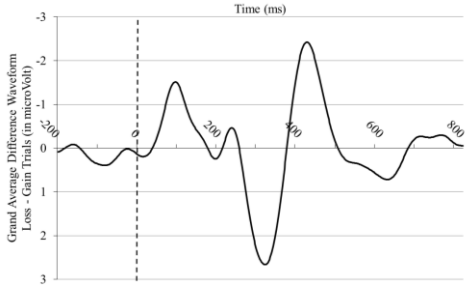

Figure 6.4. Grand average difference waveforms for the BART, averaged over all midline electrodes.

6.2.3 Analyses

First, we performed psychometric checks relevant to our planned analyses: (1) a check for common method bias to examine whether variance in the data could be attributed to the employed measurement method and thus alter correlations; and (2)

a check on the variance inflation factors (VIFs), which indicate the level of multicollinearity, high correlations in independent variables which can lead to inaccurate estimates for the regression coefficients.

Second, we calculated the mean, standard deviation (SD), minimum (Min), maximum (Max), Cronbach's alpha, and correlations. Detailed analyses on the correlations then examined the number of correlations within each measurement level, and the number of correlations between measurement levels.

Third, we used linear regression models to further investigate whether behavioral and electrophysiological measures jointly contribute to the understanding of impulsivity(-related) constructs, given that the combined predictive value of these measures may be more salient compared to when they are related to self-reports individually. For each self-reported construct, we analyzed three multiple regression models: the first model only included behavioral predictors, the second only included electrophysiological predictors, and the third included both behavior and electrophysiology. The coefficients of the regression models were estimated using Ordinary Least Squares (OLS). To allow comparison between the models, coefficients were standardized.

Finally, we used bootstrapping to obtain an overview of the number of significant correlations and associations we would have found if we had used smaller samples. By using large samples, the present study reduced the chance of identified effects being false. However, many studies investigating electrophysiology employ smaller samples of 20 to 40 participants. Therefore, we used the present data to bootstrap the results found in case of a lower sample size by selecting random subsamples sized 20, 30 and 40 from our full sample (1000 iterations).

6.3. Results

6.3.1 Psychometric Checks

Our data could be at risk of common method bias, which could lead to inflated or deflated correlations and hence to type I or II errors (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Therefore, we examined the possible common method bias using Harman's single factor test. The first principal component explained 11.94 percent of the variance in Sample 1 and 14.76 percent in Sample 2. Since this is below the threshold of 50.00 percent, the risk of common method bias in our data is small.

The VIFs are reported in Tables 6.1 and 6.2 for respectively Sample 1 and 2. The highest VIF in Table 6.1 is 3.34 for *GNG Number Post-Incorrect Incorrect*, which indicates that in a regression including all variables the standard error of the coefficient of this variable is less than two times (the square root of 3.34 is 1.83) as large as it would be if the variable was uncorrelated with the other variables. This

VIF is smaller than the suggested threshold of 10.00 (Diamantopoulos, Riefler, & Roth, 2008; Hair, Anderson, Babin, & Black, 2010). Hence, there is no indication of multicollinearity in Sample 1. Similarly, the highest VIF in Table 6.2 is 4.55 (for *REWARD N2*) and thus indicates no serious danger of multicollinearity.

Table 6.1. Descriptive statistics (mean, standard deviation (SD), minimum (Min), maximum (Max), variance inflation factor (VIF), Cronbach's alpha (on the diagonal), and correlations) for the variables of Sample 1 (n = 133).

						Correlations and Cronbach's alpha													
	Mean	SD	Min	Max	VIF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Impulsivity (self-report)	3.55	0.91	1.25	5.50	1.53	0.50														
2. Sensation Seeking (self-report)	5.12	1.03	2.00	7.00	1.29	0.39***	0.71													
3. ADHD symptoms (self-report)	2.79	0.52	1.67	5.00	1.32	0.39***	0.18*	0.52												
4. Age	22.23	2.46	17.00	32.00		-0.05	0.08	0.03	-											
5. Gender	0.39	0.49	0.00	1.00		0.04	-0.11	-0.19*	-0.11	-										
6. GNG Number Incorrect NoGo (behavior)	40.81	17.69	9.00	97.00	1.62	0.07	-0.06	0.00	0.03	0.04	-									
7. GNG Number Incorrect Go (behavior)	8.74	17.33	0.00	186.00	2.75	-0.17*	-0.13	-0.19*	0.15	0.01	0.08	-								
8. GNG Number Post-Incorrect Incorrect (behavior)	4.35	5.59	0.00	39.00	3.34	-0.09	-0.19*	-0.12	0.08	0.07	0.34***	0.76***	-							
9. GNG Average Response Time (behavior)	348.91	50.13	230.69	489.65	1.55	-0.08	-0.18*	-0.14	0.01	0.11	-0.17*	0.26**	0.25**	-						
10. EF Number Incorrect (behavior)	35.86	25.43	2.00	148.00	1.59	0.08	-0.12	-0.10	-0.09	0.13	0.34***	0.13	0.31***	0.11	-					
11. EF Average Response Time Incongruent (behavior)	429.81	41.26	320.14	543.44	1.37	-0.04	0.05	-0.12	0.05	0.18*	-0.10	-0.03	-0.13	0.22*	-0.22*	-				
12. EF Difference Average Response Time Post-Incorrect - Post-Correct (behavior)	19.05	28.53	-60.46	131.24	1.37	0.05	0.16	0.08	0.17	-0.02	-0.17*	0.12	0.03	0.06	-0.32***	0.36***	-			
13. GNG N2 (electrophysiology)[a]	-0.70	2.18	-5.13	5.20	1.65	0.13	0.03	-0.07	0.14	0.08	-0.27**	0.15	0.05	0.13	0.06	0.06	0.09	-		
14. GNG P3 (electrophysiology)[a]	5.00	4.37	-5.70	19.40	1.90	0.19*	0.16	0.12	-0.02	-0.03	0.01	-0.13	-0.21*	-0.40***	-0.03	-0.07	0.03	0.38***	-	
15. EF ERN (electrophysiology)[a]	-7.74	5.19	-20.62	5.00	1.32	-0.09	-0.14	0.02	-0.07	0.11	0.08	0.09	0.11	0.12	0.25**	0.10	-0.08	0.13	-0.07	-
16. EF Pe (electrophysiology)[a]	10.17	6.18	-3.82	30.52	1.35	-0.09	0.05	0.08	-0.23**	0.12	-0.08	-0.04	-0.10	-0.12	-0.24**	0.06	0.11	0.01	0.29***	0.20*

Note: *: p < .05, **: p < .01, ***: p < .001, GNG = Go/No-Go, EF = Eriksen Flanker, a: difference score.

Table 6.2. Descriptive statistics (mean, standard deviation (SD), minimum (Min), maximum (Max), variance inflation factor (VIF), Cronbach's alpha (on the diagonal), and correlations) for the variables of Sample 2 (n = 142).

						Correlations and Cronbach's alpha										
	Mean	**SD**	**Min**	**Max**	**VIF**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1. Reward Responsiveness (self-report)	3.24	0.38	2.25	4.00	1.14	0.78										
2. Sensation Seeking (self-report)	3.20	0.71	1.25	4.75	1.20	0.19*	0.78									
3. ADHD symptoms (self-report)	2.75	0.54	1.67	4.00	1.14	-0.06	0.27**	0.50								
4. Age	20.63	2.04	18.00	30.00		0.09	0.20*	0.25**	-							
5. Gender	0.54	0.50	0.00	1.00		0.13	-0.07	0.09	-0.02	-						
6. BART Average Pumps (behavior)	61.86	10.09	24.87	90.83	1.18	-0.09	0.03	0.14	0.14	-0.22**	-					
7. BART Average Response Time (behavior)	6457.59	29574.15	1853.38	355985.00	1.18	0.11	-0.08	-0.15	-0.11	0.07	-0.31***	-				
8. REWARD N2 (electrophysiology)[a]	0.27	4.94	-13.21	16.32	4.55	0.17*	0.01	-0.05	0.01	0.05	-0.05	-0.02	-			
9. REWARD P2 (electrophysiology)[a]	-0.68	4.47	-13.12	10.06	3.50	0.11	0.05	-0.08	0.05	-0.03	-0.03	0.04	0.83***	-		
10. REWARD P3 (electrophysiology)[a]	-0.90	5.93	-14.51	14.87	2.81	0.09	-0.04	-0.04	0.01	0.05	-0.04	-0.03	0.79***	0.71***	-	
11. BART FRN (electrophysiology)[a]	0.26	2.46	-7.32	5.56	1.04	-0.04	0.13	0.01	0.08	-0.03	0.01	-0.06	0.01	0.00	0.05	-
12. BART P3 (electrophysiology)[a]	4.09	4.58	-8.39	21.15	1.09	-0.15	0.01	0.01	0.03	0.09	-0.17*	-0.06	-0.07	-0.01	-0.08	0.08

Note: *: p < .05, **: p < .01, ***: p < .001, a: difference score.

6.3.2 Correlation Analyses

Tables 6.1 and 6.2 show the descriptive statistics for the variables in Sample 1 and Sample 2, respectively. For Sample 1, 100.00 percent of the correlations within the impulsivity(-related) self-report measures, 57.14 percent of the correlations within behavioral measures, and 50.00 percent of the correlations within the electrophysiological measures was significant. However, only 19.05 percent of correlations between behavioral and self-reported measures, 8.33 percent of correlations between electrophysiological and self-reported measures, and 17.86 percent of correlations between behavioral and electrophysiological measures reached significance.

With respect to the correlations of Sample 2, 66.67 percent of the correlations within impulsivity(-related) self-report measures, 100.00 percent of the correlations within behavioral measures, and 30.00 percent of the correlations within the electrophysiological measures was significant. However, none of the correlations between behavioral and self-reported measures, only 6.67 percent of correlations between electrophysiological and self-reported measures, and 10.00 percent of correlations between behavioral and electrophysiological measures reached significance.

6.3.3 Regression Analyses

Tables 6.3 and 6.4 show the results of the OLS regressions investigating whether the joint behavioral measures, the joint electrophysiological measures, or all behavioral and electrophysiological measures combined contributed to the prediction of impulsivity(-related) constructs in respectively Sample 1 and Sample 2. For these regressions, relevant associations are those including behavioral and electrophysiological measures, i.e. excluding those with age and gender. For Sample 1, the models including only behavior (Models 1) and the models only including electrophysiology (Models 2) together have a total of 33 relevant associations. As we allow a five percent chance at a Type I error, we may expect 1.65 of the associations to be wrongly marked as 'significant'. Hence, the one significant association (between *GNG P3* and *Impulsivity*) accounts for 3.03 percent significant associations and cannot be interpreted. Furthermore, the F-values for Models 3, in which both behavior and electrophysiology are included, are not significant. This means that all variables together do not significantly explain the variance in the self-reported constructs *Impulsivity*, *Sensation Seeking*, and *ADHD symptoms* better than just the intercept does.

For Sample 2, Models 1 and 2 have 21 relevant associations, meaning that we can expect 1.05 significant associations as a result of Type I error. In fact, none of the associations in our data is significant, and hence none of the F-values of Models 3 reached significance. Therefore, neither the models in Sample 1 nor Sample 2

provide evidence for an association between self-reported *Impulsivity*, *Sensation Seeking*, *Reward Responsiveness*, and *ADHD symptoms* on the one hand and behavioral and electrophysiological measures on the other.

Table 6.3. Coefficients of the regression analyses (standard errors in brackets) for Sample 1.

	Impulsivity (self-report)			Sensation Seeking (self-report)			ADHD symptoms (self-report)		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Age	-0.03	-0.10	-0.09	0.06	0.08	0.06	0.02	0.05	0.06
	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
Gender	0.04	0.06	0.05	-0.08	-0.09	-0.09	-0.15	-0.19*	-0.16
	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
GNG Number Incorrect No-Go (behavior)	0.07		0.12	-0.01		0.00	0.02		-0.02
	(0.11)		(0.11)	(0.10)		(0.11)	(0.10)		(0.11)
GNG Number Incorrect Go (behavior)	-0.19		-0.21	-0.01		-0.01	-0.26		-0.28
	(0.14)		(0.14)	(0.14)		(0.14)	(0.14)		(0.14)
GNG Number Post-Incorrect Incorrect (behavior)	-0.02		0.01	-0.15		-0.14	0.08		0.12
	(0.16)		(0.16)	(0.15)		(0.16)	(0.15)		(0.16)
GNG Average Response Time (behavior)	-0.02		0.02	-0.15		-0.12	-0.05		-0.00
	(0.10)		(0.11)	(0.10)		(0.11)	(0.10)		(0.11)
EF Number Incorrect (behavior)	0.12		0.07	0.01		0.04	-0.06		-0.07
	(0.10)		(0.11)	(0.10)		(0.11)	(0.10)		(0.11)
EF Average Response Time Incongruent (behavior)	-0.08		-0.07	0.02		0.04	-0.14		-0.16
	(0.10)		(0.10)	(0.10)		(0.10)	(0.10)		(0.10)
EF Difference Average Response Time Post-Incorrect - Post-Correct (behavior)	0.16		0.15	0.16		0.14	0.14		0.14
	(0.10)		(0.10)	(0.10)		(0.10)	(0.10)		(0.10)
GNG N2 (electrophysiology)[a]		0.07	0.14		-0.01	0.03		-0.13	-0.10
		(0.10)	(0.11)		(0.10)	(0.11)		(0.10)	(0.11)
GNG P3 (electrophysiology)[a]		0.20*	0.14		0.13	0.04		0.15	0.12
		(0.10)	(0.12)		(0.10)	(0.12)		(0.10)	(0.12)
EF ERN (electrophysiology)[a]		-0.07	-0.08		-0.13	-0.11		0.06	0.11
		(0.09)	(0.10)		(0.09)	(0.10)		(0.09)	(0.10)
EF Pe (electrophysiology)[a]		-0.17	-0.14		0.06	0.04		0.06	0.03
		(0.10)	(0.10)		(0.10)	(0.11)		(0.10)	(0.10)
F-value	0.96	1.70	1.34	1.38	1.27	1.08	1.70	1.55	1.40
p-value	0.47	0.13	0.20	0.20	0.28	0.38	0.10	0.17	0.17
R-squared (adj.)	-0.00	0.03	0.03	0.03	0.01	0.01	0.05	0.03	0.04
n	133	133	133	133	133	133	133	133	133

Note: *: p < .05, **: p < .01, ***: p < .001, GNG = Go/No-Go, EF = Eriksen Flanker, a: difference score.

Table 6.4. Coefficients of the regression analyses (standard errors in brackets) for Sample 2.

	Reward Responsiveness (self-report)			Sensation Seeking (self-report)			ADHD symptoms (self-report)		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Age	0.11	0.10	0.11	0.20*	0.18*	0.18*	0.23**	0.26**	0.24**
	(0.09)	(0.08)	(0.08)	(0.08)	(0.08)	(0.09)	(0.08)	(0.08)	(0.08)
Gender	0.11	0.13	0.11	-0.07	-0.05	-0.05	0.12	0.08	0.11
	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)	(0.09)	(0.08)	(0.08)	(0.09)
BART Average Pumps (behavior)	-0.04		-0.06	-0.03		-0.04	0.10		0.10
	(0.09)		(0.09)	(0.09)		(0.09)	(0.09)		(0.09)
BART Average Response Time (behavior)	0.10		0.09	-0.07		-0.08	-0.10		-0.09
	(0.09)		(0.09)	(0.09)		(0.09)	(0.09)		(0.09)
REWARD N2 (electrophysiology)[a]		0.28	0.29		0.01	-0.01		0.05	0.04
		(0.17)	(0.18)		(0.18)	(0.18)		(0.17)	(0.17)
REWARD P2 (electrophysiology)[a]		-0.04	-0.06		0.15	0.17		-0.15	-0.13
		(0.15)	(0.16)		(0.15)	(0.16)		(0.15)	(0.15)
REWARD P3 (electrophysiology)[a]		-0.12	-0.12		-0.16	-0.17		0.02	0.02
		(0.14)	(0.14)		(0.14)	(0.14)		(0.14)	(0.14)
BART FRN (electrophysiology)[a]		-0.03	-0.03		0.13	0.13		-0.01	-0.01
		(0.08)	(0.08)		(0.08)	(0.09)		(0.08)	(0.08)
BART P3 (electrophysiology)[a]		-0.15	-0.16		-0.02	-0.03		-0.00	0.01
		(0.08)	(0.09)		(0.09)	(0.09)		(0.08)	(0.09)
F-value	1.40	1.73	1.60	1.74	1.48	1.22	3.63	1.69	1.69
p-value	0.24	0.11	0.12	0.15	0.18	0.29	0.01	0.12	0.10
R-squared (adj.)	0.01	0.04	0.04	0.02	0.02	0.01	0.07	0.03	0.04
n	142	142	142	142	142	142	142	142	142

Note: *: p < .05, **: p < .01, ***: p < .001, a: difference score.

6.3.4 Bootstrapping

The reported correlations and associations are based on two relatively large samples. However, many studies employ smaller samples, which reduces the chance that discovered effects are genuinely true. Therefore, we used bootstrapping (1000 iterations) to randomly select subsamples sized 20, 30 and 40 from our full sample to create an overview of the percentage of significant correlations and associations (based on a five percent significance level) we would have found if we had used such small samples. The results of this bootstrapping analysis are summarized in Table 6.5. With respect to the correlations, we cannot provide clear evidence that using smaller samples would have led to a higher percentage of significant correlations. However, compared to analyzing the full sample, analyzing smaller subsets (sized 20, 30 and 40) increased the percentage of significant associations as found in the regression analyses for both Sample 1 (from 3.03 to 5.48-6.13) and Sample 2 (from 0.00 to 4.11-4.88). Hence, had our sample been smaller, we would have found more significant associations (using the same five percent significance level).

Table 6.5. The bootstrapped mean percentage of significant correlations/associations (based on 1000 iterations).

		Sample 1			Sample 2		
	Size subsample	**20**	**30**	**40**	**20**	**30**	**40**
Correlations	**Behavior vs. Self-report**	7.94	8.49	9.00	5.30	4.72	4.63
	Electrophysiology vs. Self-report	6.19	6.38	6.70	5.82	5.39	5.07
	Behavior vs. Electrophysiology	8.42	9.98	11.87	5.06	4.68	4.69
Associations	**Behavior/Electrophysiology vs. Self-report (Models 1 and 2)**	5.48	5.86	6.13	4.88	4.42	4.11

6.4. Discussion

The present paper examined the association between self-report measures, behavioral measures, and electrophysiological measures for the construct of impulsivity and related constructs such as sensation seeking, reward responsiveness, and ADHD symptoms. Although some previous studies report significant associations between self-reports, behavior, and electrophysiology, the present data were unable to confirm this. Using two large independent samples, we showed a high number of significant correlations *within* measurement levels, but only few significant correlations *between* different measurement levels. Regression analyses supported our correlational findings and showed no evidence of (joint) associations between behavior or electrophysiology and self-report. The few significant associations found between these measurement levels could not be interpreted as we adopted a five percent significance level. Bootstrap analyses showed that if we would have used smaller sample sizes, like the ones used in previous studies, the number of significant associations in our regression analyses would have been higher.

Our present null results deviate from the majority of previous studies, that in fact did find significant correlations/associations between self-reported impulsivity(-related) constructs and behavior/electrophysiology (e.g. Boksem, Tops, Wester, Meijman, & Lorist, 2006; Geburek et al., 2013; Lejuez et al., 2003; Littel et al., 2012). The discrepancy between our current null-findings and previous research possibly results from the limitations that characterize our study. First, some self-report measures showed low reliability. This lower consistency could have arisen from study design; participants were asked to fill out the questionnaires at home instead of in a lab, which can have provoked careless responding. Therefore, future studies may consider extending the lab session to also incorporate filling out the questionnaires. Second, although our samples are large, they are limited with regard to participant type and geographical distribution. Both samples consisted of students, who were recruited using participant databases of the same university. We therefore recommend replicating the present study in other research labs and with a

broader range of participants. Third, the measures ought to represent impulsivity, but are not entirely similar to impulsivity, which possibly led to less consistent results. For example, we adopted reward responsiveness as an impulsivity-related construct, even though Franken and Muris (2006) showed that the original reward responsiveness dimension (Gray, 1987) consists of two separate dimensions of which especially one (rash impulsiveness) is related to impulsivity. Therefore, future studies examining impulsivity could benefit from using well-defined models to operationalize the construct. An example of such a model is UPPS (Whiteside & Lynam, 2001), which proposes that impulsivity is composed of four dimensions: urgency, sensation seeking, lack of perseverance, and lack of premediation. Finally, we analyzed EEG with the use of difference waves because this method eliminates baseline differences (Miltner et al., 1997). However, the use of difference waves is also associated with interpretation issues and lower between-subject variance (Meyer et al., 2017), which possibly influenced our results.

In addition to the limitations of our study, there are several more general explanations of why we did not find significant correlations/associations between the measurement levels. First, the time frames of behavioral/electrophysiological measures on the one hand and self-report measures on the other hand differ. Typically, behavioral and electrophysiological measures are in the range of (hundreds of) milliseconds, whereas self-report measures are typically measured as a trait, so over several years. In other words, behavioral and electrophysiological measures probe state impulsivity, whereas self-reports probe trait impulsivity. However, for the present data the correlations between the two state impulsivity measures (behavior and electrophysiology) did not outperform the correlations between the trait impulsivity measure (self-report) and either state impulsivity measure, indicating that this argument is (at least in itself) not sufficient to explain the lack of correlation between different measurement levels found in the present study.

A second factor that may have contributed to the present results also focuses on the nature of the measurements. Behavior and electrophysiology are implicit measures because they operate largely outside awareness, whereas self-reports represent the more conscious processes and are therefore explicit measures (Dittmar et al., 2011; Eysenck, 1992). Again, this discrepancy between implicit and explicit measures does not appear to be sufficient to explain the current findings because again our correlations between behavior and electrophysiology (both implicit) did not clearly outperform the correlations between either of these measures and the (explicit) self-reports.

A third possible explanation for our lack of correlations and associations is that cognitive paradigms such as the ones used here may be unable to predict individual differences. Hedge, Powell, and Summer (2017) state that cognitive paradigms have become well-established as a result of the low between-subject variability of their outcomes (e.g. reaction time, performance), but that this low between-subject

variability causes low reliability for individual differences, making it difficult for tasks to consistently predict brain activity or self-report. Hedge et al. (2017) support their premise by showing that the intraclass correlations (ICCs) of seven classic tasks are relatively low. Other studies (focused on the dot-probe task) have supported the premise as well by showing that whereas ERPs in the task are internally reliable, reaction time differences are not (Kappenman, Farrens, Luck, & Proudfit, 2014; Reutter, Hewig, Wieser, & Osinsky, 2017). However, amongst the low ICCs reported by Hedge et al. (2017) were the ones with regard to our tasks (i.e. the Eriksen Flanker task and the Go/No-Go task) relatively favorable, meaning that they ranged from moderate to excellent. Furthermore, the issue raised by Hedge et al. (2017) is limited to explaining the lack of correlations/associations behavior and self-report or electrophysiology, since it cannot explain why self-reports and electrophysiology do not strongly correlate.

A final explanation for our present null-findings concerns a premise that we discussed in the introduction and that was partly supported by our own data: many previous studies employ small sample sizes, leading to low statistical power and a lower chance that findings are true. This explanation does not discard the other explanations we discussed, but can contrary to these other explanations explain both the current null-findings and the positive results reported in previous studies. The fact that most studies employing neurophysiology have a limited number of participants is understandable given that collecting such data requires a high investment of time and money. However, small samples can be considered 'unsafe' as they lead to low power (1-β), the chance that effects are genuinely true (Button et al., 2013; Forstmeier et al., 2017; Ioannidis, 2005). Low-powered studies in turn have an increased chance at a Type II error (false negative: β), and have a lower positive predictive value (PVV), the probability that a positive finding is a true positive. Sample size does not directly impact the chance at a Type I error (false positive: α) since this is a fixed value chosen by the researcher. However, this chance can increase as a result of flexibility in methodological choices (Simmons, Nelson, & Simonsohn, 2011), which is particularly powerful when using small samples.

The problems related to low sample size are augmented by the file drawer problem (Rosenthal, 1979), the observation that negative findings (such as the present ones) are often not distributed (Song et al., 2009) because journals are reluctant to publish null-findings and because scholars are hesitant to submit them in the first place (Ferguson & Heene, 2012). Together, small sample sizes and a bias towards publishing positive findings could explain the discrepancy between our current null-findings and the positive results reported in previous literature. To address these issues, it is important for future research to replicate small *n* studies. Replicating these studies in larger samples will not suddenly eradicate all positive findings. In fact, some studies examining multiple measurement levels for impulsivity did find significant associations using large samples. For example, Ait Oumeziane and Foti (2016) showed that lack of premediation (a facet of

impulsivity) is associated with decreased P3 amplitudes in individuals with low depression scores, but increased amplitudes in individuals who score high on depression. Furthermore, Hill, Samuel, and Foti (2016) reported that negative urgency, another facet of impulsivity, is associated with an increased Eriksen Flanker ERN in people who report low conscientiousness, whereas no association was observed for high conscientious people. The sample size of these studies was respectively $n = 260$ and $n = 208$. Carrying out such large-scale studies is imperative to provide results that are safe to interpret and that are hence truly informative regarding the relationship between different measurement levels.

7. Summary in English

The question ‘What makes an entrepreneur?’ has been fundamental for economics and psychology researchers over the last decade. A profound understanding of ‘the entrepreneur’ enables the establishment of better policies to stimulate entrepreneurship in modern economies. This is crucial as entrepreneurship is essential for economic growth (Erken et al., 2016; Koellinger & Thurik, 2012; Van Praag & Versloot, 2007). The present thesis deals with the definition of ‘the entrepreneur’ by investigating the roles of psychological (Part I: Chapters 2, 3, and 4) and biological (Part II: Chapters 5 and 6) traits in entrepreneurship. This interdisciplinary setting is a result of limitations of the traditional ‘homo economicus’ perspective, in which rational individuals are utility maximizing decision makers.

The results of Chapter 2 show that, based on a student sample and a sample of Small and Medium Enterprise (SME) owners, overconfidence is positively associated with entrepreneurial intention, but not with entrepreneurial orientation, while optimism is positively associated with both. The findings of Chapter 3, which are based on Dutch students, Dutch sole proprietors, and French SME owners, demonstrate a positive association between positive affect and entrepreneurial orientation and a negative association, although less strong, between negative affect and entrepreneurial orientation. Further, the chapter hints to a positive association between positive affect and entrepreneurial success and a negative association between negative affect and entrepreneurial success. Chapter 4 takes on this hint and provides evidence for the indirect positive association between positive affect and entrepreneurial success through the key aspects of the entrepreneurial process of which examples are opportunity recognition, development of broad social networks, and tolerance for intense levels of stress (Baron, 2008).

Chapters 5 and 6 show lack of evidence for the association between behavior and electrophysiology on the one hand and self-reported measures in entrepreneurship as well as impulsivity on the other. Specifically, Chapter 5 shows

that behavior and electrophysiology from tasks such as the Eriksen Flanker task, the Go/No-Go task, the Reward task, and the Balloon Analogue Risk Task cannot be substitutes for nor complements to self-reported measures of impulsivity in explaining entrepreneurship. Chapter 6 addresses whether self-reported, behavioral, and electrophysiological measures of impulsivity reflect one construct, but cannot not provide evidence for significant correlations across the different measurement levels.

The present thesis contributes to the field of entrepreneurship by focusing on the psychology of the entrepreneur, with concepts such as overconfidence, optimism, positive affect, and negative affect, and on the biology of the entrepreneur with concepts such as behavior and electrophysiology. It also contributes to the field of psychology by showing the positive role that cognitive biases, such as overconfidence, could play for entrepreneurs. Hence, this field will gain insights in why some psychological concepts can be problematic in one person (patient) but beneficial in another (entrepreneur). Finally, the present thesis contributes to the field of biology, especially electrophysiology, with null findings despite of analyzing large samples and while small samples report significant findings. This field can therefore benefit from the present thesis by investigating why larger samples fail to find presumed associations.

From a practical perspective, the present thesis contributes to our knowledge about the profile of 'the entrepreneur'. This knowledge can help correctly matching personality profiles to occupations, which is important according to Person-Environment Fit theory. A mismatch between the two could be detrimental to one's mental and physical well-being. By knowing more about the entrepreneurial personality profile, matching principles can be improved. Further, knowing whether an individual is better suited for entrepreneurship than for being an employee, especially at an early age, can improve education. For instance, the Dutch education system is better fitted for well-organized, disciplined children than for hyperactive, creative ones. The entrepreneurial profile usually does not match this present educational system, but knowing in the early age that a child is suited for entrepreneurship could result in fitting education.

Of course, psychology and biology could play a role in many occupations. Therefore, with the present thesis, we do not want to underline entrepreneurship, but rather use it as a proof of concept. Future research should not just further develop the understanding of the role of psychology and biology in entrepreneurship, but also investigate other manifestations of economic behavior and outcomes.

8. Summary in Dutch

De vraag ‘wat is een ondernemer?’ is belangrijk voor onderzoekers in de economie en psychologie. Met grondige kennis van ‘de ondernemer’ kan een beter beleid worden toegepast om ondernemerschap in moderne economieën te stimuleren. Dit is belangrijk omdat ondernemerschap essentieel is voor economische groei (Erken et al., 2016; Koellinger & Thurik, 2012; Van Praag & Versloot, 2007). Dit proefschrift onderzoekt de definitie van ‘de ondernemer’ door zowel psychologie (Deel I: hoofdstukken 2, 3 en 4) als biologie (Deel II: hoofdstukken 5 en 6) te relateren aan ondernemerschap. Deze interdisciplinaire opzet is het resultaat van de beperkingen die de oorspronkelijke focus op ‘homo economicus’, waarin rationele individuen nut maximaliseren, met zich meebrengt.

De resultaten van Hoofdstuk 2 tonen aan dat ‘overconfidence’ positief geassocieerd is met de intentie om ondernemer te worden, maar niet met de uiteindelijke strategie die de ondernemer hanteert. Optimisme wordt daarentegen positief geassocieerd met zowel intentie als strategie. Deze resultaten zijn gebaseerd op een steekproef onder studenten en een steekproef onder eigenaren van midden- en kleinbedrijven (MKB’ers). Hoofdstuk 3 gebruikt drie steekproeven: Nederlandse studenten, Nederlandse zelfstandigen zonder personeel (ZZP’ers) en Franse MKB’ers. De resultaten, op basis van deze steekproeven, duiden op een positieve associatie tussen positief affect en strategie en een (minder sterke) negatieve associatie tussen negatief affect en strategie. Verder attenderen de resultaten op een positieve associatie tussen positief affect en het succes als ondernemer en een negatieve associatie tussen negatief affect en het succes als ondernemer. Hoofdstuk 4 gaat hierop door en geeft bewijs voor een positieve, maar indirecte, associatie tussen positief affect en het succes als ondernemer via de zogenoemde kernaspecten van het ondernemerschapsproces. Voorbeelden van deze kernaspecten zijn het herkennen van kansen, het ontwikkelen van brede, sociale netwerken en het kunnen omgaan met intense stresslevels (Baron, 2008).

Hoofdstukken 5 en 6 kunnen geen bewijs geven voor de associatie tussen gedrag en elektrofysiologie aan de ene kant en zelfrapportage maten uit ondernemerschap en impulsiviteit aan de andere kant. Zo laat Hoofdstuk 5 zien dat gedrag en elektrofysiologie, gemeten met de Eriksen Flanker taak, de Go/No-Go taak, de Reward taak, en de Balloon Analogue Risk Task, geen substituerende of complementerende rol innemen voor zelfrapportage maten van impulsiviteit in het verklaren van zelfrapportage maten van ondernemerschap. In Hoofdstuk 6 wordt geanalyseerd of zelfrapportage, gedrags- en elektrofysiologische maten van impulsiviteit één dimensie omvatten. Er is echter geen bewijs gevonden voor significante correlaties tussen deze drie meetniveaus.

Dit proefschrift draagt bij aan onze kennis van ondernemerschap door zich enerzijds te richten op de psychologie van de ondernemer met begrippen als 'overconfidence', optimisme, positief affect en negatief affect en anderzijds op biologie van de ondernemer aan de hand van gedrag en elektrofysiologie. Het draagt ook bij aan psychologie door aan te tonen dat cognitieve bias (zoals 'overconfidence') een positieve rol kan spelen voor ondernemers. Daarmee krijgt de psychologie inzicht in waarom sommige psychologische concepten problematisch kunnen zijn voor de ene persoon (patiënt), maar gunstig voor de ander (ondernemer). Als laatste draagt dit proefschrift bij aan onze kennis van elektrofysiologie door het gebrek aan bewijs voor de associatie tussen elektrofysiologie en ondernemerschap/impulsiviteit ondanks het gebruik van grote steekproeven en terwijl kleine steekproeven wel significante associaties vinden. Elektrofysiologisch onderzoek kan zich ontwikkelen door te onderzoeken waarom grote steekproeven de vooraf veronderstelde associaties niet kunnen aantonen terwijl kleine steekproeven dit wel kunnen.

Vanuit praktisch oogpunt draagt dit proefschrift bij aan kennis over het profiel van 'de ondernemer'. Deze kennis kan helpen om een persoonlijkheidsprofiel succesvol aan een beroep te koppelen. Dit is belangrijk volgens de 'Person-Environment Fit' theorie. Een verkeerde match kan schadelijk zijn voor iemands mentale en fysieke gezondheid. Door meer kennis te hebben over de persoonlijkheid van een ondernemer kunnen matchingsprincipes verbeteren. Verder kan deze kennis bijdragen aan gerichter onderwijs. Als al vroegtijdig bekend is dat iemand geschikter is als ondernemer dan als werknemer, kan specifiek onderwijs worden verzorgd. Het Nederlandse onderwijssysteem is bijvoorbeeld meer gericht op goed georganiseerde, gedisciplineerde kinderen dan op hyperactieve, creatieve kinderen.

Biologie en psychologie kunnen ook het profiel van andere beroepen verklaren. Daarom is het doel van dit proefschrift niet om het onderzoek naar ondernemerschap te onderstrepen, maar om ondernemerschap te gebruiken als een bewijs voor het idee dat biologie en psychologie een rol kunnen spelen in het verklaren van beroepskeuze. Toekomstig onderzoek moet zich dus niet alleen richten op het verder ontwikkelen van onderzoek naar de rol van psychologie en biologie in ondernemerschap, maar ook andere uitingen van economisch gedrag onderzoeken.

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10. About the author

Indy Bernoster was born on the 16th of April 1992 in Vlaardingen, The Netherlands. In 2014, she obtained the degree of Master of Science (MSc) in Econometrics and Management Science cum laude at the Erasmus School of Economics, Erasmus University Rotterdam. Subsequently, in October 2014, she started as a PhD candidate at the Department of Applied Economics, Erasmus School of Economics, Erasmus University of Rotterdam as a member of the Erasmus University Rotterdam Institute for Biology and Economic Behavior (EURIBEB), under the supervision of professors A. Roy Thurik, Ingmar H. A. Franken, and Patrick J. F. Groenen.

Indy's research focuses on the intersection of psychology and entrepreneurship as well as that of electrophysiology and entrepreneurship. She presented her work at several international conferences, such as Entrepreneurship, Culture, Finance and Economic Development (ECFED), Health of Small Business Owners and Entrepreneurs, Entrepreneurship and Mental Health Workshop, Entrepreneurship Future (EF) Conference, and Interdisciplinary European Conference on Entrepreneurship Research (IECER). Her work is published in Small Business Economics and Sustainability. Currently, Indy is on the job market outside academia.

11. Portfolio

Publications

Publications in journals and conference proceedings:

Canits, I., Bernoster, I., Mukerjee, J., Bonnet, J., Rizzo, U., & Rosique-Blasco, M. (2018). Attention-deficit/hyperactivity disorder (ADHD) symptoms and academic entrepreneurial preference: is there an association? *Small Business Economics*, 1-12.

Bernoster, I., Rietveld, N., Thurik, A. R., & Torrès, O. (2018). Overconfidence, Optimism, and Entrepreneurship. *Sustainability*, *10*(7), 1-14.

Manuscript under review:

Bernoster, I., Mukerjee, J., & Thurik, A. R. (2018). The Role of Affect in Entrepreneurial Orientation.

Bernoster, I., Khedhaouria, A., & Thurik, A. R. (2018). Positive Affect, the Entrepreneurial Process, and Entrepreneurial Success of Sole Proprietors.

Manuscript submitted:

Bernoster, I., De Groot, K., Wieser, M. J., Thurik, A. R., & Franken, I. H. A. Electrophysiological, Behavioral, and Self-reported Measures of Impulsivity: Different Sides of the Same Coin?

Manuscript in progress:

Bernoster, I., De Groot, K., Franken. I. H. A., & Thurik, A. R. The Role of Behavioral and Electrophysiological Measures in Entrepreneurship.

Leung, Y. K., Bernoster, I., Franken, I. H. A., & Thurik, A. R. Psychiatric symptoms and entrepreneurial intention: the role of behavioral activation system.

Bernoster, I., Franken, I. H. A., & Groenen, P. J. F. Accurate Computation of Reliability in Event-Related Potentials Associated with the Erisken Flanker Experiment.

Teaching

2015 – 2018	Supervision of 4 bachelor and 5 master theses.
2015 – 2018	Assisting in Dutch Mathematical Olympiad.
2016 – 2018	Teaching assistant in Seminar Entrepreneurial Entry and Exit.

Ph.D. Courses

2015	Experimental Methods in Business Research (BERMAMC005, ERIM).
2015	GESIS Spring Seminar (Leibniz-Institute for Social Sciences, Cologne, Germany).
2015	Psychiatric Epidemiology (NIHES, Rotterdam).
2015	Psychopharmacology (NIHES, Rotterdam).
2015	Research Methodology and Management (BERMMC002, ERIM).
2015	The Human Body (Department of Psychology, Rotterdam).
2015	Addiction (Department of Psychology, Rotterdam).
2015	Personality Disorders (Department of Psychology, Rotterdam).
2015	Economics of Entrepreneurship (Department of Applied Economics, Rotterdam).
2016	Topics in Philosophy of Science (BERMMC001, ERIM).

Conferences (presented in)

2016	Entrepreneurship, Culture, Finance and Economic Development (ECFED) Workshop (Doctoral Dissertation Track), Lyon, France.
2016	Entrepreneurship, Culture, Finance and Economic Development (ECFED) Workshop (Session: Building new hypotheses and research challenges), Lyon, France.
2016	Health of Small Business Owners and Entrepreneurs Workshop, Montpellier, France.
2016	Entrepreneurship and Mental Health Workshop, Syracuse, NY, USA.
2017	Entrepreneurship Future (EF) Conference, Paris, France.
2017	Interdisciplinary European Conference on Entrepreneurship Research (IECER), Siegen, Germany.

Language skills and certificates

Cambridge English Advanced (CAE): CEFR Level: C1.
TOEFl
GMAT

12. The ERIM PhD Series

The ERIM PhD Series contains PhD dissertations in the field of Research in Management defended at Erasmus University Rotterdam and supervised by senior researchers affiliated to the Erasmus Research Institute of Management (ERIM). All dissertations in the ERIM PhD Series are available in full text through the ERIM Electronic Series Portal: http://repub.eur.nl/pub. ERIM is the joint research institute of the Rotterdam School of Management (RSM) and the Erasmus School of Economics (ESE) at the Erasmus University Rotterdam (EUR).

Dissertations in the last four years

Abbink, E.J., *Crew Management in Passenger Rail Transport*, Promotors: Prof. L.G. Kroon & Prof. A.P.M. Wagelmans, EPS-2014-325-LIS, http://repub.eur.nl/pub/76927

Acar, O.A., *Crowdsourcing for Innovation: Unpacking Motivational, Knowledge and Relational Mechanisms of Innovative Behavior in Crowdsourcing Platforms*, Promotor: Prof. J.C.M. van den Ende, EPS-2014-321-LIS, http://repub.eur.nl/pub/76076

Akemu, O., *Corporate Responses to Social Issues: Essays in Social Entrepreneurship and Corporate Social Responsibility*, Promotors: Prof. G.M. Whiteman & Dr S.P. Kennedy, EPS-2017-392-ORG, https://repub.eur.nl/pub/95768

Akin Ates, M., *Purchasing and Supply Management at the Purchase Category Level: Strategy, structure and performance*, Promotors: Prof. J.Y.F. Wynstra & Dr E.M. van Raaij, EPS-2014-300-LIS, http://repub.eur.nl/pub/50283

Alexander, L., *People, Politics, and Innovation: A Process Perspective*, Promotors: Prof. H.G. Barkema & Prof. D.L. van Knippenberg, EPS-2014-331-S&E, http://repub.eur.nl/pub/77209

Alexiou, A. *Management of Emerging Technologies and the Learning Organization: Lessons from the Cloud and Serious Games Technology*, Promotors: Prof. S.J. Magala, Prof. M.C. Schippers and Dr I. Oshri, EPS-2016-404-ORG, http://repub.eur.nl/pub/93818

Almeida e Santos Nogueira, R.J. de, *Conditional Density Models Integrating Fuzzy and Probabilistic Representations of Uncertainty*, Promotors: Prof. U. Kaymak & Prof. J.M.C. Sousa, EPS-2014-310-LIS, http://repub.eur.nl/pub/51560

Alserda, G.A.G., *Choices in Pension Management*, Promotors: Prof. S.G. van der Lecq & Dr O.W. Steenbeek, EPS-2017-432-F&A, https://repub.eur.nl/pub/103496

Avci, E., *Surveillance of Complex Auction Markets: a Market Policy Analytics Approach*, Promotors: Prof. W. Ketter, Prof. H.W.G.M. van Heck & Prof. D.W. Bunn, EPS-2018-426-LIS, https://repub.eur.nl/pub/106286

Benschop, N, *Biases in Project Escalation: Names, frames & construal levels*, Promotors: Prof. K.I.M. Rhode, Prof. H.R. Commandeur, Prof. M. Keil & Dr A.L.P. Nuijten, EPS-2015-375-S&E, http://repub.eur.nl/pub/79408

Berg, W.E. van den, *Understanding Salesforce Behavior using Genetic Association Studies*, Promotor: Prof. W.J.M.I. Verbeke, EPS-2014-311-MKT, http://repub.eur.nl/pub/51440

Beusichem, H.C. van, *Firms and Financial Markets: Empirical Studies on the Informational Value of Dividends, Governance and Financial Reporting*, Promotors: Prof. A. de Jong & Dr G. Westerhuis, EPS-2016-378-F&A, http://repub.eur.nl/pub/93079

Bliek, R. de, *Empirical Studies on the Economic Impact of Trust*, Promotors: Prof. J. Veenman & Prof. Ph.H.B.F. Franses, EPS-2015-324-ORG, http://repub.eur.nl/pub/78159

Boons, M., *Working Together Alone in the Online Crowd: The Effects of Social Motivations and Individual Knowledge Backgrounds on the Participation and Performance of Members of Online Crowdsourcing Platforms*, Promotors: Prof. H.G. Barkema & Dr D.A. Stam, EPS-2014-306-S&E, http://repub.eur.nl/pub/50711

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Brazys, J., *Aggregated Marcoeconomic News and Price Discovery*, Promotor: Prof. W.F.C. Verschoor, EPS-2015-351-F&A, http://repub.eur.nl/pub/78243

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Cranenburgh, K.C. van, *Money or Ethics: Multinational corporations and religious organisations operating in an era of corporate responsibility*, Prof. L.C.P.M. Meijs, Prof. R.J.M. van Tulder & Dr D. Arenas, EPS-2016-385-ORG, http://repub.eur.nl/pub/93104

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Elemes, A., *Studies on Determinants and Consequences of Financial Reporting Quality*, Promotor: Prof. E. Peek, EPS-2015-354-F&A, https://repub.eur.nl/pub/79037

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'What makes an entrepreneur?' is a fundamental question for economic, management, and psychology researchers. The present thesis addresses the definition of 'the entrepreneur' by investigating the roles of psychological (Part I: Chapters 2, 3, and 4) and biological (Part II: Chapters 5 and 6) traits in entrepreneurship. This interdisciplinary setting is a result of the limitations of the traditional 'homo economicus' perspective, where rational individuals are utility maximizing decision makers.

The present thesis contributes to the field of entrepreneurship by focusing on the psychology of the entrepreneur, using concepts like overconfidence, optimism, positive affect, and negative affect, as well as the biology of the entrepreneur, using concepts like behavior and electrophysiology. It also contributes to the field of psychology by examining why some psychological concepts are problematic in one person (patient) but beneficial in another (entrepreneur) as well as to the field of biology, especially electrophysiology, with null findings despite of analyzing large samples and while small samples report significant findings.

Of course, psychology and biology could play a role in many occupations. Thus, with the present thesis, entrepreneurship is not underlined, rather it is used as a proof of concept. Future research should not just further develop the understanding of the role of psychology and biology in entrepreneurship, but also investigate other manifestations of economic behavior and outcomes.

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