WIM RIETDIJK

The Use of Cognitive Factors for Explaining Entrepreneurship

Some Empirical Results

The Use of Cognitive Factors for Explaining Entrepreneurship: Some empirical results

The Use of Cognitive Factors for Explaining Entrepreneurship: Some empirical results

Het gebruik van cognitieve factoren om ondernemerschap te verklaren: enige empirische resultaten

THESIS

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Preface (Voorwoord)

Mijn thesis kan eindelijk naar de drukker. Mijn weg naar de doctor's graad was lang en moeizaam – en vooral de spreekwoordelijke laatste loodjes waren zeker het zwaarst. Desondanks, kijk ik met positieve gevoelens terug op mijn promotie periode, waarin zowel professioneel als privé veel gebeurd is. Het is nu ook goed om terug te kijken en reflecteren op deze periode. Gelukkig hoef ik alleen het voorwoord nog waar ik zeker heel veel mensen ga vergeten te noemen. Vandaar dat ik graag iedereen vooraf wil bedanken voor zijn/haar bijdrage aan mijn proefschrift. In het bijzonder wil ik toch een paar mensen noemen.

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Ten slotte wil ik graag mijn ouders bedanken. Jullie zijn onmisbaar. Op 5 September 2011 begonnen mijn chemo's. Mijn ziekte heeft ons een jaar bezig gehouden. Om de 2 weken "ziekenhuis-in-ziekenhuis-uit", de spanning van scans en uitslagen en nooit wetende wanneer er een einde zou zijn aan de behandelingen. Het is misschien gek maar ik kijk met een mooie herinnering terug op deze periode. Vooral omdat ik besef, elke dag weer, dat ik word omringd door ouders die me door dik en dun steunen, vol met liefde, vriendschap, en geborgenheid.

Wim Rietdijk

Rotterdam, Januari 2016

CHAPTER 1

Introduction and conclusion

1.1 Motivation and contribution

'What makes an entrepreneur?' (Blanchflower & Oswald, 1990) This has been a fundamental question for many entrepreneurship researchers over the last decades (Carland, Hoy, & Carland, 1988; Frese & Gielnik, 2014; Henderson & Robertson, 2000; Kamineni, 2002; Rauch & Frese, 2007; Stanworth et al., 1989; Wales, Patel, & Lumpkin, 2013). Studying the determinants of entrepreneurship-related behavior[1] is essential to enhance our understanding what the causes and consequences are of entrepreneurship. An enhanced understanding may enable the establishment of better policies to stimulate entrepreneurship in modern economies, as entrepreneurship is known to be important for economic growth in modern societies (Audretsch & Thurik, 2001; Thurik, Stam, & Audretsch, 2013). It is also a source of job creation (Roessler & Koellinger, 2012) and is a relevant economic instrument that is used in the economic cycle (Koellinger & Thurik, 2011).

Previous research suggest, in order to attempt to answer the fundamental question 'what makes an entrepreneur', that entrepreneurship and entrepreneurship-related behavior are likely to be partly heritable (Lindquist, Sol, & Praag, 2015; Nicolaou & Shane, 2008; van der Loos et al., 2010), and partly due to the cultural background and socialization of the individual (Tooby & Cosmides, 1992). For this reason, previous studies have looked at biological factors, such as genetics (van der Loos et al., 2013) and hormonal factors (van der Loos et al., 2013) as well as personal characteristics (Frese & Gielnik, 2014), such as self-employed parents (Lindquist, Sol, & Praag, 2015) and gender (Verheul, Stel, & Thurik, 2006).

Van der Loos (2013) state that it is likely that more than hundreds of genes are involved in the entrepreneurship-related behaviors with all having small effects and that the link between testosterone level of an individual and entrepreneurship could not be established. Further, individuals are more likely to pursue an entrepreneurship career when they are males (Verheul, Stel, & Thurik, 2006) and when they have self-employed parents (Lindquist et al., 2015). Although these studies yield important insights, they

[1] Entrepreneurship-related behavior is an umbrella term that is used to describe behaviors related to entrepreneurship such as entrepreneurial intentions (i.e., intentions to start a company), choice (i.e., the decision to start a company), orientation (i.e., the degree to which an entrepreneurs takes risk, has a proactive attitude and is innovative) and performance (i.e., financial performance of the entrepreneurial company).

typically provide, at best, incomplete and uncertain answers to the question 'what makes an entrepreneur' (Gartner, 1988; Shane & Venkataraman, 2000; van der Loos, 2013). As a consequence, recent studies state that future research about possible determinants of entrepreneurship-related behavior should move beyond current discussions and include new (cognitive) factors (Frese & Gielnik, 2014). Perhaps, recent insights discovered in the field of psychology may be a possible venue for research to explain entrepreneurship-related behaviors (Frese & Gielnik, 2014; Wales et al., 2013). Recent insights that are identified and that may be important for explaining entrepreneurship-related behavior are: neurocognitive measures, such as, the use of neurophysiological measures during cognitive-task performance (de Holan, 2013; Nicolaou & Shane, 2013), self-reported psychiatric symptoms (Verheul et al., 2015) and individual differences, such as, self-reported measures that reflect personal characteristics of an individual (Frese & Gielnik, 2014; Wales et al., 2013).

Therefore, this thesis takes entrepreneurship-related behavior as a starting point to investigate the associations with neurocognitive measures, self-reported psychiatric symptoms and individual differences. Figure 1.1 presents the conceptual model. The conceptual model is based upon a grant proposal written by our research group in 2015: the Research Excellence Initiative (REI 2014) at Erasmus University Rotterdam. In the next two sections, I elaborate in detail which two new potential cognitive factors I will study, viz., neurocognitive measures on the one hand and self-reported psychiatric symptoms and individual differences on the other hand.

Figure 1.1 Conceptual Model

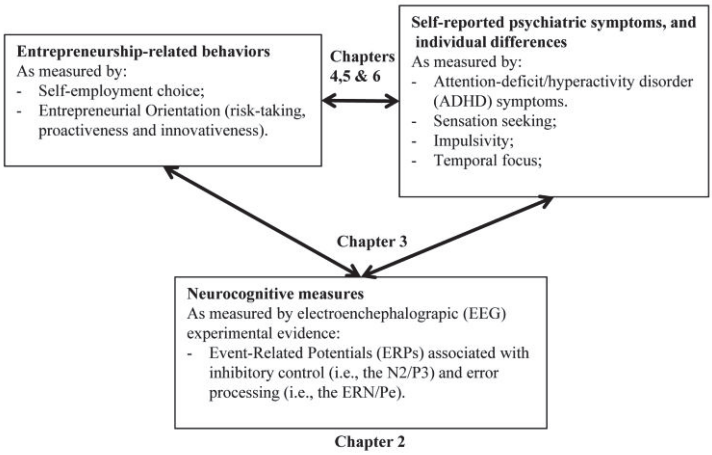


Figure 1.1 presents the conceptual model of the present thesis. It depicts the possible associations between the entrepreneurship-related behavior, neurocognitive measures, self-reported psychiatric symptoms and individual differences. The conceptual model is based upon a grant proposal written by our research group in 2014: the Research Excellence Initiative (REI 2014) at Erasmus University Rotterdam. The chapters of the thesis fit in the conceptual model and are shown at the respective association it examines.

1.1.1 Neurocognitive measure and entrepreneurship

The first cognitive factor in the conceptual model that may be of interest for explaining entrepreneurship-related behavior are neurocognitive measures. This factor fits in the field of psychological economics, a field in which economic decisions are explained by using individual cognitions through modeling bodily influences such as neurocognitive measures rather than taking the perspective of a rational, self-centered, utility-maximizing actor. In the last decades, the limitations of the traditional '*homo economicus'* perspective have become clear (Kahneman, 2011) and have led to the development of the field of psychological economics with ample room for examining the association between cognitive and affective factors and economic motivation, attitudes and behavior (Camerer, Loewenstein, & Prelec, 2005; Martins, 2011). At the same time, advances in technology (such as in electroencephalographic methods, i.e., EEG) and neuroscientific theory led to a better understanding of the functioning of the human brain and how it relates to human behavior (Becker, Cropanzano, & Sanfey, 2011; Lee, Senior, & Butler, 2012) and the establishment of neurocognitive measures. Economists have be-

gun to acknowledge these advances as they start to incorporate these methods, theories and measures into their own field (Becker et al., 2011).

Incorporating neurocognitive measures into the field of economics may contribute to our understanding of possible explanations of entrepreneurship-related behaviors in two ways. *First*, much of human behavior is usually determined by unconscious processes (Bagozzi et al., 2013; Camerer et al., 2005) which may be captured more objectively by neurocognitive measures using experimental tasks (Becker et al., 2011; Lee et al., 2012; Rietdijk, Franken, & Thurik, 2014) rather than self-reported questionnaire data (Donaldson & Grant-Vallone, 2002; Podsakoff & Organ, 1986). *Second*, studying neurocognitive measures in association to entrepreneurship-related behavior adds a new level of measurement that can advance and connect theories in both psychology, economics and management (Bagozzi et al., 2013; Becker et al., 2011; Cacioppo & Petty, 1982; Lee, Senior, & Butler, 2012).

Neurocognitive measures could mainly be obtained by functional magnetic resonance imaging (fMRI) and electroencephalography (EEG). The neuroscience technique used in the present thesis is EEG. This is a non-invasive technique that measures physiological activity that reflects the extent to which neurons have synchronized activity (Luck, 2005; Olejniczak, 2006; Teplan, 2002). Excitation of these neurons (for example, due to experimental stimuli the participants respond to) leads to a voltage difference close to the neural dendrites (connections between the neurons) that is significantly different compared to other locations along the neuron (Jackson & Bolger, 2014). Electrodes located on an elastic cap at fixed sites along the scalp are able to measure the strength of these voltage differences (Keil et al., 2014; Key, Dove, & Maguire, 2005; Olejniczak, 2006; Teplan, 2002). The strength of these voltage differences can be isolated and quantified in an experiment and attributed to behavior that is reflected in the experiment (Keil et al., 2014; Key et al., 2005). The voltages difference that are the result of a certain stimulus or reponse (an event) are usually referred to as Event-Related Potentials (ERPs) (Keil et al., 2014; Key et al., 2005).

The procedure of a typical EEG experiment is as follows. Individuals are seated on a comfortable chair in a room in which sounds and lights have been attenuated. They are placed in front of a computer screen on which an experiment is presented. Usually, experiments consist of several blocks with series of individual trials. These individual

trials can capture different experimental conditions that reflect certain cognitive or affective processes, such as behavioral inhibition, error processing or emotion recognition. The different experimental trials are usually presented in randomized order while electrodes continuously measure the 'activity' (or: ERPs) in the brain (Luck, 2005).

The strength of the ERPs under certain experimental conditions vary across individuals, and may therefore be used when associating them to relevant outcome variables (Luck, 2005). In order to quantify the ERPs, the physiological responses are averaged for similar experimental condition trials across blocks (Luck, 2005). For example, if one has 10 error trials in an experiment that measures error processing (i.e., how sensitive an individual is when responding to committing an error) which consist of 400 trials, one would average the physiological responses of these 10 errors to measure the error-response, and also average the 390 correct trials to measure a correct-response. The difference in averages between error and correct responses can be attributed to the level of error awareness of an individual.

In this thesis, I examine four ERPs using EEG reflecting two important cognitive processes that are central to the human cognitive system, viz., inhibitory control and error processing (Olvet & Hajcak, 2009a, 2009b; Riesel et al., 2013; Rietdijk et al., 2014). Both inhibitory control and error processing fall usually under the term, viz., *cognitive control processes*. Cognitive control processes are processes that are important for monitoring and appropriately adjusting behavior in individuals. From previous studies we know that these two cognitive processes are important processes in psychopathology such as excessive gaming (Littel et al., 2012), smoking (Luijten, Littel, & Franken, 2011) and substance abuse (Groman, James, & Jentsch, 2009; Luijten et al., 2014; Marhe, Van De Wetering, & Franken, 2013), but also in other human behaviors such as impulsivity (Lansbergen, Böcker, Bekker, & Kenemans, 2007; Martin & Potts, 2009; Potts, George, Martin, & Barratt, 2006), sensation seeking (Zheng et al., 2010) and academic performance (Hirsh & Inzlicht, 2010).

To fully understand the meaning of these ERPs associated with cognitive control, it is important to examine both their internal consistency and functional significance, for example by associating the ERPs to self-reported measures. In recent studies, there is an increased attention to studying the internal consistency of the ERPs associated with inhibitory control (the N2 and P3) (Cohen & Polich, 1997) and error processing (the

ERN and Pe) (Meyer, Riesel, & Proudfit, 2013; Olvet & Hajcak, 2009b). In the previous example, it would be important to know how many errors are needed to have an internally consistent measure for an error-response, meaning that if all errors induce exactly the same physiological responses, only one error would be sufficient to measure error processing. In Chapter 2, the internal consistency of the ERPs associated with inhibitory control is examined, the N2 and P3, in a Go/No-Go task, and at the same time attempts to replicate the internal consistency of the ERPs associated with error processing, the ERN and Pe (Olvet & Hajcak, 2009b).

Another essential topic in psychology is the functional significance of these ERPs. It is important to understand what these ERPs represent and how they relate to other aspects of human behavior (Heil et al., 2000; Heil, 2002; Overbeek, Nieuwenhuis, & Ridderinkhof, 2005; Ridderinkhof, Ramautar, & Wijnen, 2009; Rugg & Coles, 1996). Studies usually examine the functional significance by associating these ERPs to self-reported psychiatric symptoms and individual differences, or even aspects that are important for entrepreneurship-related behavior, such as impulsivity, risk-taking and proactiveness. The aim of Chapter 3 is to enhance the understanding of the functional significance of these ERPs, and examine the correlations between these ERPs, and the association between these ERPs and an entrepreneurship-related behavior, i.e., proactiveness, as well as self-reported psychiatric symptoms and individual differences, i.e., attention-deficit/hyperactivity disorder (ADHD) symptoms, sensation seeking, and impulsivity.

1.1.2 Self-reported psychiatric symptoms and individual differences and entrepreneurship

The second cognitive factor in the conceptual model is self-reported psychiatric symptoms and individual differences. This factor consists of two separate dimensions, viz., self-reported psychiatric symptoms and self-reported individual differences. To start with the self-reported psychiatric symptoms and in particular attention-deficit/hyperactivity disorder (ADHD) symptoms, which is a psychiatric disorder that consists of three primary symptoms: poor sustained attention, impulsivity and hyperactive behavior (American Psychiatric Association, 2013; Barkley, 1997). Anecdotal evidence and some initial evidence suggest that ADHD symptoms are important in the cognition of the entrepreneur to (have an intention to) start and manage their firm

(Archer, 2014a, 2014b; Verheul et al., 2015). In particular, Verheul et al., (2015) associate ADHD symptoms to entrepreneurial intentions. The question that remains is whether ADHD symptoms are also associated with other levels of entrepreneurship-related behavior, e.g., self-employment choice and entrepreneurial orientation.

Therefore, in Chapter 4 we moved beyond the initial study of Verheul et al., (2015) and investigate the association between ADHD symptoms and the choice to become self-employed in two large samples of individuals. The results indicate that the positive association between ADHD symptoms and self-employment choice is primarily driven by hyperactivity symptoms. This suggests that, in line with other studies in psychiatry, that it is important to distinguish between the two dimensions that constitute ADHD symptoms, viz., attention-deficit and hyperactivity symptoms (Rietdijk et al., 2015b). For this reason, in Chapter 5 we associated ADHD symptoms with entrepreneurial orientation and also distinguish between the two dimensions of ADHD in two samples. The first sample consists of Dutch solo self-employed individuals, whereas the second sample consists of French small business owners. We re-analyzed the data from the latter sample to enable comparison of the results from both datasets.

Chapter 4 and 5 contribute in two ways to the economics and psychiatry literature. *First*, from an economics perspective, Kessler et al. (2009) find that individuals in wage-paid working-environments with high versus low levels of ADHD symptoms usually face huge problems, such as more sickness, lower work performance, and higher chance of accidents. Consequently these work-related problems lead a high loss of human capital on an annual basis (Halleland et al., 2015; Kessler et al., 2005). Usually these wage-paid working-environments are typified by formal procedures, high routines and where there is less room for innovation (Kessler et al., 2009). According to the '*job-person fit*' theory (Kristof-Brown, Zimmerman, & Johnson, 2005), individuals with high levels of ADHD symptoms may not necessarily fit in a wage-paid working-environment compared to individuals with low levels of ADHD symptoms. Therefore, in line with Verheul et al. (2015) it may well be that individuals with high levels of ADHD symptoms are more suitable for entrepreneurship as an occupational choice.

Second, from a psychiatry perspective, usually psychiatry research focuses on negative aspects of ADHD symptoms (Kessler, Adler, & Ames, 2005; Kooij et al., 2005). Given the high prevalence of psychiatric symptoms and its persistence into

adulthood (American Psychiatric Association, 2013; de Graaf et al., 2008), it is plausible to assume (from a Darwinian perspective) that these psychiatric symptoms not only bear negative consequences but may also be, under certain circumstances beneficial for the individual (Glass, Flory, & Hankin, 2012; Panksepp & Scott, 2012; White & Shah, 2006, 2011). For the field of psychiatry it is important to study the potential positive aspects of these psychiatric symptoms (Glass et al., 2012; Panksepp & Scott, 2012; White & Shah, 2006, 2011). Hence, adults who experience high levels of ADHD symptoms may benefit rather than suffer from them, provided they find ways to develop resilience mechanisms to cope with the negative consequences (Glass et al., 2012; Shelley-Tremblay & Rosén, 1996; Verheul et al., 2015; Williams & Taylor, 2006).

Finally, another dimension of the second cognitive factor that may be important for explaining entrepreneurship-related behavior are self-reported individual differences (Foo, Uy, & Baron, 2009; Frese & Gielnik, 2014; Wales et al., 2013). Individual differences are usually self-reported measures that reflect aspects of personal characteristics of an individual, such as the level of sensation seeking, impulsivity, or the extent to which an individual focuses on the present or future (i.e., temporal focus). Shipp, Edwards, & Lambert (2009) noted the importance of temporal focus, and taking both the present and future into account when it comes to decision-making and long-term economic outcomes (Das & Teng, 1997; Golsteyn, Grönqvist, & Lindahl, 2014; Stewart & Roth, 2001).

However, there are no studies that associate these temporal foci (and their interaction) with entrepreneurial orientation in a sample of solo self-employed individuals. Solo self-employed are an unique sample of individuals that are solely in charge of their firms, but play an increasingly important role in modern economics (Blanchflower, 2000; Rapelli, 2012). In Chapter 6 an attempt is made to answers the question whether both temporal foci are also important in entrepreneurial orientation. In addition, this chapter covers the topic whether both temporal foci interact to yield a higher entrepreneurial orientation compared to when entrepreneurs focus on either present or future, or not do not focus on any temporal focus dimension at all.

1.2 Thesis outline, research questions and main results

The remainder of this thesis consists of five chapters that attempt to answer five research questions. These questions are described in detail below, also including the main results.

Research question 1: How many trials are required to obtain an internally consistent measure for the Event-Related Potentials (ERPs) associated with cognitive control: the N2, P3, ERN and Pe? (Chapter 2)

Recent studies in psychophysiology show an increased attention towards studying the internal consistency of ERPs associated with cognitive control (Wöstmann et al., 2013). Cohen & Polich (1997) and Olvet & Hajcak (2009) are one of the first to present an analysis on how many trials are necessary to obtain an internally consistent measure for the ERPs associated with inhibitory control (the P300) and error processing (the ERN/Pe), respectively. In Chapter 2, we attempt to replicate the findings by Olvet & Hajcak (2009) concerning the ERN and Pe. Furthermore, in the same sample, we examine the internal consistency of the ERPs associated with inhibitory control (the N2/P3) measured in a Go/No-Go task are also examined. We present evidence that we are able to replicate the findings of Olvet & Hajcak (2009), who find that 6 trials are necessary to obtain an internally consistent measure for both the ERN and Pe. At the same time 14 and 20 trials are necessary to obtain an internally consistent measure for the N2 and P3 in a Go/No-Go task, respectively.

Research question 2: Are the ERPs associated with inhibitory control and error processing correlated? Furthermore, are these ERPs related to important self-reported individual differences? (Chapter 3)

Another important aim of psychophysiology is to understand the functional significance of Event-Related Potentials associated with cognitive control (Heil, 2002; Overbeek et al., 2005). For this purpose, studies examine the association between these ERPs and self-reported individual differences. It is also important to examine to what extent these ERPs are correlated among each other, but wide empirical evidence is missing. In Chapter 3, we examine the functional significance of the four ERPs (the N2, P3, ERN and Pe) by: (a) associating these ERPs to four relevant self-reported individual differences, and (b) investigating the correlation among the four ERPs, in a relatively large sample of 133 healthy young participants. Taken together, the results suggest that the correla-

tions between these ERPs are significant, but small, meaning that these ERPs reflect different aspects of cognitive control processes. In addition, we find no significant relations between the ERPs and the self-reported individual differences, suggesting that the ERPs and SRIDs capture different aspects of cognitive control processes.

Research question 3: Are attention-deficit/hyperactivity disorder (ADHD) symptoms associated with the decision to become self-employed? (Chapter 4)

Prominent entrepreneurs and popular media claim the importance of attention-deficit/hyperactivity (ADHD) symptoms for their self-employed choice, creativity and performance (Archer, 2014a, 2014b). However, to our knowledge, Chapter 4 is the first study to structurally examine the association between ADHD symptoms and the decision to become self-employment in both large, population-based cohort study (STAGE sample, 14,039 Swedish adults) and a large sample of Dutch students taken from the Global University Entrepreneurial Spirit Student' Survey (GUESSS sample, 13,119 individuals). Taken together, the results provide evidence that there is a positive association ADHD symptoms and self-employment which hinges primarily on hyperactivity symptoms.

Research question 4: Are ADHD symptoms associated with entrepreneurial orientation? (Chapter 5)

Chapter 5 examines the association between ADHD symptoms and entrepreneurial orientation. Previous studies have examined the association between ADHD symptoms and entrepreneurship-related behavior such as entrepreneurial intentions, choice and orientation (Khedhaouria, Thurik, Verheul, & Torres, 2014; Rietdijk, Block, Larsson, Verheul, et al., 2015; Verheul et al., 2015). The potential limitation of these studies is usually that they do not distinguish between the two dimensions that constitute ADHD, viz., attention-deficit and hyperactivity symptoms (Hesse, 2012). For this reason, we attempt to replicate the association between ADHD symptoms and entrepreneurial orientation in a sample of solo self-employed. At the same time we re-analyze the data from the initial study (Khedhaouria et al., 2014), to investigate whether the association between ADHD symptoms and entrepreneurial orientation is driven by either attention-deficit, hyperactivity symptoms or both. The results suggest that in both samples coefficients have similar trends, strengths and direction. Taken together, this suggests that there is some evidence that ADHD symptoms are associated with ADHD.

Research question 5: Is temporal focus associated with entrepreneurial orientation in a sample of solo self-employed? (Chapter 6)

In Chapter 6, we examine using a sample of 783 solo self-employed individuals who are solely responsible for their ventures, the association between temporal focus and entrepreneurial orientation (March, 1991; O'Reilly & Tushman, 2011; Shipp et al., 2009). We distinguish between two dimensions of temporal focus, i.e., present and future temporal focus, which are both important for entrepreneurship. The results indicate that indeed there are positive associations between present and future temporal focus and EO. Also, in line with previous research, future temporal focus is relatively more important compared to present temporal focus. Finally, we find a significant negative interaction coefficient when we include an interaction term between present and future temporal focus. The negative interaction coefficient provides evidence that present and future temporal focus are substituting factors; this suggest that solo self-employed individuals predominantly focus on either the present or the future, and that they do not balance between multiple temporal foci simultaneously.

1.3 Discussion, conclusion and future research

The present section addresses the question of how the different chapters in this thesis contribute to our understanding of the proposed associations in the conceptual model presented in section 1.1. I attempt to examine the associations between entrepreneurship-related behavior and two new cognitive factors: neurocognitive measures on the one hand and self-reported psychiatric symptoms and individual differences on the other. This question is important to enhance our understanding of possible determinants of entrepreneurship.

Chapter 2 and 3 employ four ERPs measured in two experimental tasks, viz., the Go/No-Go task and the Eriksen Flanker task. The results in Chapter 2 shows that although these ERPs are usually measured with a substantial noise they reach a certain level of internal consistency after several trials are included. For the N2 and P3 around 21 and 14 trials are necessary to obtain an internal consistent measure for inhibitory control, and for the ERN and Pe around 6 and 8 trials are necessary to obtain an internal consistent measure for error processing, respectively. In psychology, there are many other experimental tasks that measure cognitive processes and ERPs but have not been addressed yet in terms of reliability, i.e., measuring the internal consistency (Olvet &

Hajcak, 2009b), test-retest reliability (Kiang et al., 2013; Olvet & Hajcak, 2009a) and alternative forms (i.e., same ERPs measured by different experiments) (Meyer et al., 2013; Wöstmann et al., 2013). Further research is needed in order to uncover the functional significance of these ERPs by associating them to other self-reported individual differences or to other ERPs measured by other behavioral paradigms such as the balloon analogue risk taking (BART) task or stop-signal task (Lejuez et al., 2002; Ramautar, Kok, & Ridderinkhof, 2004).

The results in Chapter 3 are line with Brenner, Beauchaine, & Sylvers (2005), who suggest that these neurocognitive measures capture different aspects of a phenomenon compared to self-reported psychiatric symptoms and individual differences. This may be in line with our previous statement that many decisions individuals make are due to unconscious processes (Camerer et al., 2005), and that the ERPs are more objective measures and better able to capture the cognitive control processes than self-reported measures (Bagozzi et al., 2013; Rietdijk et al., 2014). Still the question remains what the exact difference is between neurocognitive measures and self-reported measures. It is for future research to study where these two measure types overlap and differ.

In addition, Chapter 3 attempts to associate the ERPs to an important aspect of entrepreneurship, viz., proactiveness. Although there are theoretical conjectures that suggest that there should be an association, the results suggest that none of the four ERPs reflecting inhibitory control and error processing are associated to proactiveness (Bateman & Crant, 1993; Verbruggen & Logan, 2009). For future research, there is an important task to examine the association between inhibitory control and error processing and two other important aspects of entrepreneurship, viz., risk-taking and innovativeness (Krauss, Frese, Friedrich, & Unger, 2005). Besides, given the lack of an association between the two cognitive processes and proactiveness, it may be that these two processes may be less relevant for explaining entrepreneurship-related behaviors. Other processes, such as reward-sensitivity (Van den Berg, Franken, & Muris, 2011) and risk-sensitivity (Lejuez et al., 2002; Ramautar et al., 2004) may be more directly linked to entrepreneurial processes and are therefore better in explaining entrepreneurship-related behaviors. It is for future research important to examine the associations be-

tween the ERPs associated with reward- and risk-sensitivity and entrepreneurship-related behaviors.

We show in Chapter 4 and 5 that there are indeed positive associations between attention-deficit/hyperactivity disorder (ADHD) symptoms and entrepreneurship-related behavior, but that this association is primarily driven by hyperactivity symptoms and not by attention-deficit symptoms. The results of Chapter 4 and 5 are similar to an initial study associating ADHD symptoms to entrepreneurial intentions (Verheul et al., 2015). These studies together are initial steps to 'destigmatize' ADHD as a psychiatric disorder and uncover potential beneficial effects for individuals that experience high levels of ADHD symptoms.

An essential question that follows is whether ADHD symptoms also positively impact the fourth level of entrepreneurship, viz., entrepreneurial performance. In addition, other psychiatric disorder symptoms may also have positive associations with entrepreneurship-related behavior. For example, hypomania is a symptom of bipolar disorder which is typified by an increased goal-orientation, risk-taking and racing thoughts (Furnham et al., 2008). These aspects are believed to some extent, enhance creative abilities (Flach, 1990; Furnham et al., 2008; Healey & Rucklidge, 2006; Johnson et al., 2012; Lloyd-Evans et al., 2006; White & Shah, 2006, 2011), which in turn, are considered an important aspect of entrepreneurship (Amabile, 1996; Lee, Florida, & Acs, 2004; Ward, 2004). However, there is no direct evidence for the association between hypomania and entrepreneurship.

Finally, in Chapter 6, we find that both present and future temporal foci are positively associated with entrepreneurial orientation. In addition, we find that present and future temporal foci are substituting factors, suggesting that solo self-employed individuals focus predominantly on one of the temporal foci and not on multiple temporal foci simultaneously. These results shows that there are ample opportunities for future research aimed at deepening our understanding of the cognitive characteristics of entrepreneurs and in particular of solo self-employed individuals (Frese & Gielnik, 2014; William J. Wales et al., 2013).

Although our results suggest that temporal focus is associated with entrepreneurial orientation, we were unable to examine the link with entrepreneurial choice and performance. Given the link between entrepreneurial orientation and performance

(Lumpkin & Dess, 1996, 2001; Rauch, Wiklund, Lumpkin, & Frese, 2009), temporal focus may also be associated with entrepreneurial performance and new venture development. Moreover, future research may contribute by studying other concepts such as organizational ambidexterity (Benner & Tushman, 2003; Jansen, Volberda, & Van Den Bosch, 2005) and effectuation versus causation (Sarasvathy, 2001) from a temporal focus perspective. According to Shipp et al. (2009) it is important to study the temporal focus aspects in different managerial settings, ranging from small business owners to top management teams.

Taken together, the present thesis sets out to examine the association between entrepreneurship and neurocognitive measures and self-reported psychiatric symptoms and individual differences. The results in this thesis suggest that further research is required in order to fully understand the determinants of entrepreneurship. In addition, we find no association between neurocognitive and self-reported measures and an aspect of entrepreneurship-related behaviors. This suggests that more studies are needed to build a bridge between the two research streams using different cognitive tasks, such as reward-sensitivity and risk-taking tasks. Finally, self-reported measures are still important in explaining aspects of entrepreneurship, but future research should go beyond current discussion and include other psychiatric symptoms and individual differences.

1.4 Publication status of chapters

Table 1.1 presents the publication status and respective research question it addresses for each chapter of the present thesis. One chapter has been published in an international peer-reviewed journal, two are currently under review in international peer-reviewed journals, and two are work-in-progress that will be submitted in the near future to international peer-reviewed journals. The table also lists remaining studies ('*other papers*') I contributed to during my period as a PhD student. This thesis includes studies concerning cognitive factors that are associated with entrepreneurship-related behavior. The remaining studies that are not part of the thesis examine the associations between affective processes (i.e., emotions, empathy, theory of mind) and other economic behaviors, such as customer orientation, and financial decision-making. They have in common that an attempt is made to associate several neurocognitive measures to economic decision-making. These '*other studies*' do not fall under the responsibility of my supervisors.

Table 1.1 Publication status of the chapters and 5 other papers.

Chapter	Title	Research question	Publication status	Reference
1	Introduction and conclusion	-	-	-
2	Internal consistency of Event-Related Potentials associated with cognitive control: N2/P3 and ERN/Pe	1	Published in *PLoS ONE*	Rietdijk, Franken and Thurik (2014)
3	The association between Event-Related Potentials associated with cognitive control and self-reported individual differences	2	Under review.	Rietdijk, Luijten, Marhe, Franken and Thurik (2015a)
4	Positive associations of attention-deficit/hyperactivity disorder (ADHD) symptoms? The association between ADHD symptoms and self-employment.	3	Under review.	Rietdijk, Block, Larsson, Verheul, Franken and Thurik (2015b)
5	Attention-deficit/hyperactivity disorder symptoms and entrepreneurial orientation	4	To be submitted.	Rietdijk, Khedhaouria, Verheul and Thurik(2015c)
6	Temporal Focus and entrepreneurial orientation of solo self-employed	5	To be submitted.	Rietdijk, Verheul, De Vries and Thurik (2015d)
	Summary/Samenvatting			
	Other papers			
	The making of the machiavellian brain: A structural MRI analysis		Published in *Journal of Neuroscience, Psychology and Economics*	Verbeke, Rietdijk, Van den Berg, Dietvorst, Worm and Bagozzi (2011)
	Genetic and neurological foundations of customer orientation: field and experimental evidence		Published in *Journal of the Academy of Marketing Science*	Bagozzi, Verbeke, Van den Berg, Rietdijk, Dietvorst and Worm (2012)
	fMRI activities in the emotional cerebellum: A preference for negative stimuli and goal-directed behavior		Published in *the Cerebellum*	Schraa-Tam, Rietdijk, Verbeke, Dietvorst, Van den Berg, Bagozzi and De Zeeuw (2012)
	Empathic and theory of mind explanations of machiavellianism: A neuroscience perspective		Published in *Journal of Management*	Bagozzi Verbeke, Dietvorst, Belschak, Van den Berg and Rietdijk (2013)
	Why controllers compromise on their fiduciary duties: EEG evidence on the role of the human mirror neuron system		Under review.	Eskenazi, Rietdijk and Hartmann (2014)

CHAPTER 2

Internal consistency of Event-Related Potentials associated with cognitive control: N2/P3 and ERN/Pe

Based on Rietdijk, Franken, & Thurik, (2014) Internal consistency of Event-Related Potentials associated with cognitive control: N2/P3 and ERN/Pe. PLoS ONE.

Abstract

Recent studies in psychophysiology show an increased attention for examining the reliability of Event-Related Potentials (ERPs), which are measures of cognitive control (e.g., Go/No-Go tasks). An important index of reliability is the internal consistency (e.g., Cronbach's alpha) of a measure. In this study, we examine the internal consistency of the N2 and P3 in a Go/No-Go task. Furthermore, we attempt to replicate the previously found internal consistency of the Error-Related Negativity (ERN) and Positive-Error (Pe) in an Eriksen Flanker task. Healthy participants performed a Go/No-Go task and an Eriksen Flanker task, whereby the amplitudes of the correct No-Go N2/P3, and error trials for ERN/Pe were the variables of interest. This study provides evidence that the N2 and P3 in a Go/No-Go task are internally consistent after 20 and 14 trials are included in the average, respectively. Moreover, the ERN and Pe become internally consistent after approximately 8 trials are included in the average. In addition guidelines and suggestions for future research are discussed.

2.1 Introduction

Event-related potentials (ERPs) of cognitive control are increasingly used in clinical studies to examine the relevance in several forms of psychopathology (Olvet & Hajcak, 2009a, 2009b), such as addiction (Luijten et al., 2014) and obsessive-compulsive disorder (Gehring, Himle, & Nisenson, 2000). Although ERPs have certain advantages over self-reporting (e.g., they are more objective) and behavioral measures (e.g., they provide more information on the neural level), relatively little attention has been paid to their psychometric properties, especially their reliability (Riesel et al., 2013). Reliability is a key psychometric criterion of physiological tasks (Anastasi & Urbina, 1997; Cook & Beckman, 2006), and it is a necessary prerequisite to demonstrate their validity (i.e., the degree to which an ERP represents the intended underlying construct) (Anastasi & Urbina, 1997; Cook & Beckman, 2006; Cronbach & Meehl, 1955; Wöstmann et al., 2013).

Reliability is frequently examined in terms of internal consistency (e.g., Cronbach's alpha) (Cohen & Polich, 1997; Cronbach & Meehl, 1955; Wöstmann et al., 2013). The internal consistency of an ERP is defined as the similarity of the ERP across trials in a single task (Wöstmann et al., 2013). ERPs are usually derived by averaging (many) trials, and if the trial-to-trial waveforms are unreliable, the participant's average will also be unreliable (i.e., less internally consistent) (Cohen & Polich, 1997; Cronbach & Meehl, 1955; Wöstmann et al., 2013). Olvet & Hajcak (2009) and Cohen & Polich (1997) were among the first to examine the internal consistency of several cognitive control task ERPs, such as the ERN, Pe, and P300. Among others, Riesel et al., 2013 stated that there is ample room for more studies examining the reliability (especially, the internal consistency) of ERPs in cognitive control tasks (e.g., Kiang, Patriciu, Roy, Christensen, & Zipursky, 2013; Olvet & Hajcak, 2009; Pontifex et al., 2010; Riesel et al., 2013; Wöstmann et al., 2013), such as the N2 and P3 in a Go/No-Go task. This study addresses the internal consistency of four frequently used ERP measures in two cognitive control tasks: the N2/P3 components measured during a Go/No-Go task, and the ERN/Pe components measured during an Eriksen Flanker task.

In a Go/No-Go task, two major ERP components are enhanced for No-Go trials compared with Go trials, suggesting that they reflect brain activity related to inhibitory control. The first component is the N2, which is a negative wave emerging approximate-

ly 200 – 300 ms after stimulus onset. The N2 reflects the first stage of inhibition, and/or it is related to conflict monitoring (Clayson & Larson, 2013; Falkenstein, Hoormann, & Hohnsbein, 1999; Garavan, Ross, & Stein, 1999). The other ERP component is the P3, which is a positive wave emerging approximately 300 – 500 ms after stimulus onset. Several studies suggest that the P3 reflects a later stage of the inhibition process that is closely related to actual inhibition of the motor response in the premotor cortex (Garavan et al., 1999). Previous studies have reported differences in the electrophysiological correlates of inhibitory control (i.e., the N2 and P3) that are driven by variations of the specific characteristics of the Go/No-Go task set up (e.g., single, multiple and semantic Go/No-Go stimuli) (Maguire, White, & Brier, 2011). Therefore, it is important to understand these variations and study the consequences for the internal consistency of the electrophysiological measures of inhibitory control (i.e., the N2 and P3) (Maguire et al., 2011). In a previous study, Clayson & Larson, 2013 examined the internal consistency of the N2 in an Eriksen Flanker task and found an internally consistent N2 after 30 trials. Furthermore, Cohen & Polich (1997) found the P3 to be internally consistent after 21 trials, measured in an oddball task. To our knowledge, ours is the first study to examine the internal consistency of both the N2 and P3 in a Go/No-Go task.

Previous research also identified two major ERPs that are enhanced for incorrect behavioral response trials (i.e., an error) compared with correct behavioral response trials, the Error-Related Negativity (ERN) and Positive error related wave (Pe) (Falkenstein, Hohnsbein, Hoormann, & Blanke, 1991; Gehring, Goss, & Coles, 1993). The ERN is an automatic response-locked negative deflection, emerging between 0 – 150 ms after the onset of an incorrect behavioral response (Bernstein, Scheffers, & Coles, 1995; Hajcak, 2012). The second positive deflection is the Pe, which peaks around 200 – 400 ms after the onset of an erroneous behavioral response. Although there is discussion about the exact meaning of the Pe (Overbeek et al., 2005), most studies indicate that the Pe is related to error recognition (Falkenstein, Hoormann, Christ, & Hohnsbein, 2000; Meyer, Bress, & Proudfit, 2014; Meyer et al., 2013; Overbeek et al., 2005). Olvet & Hajcak (2009) and Pontifex et al. (2010) found an internally consistent ERN and Pe after 6 and 8 trials were included to the participant's average, respectively.

In cognitive control tasks, the participants usually perform about 500 trials of a speeded reaction time task in relatively rapid succession. Errors and correct No-Go trials (i.e., successful inhibition of a participant's motor response) tend to be rare, resulting in a relatively low number of trials in the ERP averages. In fact, the number of trials for these conditions and participants varies greatly (Kiang et al., 2013; Olvet & Hajcak, 2009b). It has been suggested that only 6 and 8 trials are required for ERN and Pe, respectively (Olvet & Hajcak, 2009b). However, guidance on the actual number of trials required to obtain an internally consistent ERP component for the N2 and P3 is largely lacking (Clayson & Larson, 2013; Olvet & Hajcak, 2009b). As a result, the current study is set up to test the internal consistency of the N2 and P3 in a Go/No-Go task. Moreover, to ensure the quality of our inferences about the internal consistency of the N2 and P3, we attempt to replicate the results of previous studies that address the internal consistency of the ERN/Pe in the same sample (Meyer et al., 2014; Olvet & Hajcak, 2009b; Pontifex et al., 2010; Riesel et al., 2013).

2.2 Methods

2.2.1 Participants and procedures

118 healthy right-handed participants (M_{age} = 21.7 years, SD_{age} = 2.8, 61 males) participated in the electroencephalographic (EEG) task. Data from 10 participants were not analyzable due to computer errors during recoding of the data. Only participants with at least 30 correct No-Go trials (N = 95, 87%) were included in the EEG analysis. Additionally, only participants with at least 14 errors in the Eriksen Flanker (N = 70, 65%) were included. These sample selection criteria, and sample inclusion rates are similar to that of (Meyer et al., 2014; Olvet & Hajcak, 2009b; Pontifex et al., 2010; Riesel et al., 2013). Using an online questionnaire, participants were screened for previous brain surgeries, pregnancy, or history of psychiatric disorders (no participants had to be excluded due to these criteria). Participants were asked not to drink coffee or smoke for 1.5 hours before the experiment. The study was conducted in accordance with the Declaration of Helsinki, and written consent was obtained from each participant prior to participation. The ethics committee of the Erasmus Medical Center, Erasmus University Rotterdam approved the study.

2.2.2 Tasks

Participants performed a Go/No-Go task (Littel et al., 2012). A letter (A, I, E, O, or U) was presented for 200ms. Each stimulus was followed by a black screen for a randomly varying duration (1020 ms – 1220 ms) (Littel et al., 2012; Luijten et al., 2011). Participants were instructed to respond to the letters in the Go trials by pressing a button with the index finger as fast as possible, and in the No-Go trials, participants were instructed to withhold their response (i.e., when the letter was similar to the previous letter). The task had 500 trials, 125 of which were No-Go trials (25%) (Luijten et al., 2011).

Participants also performed an Eriksen Flanker task (200 congruent trials: SSSSS, HHHHH; and, 200 incongruent trials: SSHSS, HHSHH) (Franken, van Strien, Franzek, & van de Wetering, 2007; Marhe et al., 2013). Participants were instructed to respond to the central letter. On a response box, they had to press H with their right index finger when the central letter was an H and S with their left index finger if the central letter was an S. Each trial started with a fixation cue (^) for 150 ms. Letter strings were presented for 52 ms, followed by a blank screen for 648 ms. The participants had 700 ms from stimulus onset to respond. At the end of the respond period, a feedback symbol appeared indicating whether the response was correct (ooo), incorrect (xxx), or too late (!). An interval of 100 ms was used (Marhe et al., 2013).

2.2.3 ERP measurement and statistical analysis

EEG was recorded using a Biosemi Active-Two amplifier system (Amsterdam, the Netherlands) at 32 scalp sites (positioned following the 10 – 20 International System and two additional electrodes: FCz and CPz) with active Ag/AgCl electrodes mounted in an elastic cap. Six additional electrodes were attached to the left and right mastoids, the two outer canthi of both eyes (HEOG), and the infraorbital and supraorbital region of the right eye (VEOG). All signals were digitalized with a sample rate of 512 Hz and 24-bit A/D conversion, with a band pass of 0 – 134 Hz. The data were off-line referenced to compute mastoids. Off-line, EEG and EOG activities were filtered with a band pass of 0.15 – 30 Hz (phase shift free Butterworth filters; 24 dB/octave slope). During offline processing, no more than four bad channels per participant were removed from the EEG signal, and new values per channel were calculated using topographic interpolation (Littel et al., 2012). Data were segmented in epochs of 1000 ms (-200 – 800 ms after stimulus presentation) and 700 ms (-100 – 600 ms after the response) for inhibitory

control and error processing, respectively (Littel et al., 2012; Luijten et al., 2011; Marhe et al., 2013). The average of 200 ms before stimulus onset in the Go/No-Go task and 100 ms before the response in the Eriksen Flanker period served as a baseline that was subtracted from all subsequent time points (Luijten et al., 2011; Marhe et al., 2013). Segments with incorrect responses (i.e., false alarm for No-Go trials, incorrect Go response, or false alarms for Eriksen Flanker trials) were all excluded from the EEG analysis (Luijten et al., 2011; Marhe et al., 2013). After ocular correction (Gratton, Coles, & Donchin, 1983), epochs, including an EEG signal exceeding ±100μV, were excluded from the average (Meyer et al., 2013). All epochs were also visually inspected for other artifacts. Average ERP waves were calculated after baseline correction for artifact-free trials at each scalp site in each condition.

Go/No-Go inhibitory control studies have predominantly examined and observed inhibition-related N2 and P3 effects at Fz, Cz, Pz (e.g., Donkers & Van Boxtel, 2004; Maguire et al., 2009). Therefore, in the current study we examine the internal consistency of the N2 and P3 at Fz, Cz, and Pz. The N2 is defined as the average value in the 175 – 250 ms time interval after stimulus onset (Littel et al., 2012; Luijten et al., 2011). The P3 is defined as the average value in the 300 – 500 ms time interval after stimulus onset (Luijten et al., 2011). In the Eriksen Flanker task, the ERN is defined are the as the average value of FCz in the 25 – 75 ms time segment after response onset. The Pe is defined as the average value of Pz in the 200 – 400 ms time segment after response onset (Littel et al., 2012; Luijten et al., 2011). Note that both Figures 1 and 3 present the grand average difference waveforms of the electrodes important in the Go/No-Go (Fz, Cz, Pz) and Eriksen Flanker (FCz and Pz) task, respectively. The grand average difference waveforms are more informative for observing the temporality of the ERP measures, compared to the average waveforms of the Go and No-Go correct and Eriksen Flanker error and correct trials separately. However, in our analysis we took the amplitudes for correct No-Go N2 and P3 and ERN and Pe error trials as the variables of interest, similar to Meyer et al., 2014, 2013; Olvet & Hajcak, 2009; Pontifex et al., 2010. The separate figures for Go/No-Go and error/correct trials are available upon request from the corresponding author.

The current study employed a methodology similar to that described by Meyer et al. (2013, 2014); Olvet & Hajcak (2009); and Pontifex et al. (2010). For the ERPs of

inhibitory control and error processing, we measured the average of N2/P3 and ERN/Pe trials, respectively. Random pairs of trials were included in the average (i.e., 2, 4, 6, 8, 10, …, and the participants' average, across all trials), and paired *t*-tests were used to determine statistically significant differences. Signal-to-Noise ratios (SNRs) were estimated using a process available in Brain Vision Analyzer Version 2.0 software (www.brainproducts.com). First, noise is estimated by summing the squares of the difference between each data point and the average EEG value; this sum is then divided by the number of data points minus one. Second, average total power is estimated by taking the average of the squared values of each data point. Average power of the signal then equals the average total power minus the average noise power (Olvet & Hajcak, 2009b). SNRs of the trial pair averages were assessed using paired *t*-tests. Additionally, we assessed internal consistency measuring the correlation between these smaller trial averages and the N2/P3 and ERN/Pe participants' average (i.e., all trials), and Cronbach's alpha when an increasing number of trials were included in the average (Meyer et al., 2014, 2013; Olvet & Hajcak, 2009b; Pontifex et al., 2010), both available in SPSS 19.0. The thresholds in the current study are similar to previous studies, where internal consistency is indicated when correlations reached 0.8 and Cronbach's alpha reached 0.6 (Meyer et al., 2014, 2013; Olvet & Hajcak, 2009b; Pontifex et al., 2010).

2.3 Results

2.3.1 Inhibitory control

The purpose of this study is to examine internal consistency of the N2 and P3 in a Go/No-Go task. On average, the participants had 73.87 (SD = 19.87; 60% No-Go correct) correct No-Go trials (i.e., participants successfully inhibited their motor response while performing the task). Figure 1 presents the grand average difference waveforms for Go/No-Go task for the midline electrodes Fz, Cz, and Pz. Moreover, Figure 2 presents for all three midline electrodes the average (Figure 2A) and Pearson's correlations (Figure 2B), and the Cronbach's alpha (Figure 2C) all as a function of an increasing number of trials. Paired *t*-tests were performed using the N2 area measures, for all three midline electrodes (Fz, Cz, and Pz). Significant differences were only observed for electrodes Fz (30 vs. participants' average, $p < 0.05$), and Pz (18 vs. 20 trials, and 30 vs participants' average, $p < 0.05$), while all other pairs comparing increasing numbers of trial averages (2 vs. 4 trials, 4 vs. 6 trials, 6 vs. 8 trials, 8 vs. 10 trials, 10 vs. 12 trials,

…, 28 vs. 30 trials, and 30 trials vs. participants' average (i.e., all trials) were insignificant (all *p*s > 0.05); this suggests that the N2 average is still relatively instable after 30 trials.

When comparing increasing trial numbers for the P3 significant differences at the three electrodes (Fz, Cz, Pz) were found for Fz (6 vs. 8 trials, p = 0.02; 8 vs. 10 trials, p = 0.04; 14 vs. 16 trials, p = 0.04), while all other pairs comparing increasing numbers of trial average were insignificant (all ps>0.05). Significant differences between increasing trials averages were found for Cz (6 vs. 8 trials, p = .018; 8 vs. 10 trials, p = .043; 14 vs. 16 trials, p = .045; 30 vs. grand average, p = .013), while all other pairs comparing increasing number of trial averages were insignificant (all ps>0.05). Significant differences between increasing trials averages were found for Pz (6 vs. 8 trials, p = .019; 26 vs. 28 trials, p = .039; 30 vs. grand average, p = .02), while all other pairs comparing increasing number of trial averages were insignificant (all ps>0.05). This suggests that the P3 is still relatively instable after 30 trials.

Estimates of the SNR for N2 and P3 at Fz, Cz and Pz were also examined. SNR scores for the Fz electrode, starting with at least 6 errors, ranged from 0.43 to 0.14. Paired *t*-tests show that there were significant differences for 6 vs 8 trials, 8 vs. 10 trials, 10 vs. 12 trials, 22 vs. 24 trials, 24 vs. 26 trials, 28 vs. 30 trials and 30 vs. participants' average ($p < 0.05$). SNR scores for the Cz electrode, starting with at least 6 errors, ranged from 0.67 to 0.28. Paired t-tests show that there were significant differences for 6 vs. 8 trials, 8 vs. 10 trials, 10 vs.12 trials, 16 vs. 18 trials, 22 vs. 24 trials, 24 vs. 26 trials, 30 vs. participants' average ($p < 0.05$). SNR scores for the Pz electrode, starting with at least 6 errors, ranged from 0.61 to 0.30. Paired *t*-tests show that there were significant differences for 6 vs. 8 trials, 8 vs. 10 trials, 24 vs. 26 trials and 30 vs. participants' average ($p < 0.05$). Taken together, one can conclude that the signal-to-noise ratio remains relatively unstable even when including as many as 30 trials.

Figure 2.1 Grand average difference waveform: No-Go – Go trials

Figure 2.1 presents the grand average difference waveforms (i.e., average of all trials, across all participants) of the No-Go minus Go trials for electrodes Fz, Cz, and Pz. Note: we use the grand average difference waveforms for this figure as this is more informative compared to separate waveforms of No-Go correct trials and Go correct trials. However, in further analysis we took the amplitude for correct No-Go trials N2 and P3 at the midline electrodes Fz, Cz and Pz as the variables of interest.

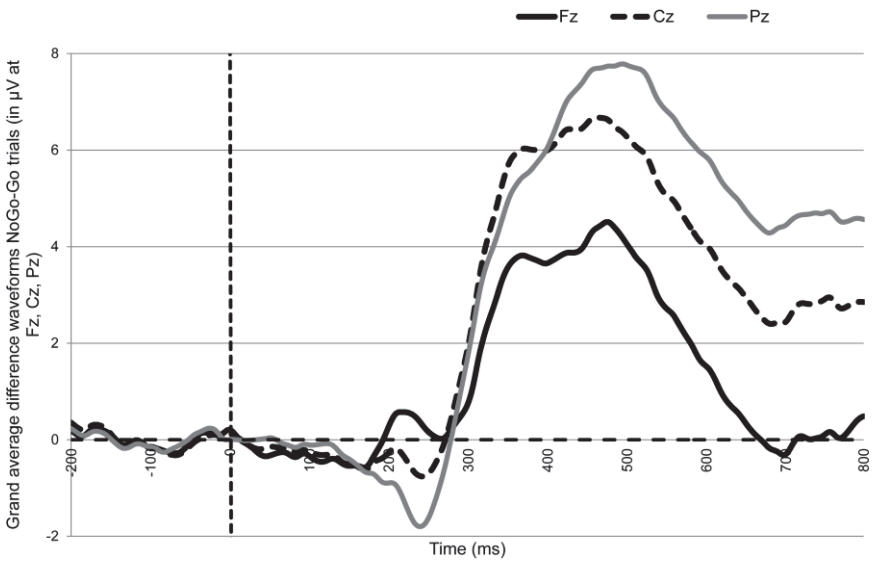
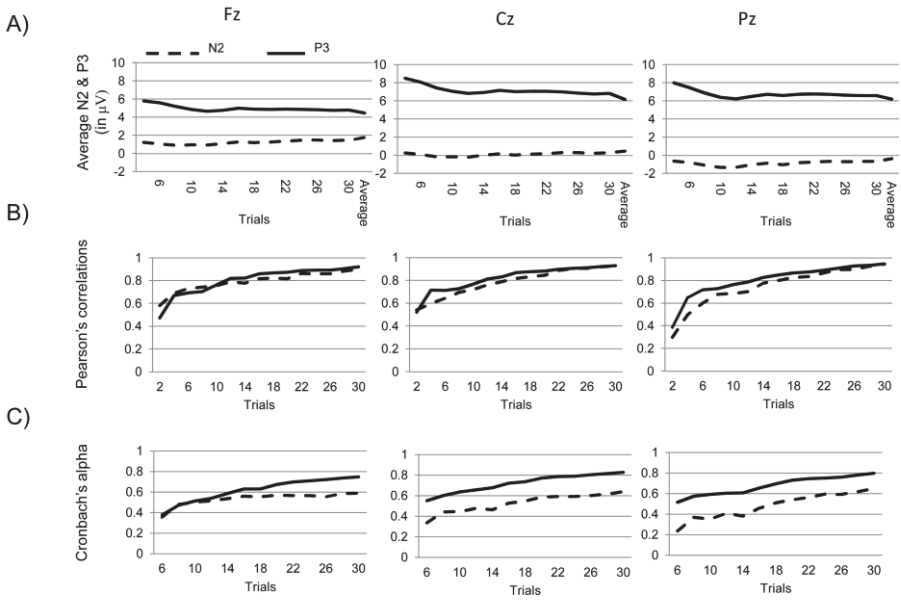


Figure 2.2 Correct No-Go N2 and P3– Internal consistency analysis

Figure 2.2 presents (A) the average N2 and P3, (B) Pearson's correlations, and (C) Cronbach's alpha as progressively more trials are included in the participants' average, all for the three midline electrodes Fz (left), Cz (middle), and Pz (right). The average presented in this figure refers to the grand average (all trials and all participants).



Additionally, we explored the relationship between each trial average and the N2/P3 participants' averages using Pearson's correlation coefficient for Fz, Cz and Pz (Figure 2B). All pairs were highly significant ($p < 0.001$), suggesting that individual trial averages share a degree of similarity with the participants' average when including only a couple of ERP trials. However, high correlations (rs > 0.8; i.e., higher internal consistency) were reached after including 18 and 14 trials to the N2 and P3 averages, respectively. These data indicate that the ERP measures become similar to the participants' average (i.e., across all trials) after including 18 and 14 trials for N2 and P3, respectively.

Next, we determined the Cronbach's alpha for the N2 and P3 as progressively more trials were considered (Figure 2C). They both show an increasing trend. However, in order to obtain an adequate Cronbach's alpha ($\alpha > 0.6$) for the N2, at least 20 trials should be included in the participants' average. For the P3, an adequate Cronbach's alpha ($\alpha > 0.6$) was obtained after 10 trails were included in the average. It is important to note that the Cronbach's alpha for the N2 remains low compared to that for the P3. Taken together, these data demonstrate that in order to obtain an internally consistent estimate for the N2 and P3, 20 and 14 trials are required taking into account both the Pearson's correlations and Cronbach's alpha analyses, respectively.

2.3.2 Error processing

To support the quality of our results regarding the internal consistency of the N2 and P3 in a Go/No-Go task, we attempted to replicate previous findings regarding the internal consistency of the ERN and Pe initially performed by Olvet & Hajcak (2009). On average, the participants made 26.31 errors (SD = 17.06) while performing the Eriksen Flanker task. The grand average difference waveforms for the Eriksen Flanker task for the electrodes FCz and Pz are presented in Figure 3. Moreover, Figure 4 presents for all three midline electrodes the average (Figure 4A), Pearson's correlation (Figure 4B), and the Cronbach's alpha (Figure 4C) as a function of an increasing number of trials. Paired t-tests were performed on the ERN area measures, and significant differences were observed only when comparing increasing numbers of trial averages for 4 vs. 6 trials ($p = 0.03$), and 6 vs. 8 trials ($p = 0.03$), while all other pairs were statistically insignificant (2 vs. 4 trials, 8 vs. 10 trials, 10 vs. 12 trials, 12 vs. 14 trials, and 14 vs. participants' average [i.e., all trials]; all ps > 0.05); meaning that the average became stable after 8

trials were added to the participants' average. For the Pe, no significant differences were found ($p > 0.05$); meanings that the Pe was relatively stable after 4 trials were included in the participants' average.

We also estimated the SNR for the ERN and Pe. SNR scores for the ERN starting with at least 6 errors ranged from 0.43 to 0.29, which is comparable to the magnitude reported in previous studies. For the ERN, only significant difference between SNR of trials averages 6 vs. 8 trials, 8 vs. 10 trials, and 10 vs. 12 trials, 12 vs. 14 trials ($p < 0.05$), while for 14 trials vs. participants' average ($p > 0.05$) was insignificant different. This means that after 14 trials the ERN signal-to-noise ratio became stable. As for the Pe SNR significant differences were observed for 12 vs. 14 trials and 14 trials vs. participants' average ($p < 0.05$). This means that signal-to-noise for the Pe remained relatively unstable after 14 trials were included in the participants' average.

Figure 2.3 Grand average difference waveform: error - correct trials

Figure 2.3 presents the grand average difference waveforms (i.e., average of all trials, across all participants) of the error minus correct trials in the Eriksen Flanker task. Note: we use the grand average difference waveforms for this figure as this is more informative compared to separate waveforms of error versus correct trials. However, in further analysis we took the amplitude for ERN (at FCz) and Pe (at Pz) error trials as the variables of interest.

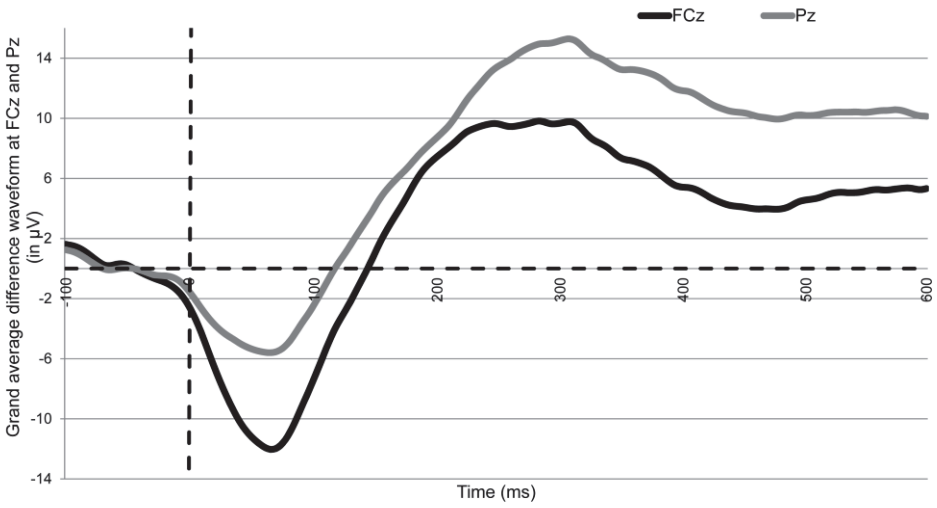
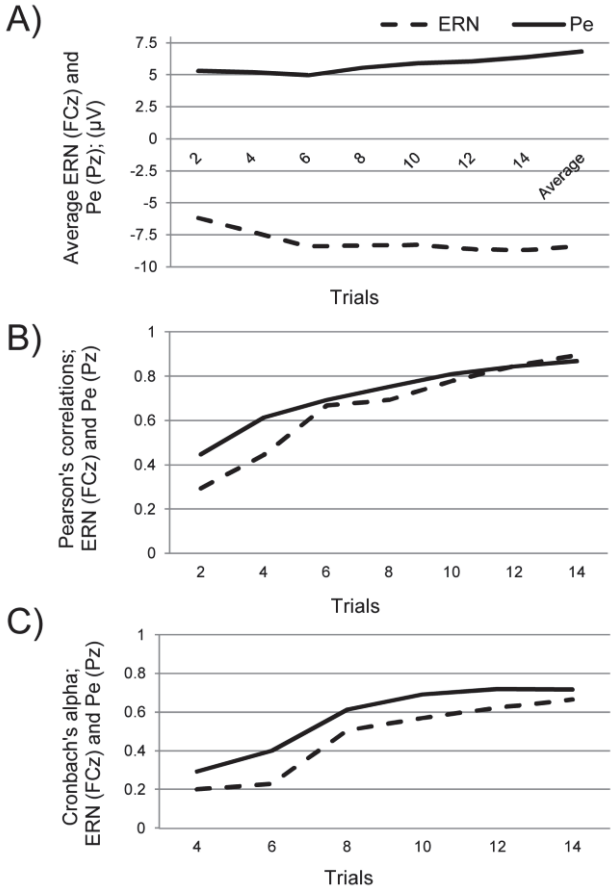


Figure 2.4 Error trials – Internal consistency analysis

Figure 2.4 presents the (A) average ERN and Pe, (B) Pearson's correlations, and (C) Cronbach's alpha as progressively more trials are included in the participants' average, for the ERN (at FCz) and Pe (at Pz). The average presented in this figure refers to the grand average (all trials and all participants).



Additionally, we explored the relationship between each trial average and the ERN/Pe grand average using Pearson's correlation coefficient (Figure 4B). All pairs were highly significant (all ps < 0.001), suggesting that individual trial averages share a degree of similarity with the participants' average when including only several ERP trials. However, the ERN and Pe trial averages showed high Pearson's correlations (i.e., higher internal consistency) after approximately 8 trials (rs > 0.8) were included in the participants' average.

We also calculated the Cronbach's alpha for the ERN and Pe as progressively more trials were considered (Figure 4C). The Cronbach's alpha for the ERN and Pe were adequate ($\alpha > 0.6$) after 8 trials were included in the participants' average. Thus, the ERN and Pe were both internally consistent around 8 trials were included in the participants' average, respectively.

2.4 Discussion

The present study examined the minimum number of trials required to obtain an internally consistent measure for ERPs in cognitive control tasks, the N2 and P3 in a Go/No-Go task and the ERN and Pe in an Eriksen Flanker task. The N2 in the Go/No-Go task displayed a less favorable internal consistency pattern compared to the Eriksen Flanker task ERPs. In the Go/No-Go task, the N2 showed high Pearson's correlation coefficients after 14 trials were included in the participants' average. However, adequate Cronbach's alpha was obtained only after approximately 20 trials. This suggests that approximately 20 trials are required to obtain an internally consistent estimate for the No-Go N2. As for the P3 in the Go/No-Go task, high Pearson's correlation coefficients were reached after 14 trials were included in the participants' average, and an adequate Cronbach's alpha was already obtained after including 8 trials. Thus, 14 trials are required to obtain an internally consistent estimate for the P3. Cohen & Polich (1997) found an internally consistent P3 in an oddball task after 21 trials were included in the participants' average.

In addition, we replicate in the same sample the study by Meyer et al. (2013, 2014); Olvet & Hajcak (2009); Pontifex et al. (2010). In the current study, we found that approximately 8 trials are required to obtain an internally consistent estimate for the ERN and Pe. These recommendations are similar to previous studies (Meyer et al., 2014, 2013; Olvet & Hajcak, 2009b; Pontifex et al., 2010).

In the current design of the Go/No-Go task, participants are required to withhold a response when a letter (A, E, I, O, or U) was repeated. This adds two components to the Go/No-Go task: a working memory component and a response conflict component (i.e., in which a participant must withhold a response to a stimulus to which the participant just responded). Maguire et al. (2009, 2011) found that both the N2 and P3 amplitudes decrease with task difficulty (e.g., adding working memory components); which implies that the amplitudes of the N2 and P3 in the current study may be affected by task complexity, and this could potentially influence the internal consistency of the N2 and P3. Therefore, for future research it is important to examine the internal consistency of the N2 and P3 in three ways: (a) in a Go/No-Go task with lower complexity levels of the No-Go stimuli (e.g., a single Go and No-Go stimuli), (see Maguire et al., 2009, 2011); (b) other cognitive control tasks eliciting the N2 (e.g., stop-signal task); and/or (c) a context-specific N2 and P3, e.g., Luijten et al., 2011).

Based on the present findings, we recommend including at least 20 and 14 trials when measuring the N2 and P3 in a Go/No-Go task, respectively. Further, we recommend that at least 8 trails are required to measure the ERN and Pe in an Eriksen Flanker task.

The current study was set up to examine the internal consistency of brain activity related to error processing and inhibitory control. In line with previous findings, we have similar advice for the N2/P3 and ERN/Pe (Cohen & Polich, 1997; Meyer et al., 2014, 2013; Olvet & Hajcak, 2009b; Pontifex et al., 2010; Wöstmann et al., 2013). However, replication is needed to uncover the internal consistency of especially the N2 for similar as well as different behavioral tasks to confirm our conclusions and generalize the findings to other tasks (e.g., stop-signal task). Lastly, we employed a number of commonly employed statistical approaches to determine the internal consistency of the N2, P3, ERN and Pe. Future research may further examine this issue using more sophisticated statistical methods (e.g., simulation based methods).

CHAPTER 3

The relation between Event-Related Potentials associated with cognitive control and self-reported individual differences

Based on Rietdijk, Luijten, Marhe, Thurik and Franken (2015a)

Abstract

We investigated the functional significance of four Event-Related Potentials (ERPs) that reflect aspects of cognitive control by associating these ERPs with four self-reported individual differences (SRIDs) using a sample of 133 healthy young adults. The ERPs are associated with inhibitory control, N2/P3 in a Go/No-Go task, and error processing, ERN/Pe in an Eriksen Flanker task. The SRIDs are sensation seeking, impulsivity, attention-deficit/hyperactivity disorder (ADHD) symptoms, and proactiveness. Previous research has suggested that these ERPs reflect related processes and may be correlated to some extent. Our results showed significant but small correlations between the N2/P3, the ERN/Pe and the P3/Pe. This finding allowed the use of all four ERPs, verifying their functional significance in linear regressions on all four SRIDs. Also, this finding adds evidence to the notion that these ERPs are somehow correlated but reflects separate aspects of cognitive control processes. We found no relations between these ERPs and the SRIDs, suggesting that the aspects of cognitive control captured by the ERPs are unrelated to those captured by the SRIDs.

3.1 Introduction

One of the goals of psychophysiology is to understand the functional significance of Event-Related Potentials (ERPs) associated with cognitive control processes (Martin Heil, 2002; Overbeek et al., 2005; Ridderinkhof et al., 2009; Rugg & Coles, 1996). Two second-order processes reflecting cognitive control are inhibitory control and error processing (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Hajcak, Holroyd, Moser, & Simons, 2005; Larson, Clayson, & Clawson, 2014; Ridderinkhof et al., 2004; Vilà-Balló, Hdez-Lafuente, Rostan, Cunillera, & Rodriguez-Fornells, 2014).

Previous electroencephalographic (EEG) studies have identified ERPs associated with inhibitory control and error processing, the N2/P3 and the ERN/Pe, respectively (Burle, Vidal, & Bonnet, 2004; Falkenstein et al., 1991, 2000; Gehring et al., 2000). Recent studies have investigated the functional significance of these ERPs by relating them to relevant self-reported individual differences (SRIDs) (Brenner et al., 2005; Debener, Makeig, Delorme, & Engel, 2005; Wang & Wang, 2001; Zheng et al., 2010). These studies have usually presented statistically significant relations between ERPs and SRIDs. However, in a study comparing the psychophysiological measures and SRIDs of response inhibition (BIS/BAS) measures, Brenner, Beauchaine, & Sylvers (2005) suggested that these ERPs and SRIDs reflect different aspects of cognitive control, and may therefore be unrelated.

Although these studies have revealed important insights and are excellent starting points for further study, they generally have two important limitations. *First*, most of these studies have used relatively small samples and may be susceptible to false positive findings (Button et al., 2013a, 2013b). *Second*, these studies have usually included a single SRID related to ERPs measured in either inhibitory control or error processing. Therefore, the present study included a relatively large sample (N=133), four ERPs and four SRIDs to examine their association more thoroughly.

Inhibitory control is the ability to adaptively suppress behavior when required by environmental contingencies (Groman et al., 2009). Inhibitory control is usually assessed by means of behavioral paradigms, such as Go/No-Go or stop-signal tasks. In the Go/No-Go tasks, participants have to respond as quickly as possible to frequently occurring Go stimuli, and inhibit responses to infrequent No-Go stimuli (Kok et al., 2004).

Two major ERP components are enhanced for No-Go trials compared to Go trials, which suggest that they reflect changes in brain activity related to inhibitory control.

The first ERP is the stimulus-locked N2 which is a negative wave that emerges approximately 200–300 ms after stimulus presentation. There is some discussion about the exact role and functional significance of the N2 (Enriquez-Geppert, Konrad, Pantev, & Huster, 2010). Some have argued that the N2 is related to behavioral outcomes of inhibitory control within the Go/No-Go task (Falkenstein, Hoormann, & Hohnsbein, 1999) irrespective of the stimulus modality used in these paradigms (Kaiser et al., 2006). Others have argued that the N2 represents a more general process, such as "conflict monitoring" (Burle et al., 2004; Enriquez-Geppert et al., 2010). Nevertheless, Go and No-Go trials differ with respect to the inhibition of a motor response, which could be explained by the difference between Go and No-Go amplitudes. Furthermore, the N2 associated with inhibitory control is observed in other inhibition-related paradigms besides the Go/No-Go task (Ciesielski, Harris, & Cofer, 2004; Dimoska, Johnstone, & Barry, 2006).

The second ERP that is associated with inhibitory control is the stimulus-locked P3, which is a positive wave that emerges approximately 300-500 ms after stimulus onset. The exact role and functional significance of the P3 associated with inhibitory control is less well understood (Bruin & Wijers, 2002; Falkenstein, Hoormann, & Hohnsbein, 1999; Luijten et al., 2011; Smith, Johnstone, & Barry, 2004). Because the P3 is a rather late ERP component (>300 ms), the literature has suggested that it does not reflect the initial reflexive stage of the inhibition process but rather a later stage of the inhibition process that is closely related to the actual inhibition of the motor system in the premotor cortex (Garavan et al., 1999). Generally, the N2 and P3 are thought to reflect different inhibitory control processes (Enriquez-Geppert et al., 2010). However, it is unknown whether and how the N2 and the P3 are correlated during inhibitory control task performance.

Another aspect of the human cognitive control system is *error processing* which refers to the ability to adequately monitor and process errors to appropriately adapt subsequent behavior (Falkenstein et al., 1991; Gehring, Himle, & Nisenson, 2000; Hajcak, 2012; Maier, Di Pellegrino, & Steinhauser, 2012). Generally, error processing is assessed by means of behavioral paradigms with a high probability of making errors,

such as the Eriksen Flanker task (Eriksen & Eriksen, 1974; Gehring, Himle, & Nisenson, 2000). Two specific ERPs relevant in this context are the error-related negativity (ERN) and the error-positivity (Pe). The ERN is a fast and automatic response-locked negative ERP deflection that emerges between 0-150 ms after the onset of an incorrect behavioral response (Bernstein et al., 1995). Recent studies have suggested that this early component reflects the initial automatic brain response as a result of an error (Overbeek, Nieuwenhuis, & Ridderinkhof, 2005). Usually, this ERN is followed by a positive ERP, the response-locked Pe, which peaks approximately 200-400ms after the onset of the incorrect behavioral response. Although there is discussion about the exact functional significance of the Pe (Overbeek, Nieuwenhuis, & Ridderinkhof, 2005), most studies have indicated that the Pe may be related to more conscious reflection on the error (Kok et al., 2004).

There are two main goals of the present study. *First*, we investigated the functional significance of the ERPs associated with cognitive control by relating these ERPs to SRIDs that reflect relevant aspects of cognitive control (Debener et al., 2005; Dimoska et al., 2006; Nieuwenhuis, Yeung, van den Wildenberg, & Ridderinkhof, 2003; Zheng et al., 2010). Recent studies have suggested that a larger (i.e., more negative) N2 amplitude associated with inhibitory control is related to lower scores on novelty seeking (Zheng et al., 2010), whereas the N2 amplitude is not related to sensation seeking (Wang & Wang, 2001), and impulsivity (Littel et al., 2012). At the same time, studies have found that a larger P3 amplitude associated with inhibitory control is negatively related to novelty seeking and psychopathy (Carlson, Thái, & McLarnon, 2009; Zheng et al., 2010) and sensation seeking (Wang & Wang, 2001). Lansbergen et al. (2007) found a positive relation between the P3 amplitude and impulsivity (also Martin & Potts, 2009).

Moreover, recent research has suggested that a larger (i.e., more negative) ERN amplitude associated with error processing is related to better academic performance (Hirsh & Inzlicht, 2010), lower impulsivity (Littel et al., 2012; Martin & Potts, 2009; Potts, George, Martin, & Barratt, 2006; Ruchsow et al., 2005), lower risk-propensity (Santesso & Segalowitz, 2009), and higher scores on behavioral inhibition (BIS/BAS) scales (Boksem, Tops, Wester, Meijman, & Lorist, 2006; Potts et al., 2006). However, a smaller (i.e., less negative) ERN amplitude associated with error processing is related to

higher levels of empathy (Larson, Fair, Good, & Baldwin, 2010; Santesso & Segalowitz, 2009) and sensation seeking (Zheng, Sheng, Xu, & Zhang, 2014). Moreover, the Pe amplitude associated with error processing is unrelated to impulsivity (Ruchsow et al., 2005) and empathy (Larson et al., 2010). To conclude this overview of studies of the functional significance of ERPs, some have found that higher scores on ADHD symptoms are related to smaller amplitudes of the four ERPs, viz., the N2, the P3, the ERN and the Pe (Du et al., 2006; Groen et al., 2008; Liotti et al., 2005; Polner, Aichert, & Macare, 2014; van Meel, Heslenfeld, Oosterlaan, & Sergeant, 2007; Wiersema, van der Meere, & Roeyers, 2005, 2009; Wiersema & Roeyers, 2009). This finding was also reported in a sample of non-clinical participants (Herrmann et al., 2009).

In the present study, we focus on four relevant SRIDs that have been associated with cognitive control, viz., sensation seeking, impulsivity, ADHD symptoms, and proactiveness. With respect to the relations between the ERPs and SRIDs, we expect that sensation seeking is not related to the N2 amplitude (Wang & Wang, 2001) and is negatively related to the P3, ERN, and Pe amplitudes (Wang & Wang, 2001; Zheng et al., 2014). For impulsivity, we expect a positive relation with the P3 amplitude (Carlson et al., 2009; Lansbergen et al., 2007; Martin & Potts, 2009; Zheng et al., 2010) and a negative relation with the N2, ERN, and the Pe amplitude (Martin & Potts, 2009; Zheng et al., 2014). Concerning ADHD symptoms, we expect that smaller ERP amplitudes are associated with higher scores on ADHD symptoms (Groen et al., 2008; Herrmann et al., 2009; Wiersema, Van der Meere, & Roeyers, 2009; Wiersema & Roeyers, 2009). Finally, we expect that larger ERP amplitudes are associated with higher scores on proactiveness (Verbruggen & Logan, 2009).

The *second* goal was to investigate to what extent these ERPs reflect similar aspects of cognitive control processes, and hence are to some extent correlated. Miyake et al. (2000, p.49) found that cognitive control processes, such as information updating, monitoring and inhibition are moderately correlated with each other, but are still dissociable. In addition, previous research has suggested that the ERPs of inhibitory control and error processing may be correlated (Hughes & Yeung, 2011; Rodriguez-Fornells, De Diego Balaguer, & Münte, 2006; Yeung, Botvinick, & Cohen, 2004; Yeung & Cohen, 2006; Yeung & Nieuwenhuis, 2009). In particular, Botvinick et al. (2004) stated

that an area of inquiry for future research would be to investigate the correlation between the ERPs associated with inhibitory control and error processing. A theoretical link between these cognitive control processes is the concept of conflict monitoring (Botvinick et al., 2001, 2004; Hajcak et al., 2005; Larson et al., 2014; Luijten et al., 2014; Pailing & Segalowitz, 2004), which could drive the correlations between these ERPs. The process of conflict monitoring serves to translate the occurrence of conflict into compensatory adjustments in control: the conflict monitoring system first evaluates current levels of conflict and then passes this information on to centers responsible for control, triggering them to adjust the strength of their influence on processing (Botvinick et al., 2001; Braver et al., 2001; Menon et al., 2001). In line with the conflict monitoring perspective, it is plausible to expect that there are correlations between the ERPs within a task (i.e., the correlations between the N2/P3, and ERN/Pe). We expect low to moderate correlations across tasks, specifically between the N2/ERN and the P3/Pe (Kaiser et al., 1997; Leuthold & Sommer, 1999; Yeung et al., 2004; Yeung & Cohen, 2006; Yeung & Nieuwenhuis, 2009) whereas we have no specific expectations regarding the correlations between the N2/Pe and ERN/P3. However, extensive empirical evidence about the correlations among the ERPs is unavailable. An issue that might arise if these ERPs are indeed strongly correlated (and hence they reflect similar aspects of cognitive control) is that if they are regressed together on a SRID (the first goal of the study), this may lead to inappropriate conclusions. Therefore, it is important to investigate the correlations among the ERPs. In line with previous conjectures that have suggested that ERPs reflect, to some extent, similar aspects of cognitive control processes, we expect small correlations between the ERPs of inhibitory control and error processing. We used a relatively large sample of healthy participants (N=133) to investigate these two goals.

3.2 Methods

3.2.1 Participants

Initially, 169 participants participated in our study. However, data from 10 participants were excluded because of errors during data recording. For the Go/No-Go out of 159 participants an additional 12 participants were removed from the sample due to too many artefacts (e.g., movement, noise) or too few correct No-Go trials (< 20 correct No-Go trials), leaving the total Go/No-Go sample at N=147 (Rietdijk, Franken, & Thurik,

2014). For the Eriksen Flanker task out of the 159 participants, an additional 16 participants were removed from the sample due to too many artefacts (e.g., movement, noise) in the data, or too few errors (< 5 error trials), leaving the total of the Eriksen Flanker sample at N=143 (Marhe, Van De Wetering, & Franken, 2013; Olvet & Hajcak, 2009; Rietdijk, Franken, & Thurik, 2014). In the final analysis, we included only the participants who had complete data for both the Go/No-Go and the Eriksen Flanker tasks. Therefore, the final sample consisted of 133 participants (M_{age} = 22.1 years, SD= 3.1, 94 males).

All participants were third- and fourth-year students at Erasmus University, Rotterdam. At least two days before the experiment, an information letter was sent to the candidates about the study. The letter included a link to an online questionnaire used for exclusion criteria (head surgeries, pregnancy, or any history of psychiatric disorders). None of the candidates reported any of the exclusion criteria. Furthermore, the SRIDs were included in the online questionnaire (to measure sensation seeking, impulsivity, ADHD symptoms, and proactiveness). Participants were asked not to drink coffee or smoke cigarettes for 1.5 hours before the EEG experiment to prevent acute caffeine/nicotine effects on the ERPs. The six best-performing (highest accuracy in both tasks) participants received a monetary reward for participation (€100 ≈ $80). This was communicated to the participants before the experiment. The study was conducted in accordance with the Declaration of Helsinki and written informed consent was obtained from the participants prior to participation. The institutional review board of the Erasmus University Medical Centre approved this study. Part of the data is reported in a previous study (Rietdijk, Franken, & Thurik, 2014) that addresses the internal consistency of the ERPs.

3.2.2 Self-reported individual differences

Four SRIDs were included in the online questionnaire. The ImpSS-8 scale (Webster & Crysel, 2012) was used to measure impulsivity and sensation seeking. Next, we measured ADHD symptoms using the ADHD Self-Report Scale-6 version 1.1 (ASRS-6 V1.1) (Hesse, 2012; Kessler, Adler, & Ames, 2005; Kessler et al., 2007). Lastly, we measured proactiveness (Bateman & Crant, 1993). Proactiveness is usually defined as behavior that identifies differences among people in the extent to which they take action to influence their environments. Too avoid an overly extensive questionnaire, we only

included the 12 best fitting items from the original questionnaire (Bateman & Crant, 1993). These SRIDs were measured using a 7-point Likert scale (from 1= very unlikely to 7= very likely), with the exception of ADHD symptoms which were measured using a 5-point Likert scale (from 1= unlikely to 5= likely) (Kessler et al., 2007). In the present study, the Cronbach's alphas for sensation seeking, impulsivity, ADHD symptoms, and proactiveness scales were .72, .50, .53, and .85, respectively.

3.2.3 Experimental paradigms

Upon arrival, the participants were informed about the procedure. The participants were seated on a comfortable chair in a light- and sound-attenuated room. Participants conducted a Go/No-Go task with vowels (A, I, E, O and U) (Littel et al., 2012). These vowels are presented for 200 ms. A black screen followed each stimulus for a randomly varying duration of 1020ms-1220 ms. The participants were instructed to respond to the letters in Go trials by pressing a button with the right index finger as fast as possible and to withhold their response in the No-Go trials (if the letter was the same as the previous letter). The letters were presented in white on a black background. The visual angles for the Go and No-Go trials were 1.15˚ horizontally and 1.43˚ vertically. The task consists of 500 trials in total containing 125 No-Go trials (25%). The main ERPs of interest for the Go/No-Go task were the stimulus-locked N2 and P3.

Second, the participants performed an Eriksen Flanker task (Eriksen & Eriksen, 1974; Marhe et al., 2013) while ERPs were measured. Four different letter strings (SSHSS, SSSSS, HHSHH, HHHHH) were presented on the computer screen and subjects were instructed to press a button with the right index finger if the central letter was an H and with the left index finger if the central letter was an S. Response times from onset stimuli to button press on congruent (SSSSS, HHHHH; n = 200) and incongruent trials (SSHSS, HHSHH; n = 200) were recorded. Trials started with a 150 ms cue (^) where the central letter of the letter strings would appear. Letter strings were presented for 52 ms followed by a black screen for 648 ms. Participants had 700 ms from stimulus onset to respond. After the end of the respond period, a feedback symbol appeared for 500 ms indicating whether the given response was correct (ooo), incorrect (xxx), or too late (!). An interval of 100ms was used. The letter strings were presented in white on a black background, and the feedback symbols were presented in red. The visual angles for the congruent and incongruent stimuli were 2.57˚ horizontally and 0.86˚ vertically.

The main ERPs of interest for the Eriksen Flanker task were the response-locked ERN and Pe.

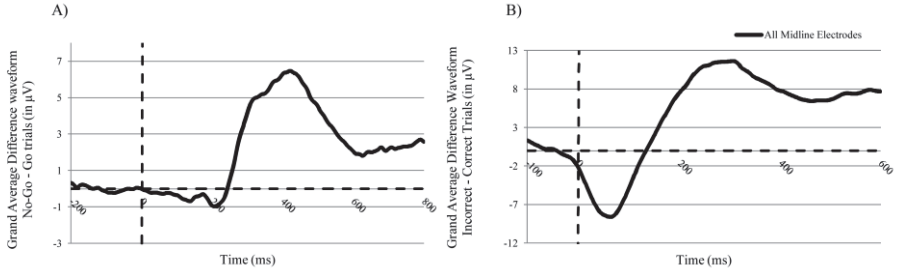
3.2.4 ERP recordings and measurement

The EEG was recorded using a Biosemi Active-Two amplifier system (Biosemi, Amsterdam, the Netherlands) from 34 scalp sites (positioned following the 10–20 International System with two additional electrodes at FCz and CPz) with active Ag/AgCl electrodes mounted in an elastic cap. Six additional electrodes were attached to the left and right mastoids, to the two outer canthi of both eyes (HEOG) and to an infraorbital and a supraorbital region of the right eye (VEOG). Ocular correction was performed using the Gratton et al. (1983) algorithm which is implemented in Brain Vision Analyzer (Brain Products, Munich, Germany) (Gratton et al., 1983). All signals were digitalized with a sample rate of 512 Hz and 24-bit A/D conversion with a band pass of 0–134 Hz. The data were offline re-referenced to computed mastoids. Off-line, all signals were filtered with a band pass of 0.10–30 Hz (phase shift free Butterworth filters; 24 dB/octave slope). During offline processing, no more than three bad channels per participant were removed from the EEG signal, and new values were calculated using topographic interpolation (Soong, Lind, Shaw, & Koles, 1993). The data were excluded if more than three bad channels had to be interpolated. Data were segmented in epochs of 1 second (200 ms before and 800 ms after stimulus presentation) and 700 ms (-100 ms before and 600 ms after the response) for the Go/No-Go and Eriksen Flanker tasks, respectively. After ocular correction epochs including an EEG signal exceeding ±100μV were excluded from the average. The mean 200 ms pre-stimulus period served as the baseline for the Go/No-Go task and 100ms pre-stimulus served as the baseline for the Eriksen Flanker task.

For the Go/No-Go task, after baseline correction, average ERP waves were calculated for artefact-free trials at each scalp site for correct No-Go and correct Go stimuli separately. Segments with incorrect responses (miss for GO trials or false alarm for No-Go trials) were excluded from EEG analyses. The N2 was defined as the mean value within the 175–250 ms time interval, averaged over all midline electrodes (Fz, FCz, Cz, CPz and Pz). The P3 was defined as the mean value within the 300–500 ms time interval after stimulus onset for all midline electrodes (Littel et al., 2012).

For the Eriksen Flanker task, after baseline correction, average ERP waves were calculated for artefact-free trials at each scalp site in the two (i.e., correct and incorrect) response conditions. The ERN was defined as the mean value in the 25–75 ms time segment after onset of the response. The Pe was defined as the mean value in the 200–400 ms time segment after onset of the response. For both the ERN and Pe, averages over all the midline electrodes (Fz, FCz, Cz, CPz and Pz) were studied. In a further analysis, the difference between No-Go and Go stimulus trials and incorrect and correct response trials were the main variables of interest representing inhibitory control and error processing, respectively. For both the Go/No-Go and Eriksen Flanker tasks, the selection of the electrodes and time windows for calculating the average area measures were consistent with previous studies. See Littel et al. (2012) and Rietdijk, Franken, & Thurik, (2014) for the Go/No-Go task and Marhe et al. (2013) and Rietdijk, Franken, & Thurik (2014) for the Eriksen Flanker task. Grand average difference waveforms for both the Go/No-Go and Eriksen Flanker tasks averaged over all the midline electrodes are presented in Figure 3.1.

Figure 3.1
Grand Average Difference Waveforms of the Go/No-Go task (Panel A) and the Eriksen Flanker task (Panel B), N=133



3.2.5 Statistical analysis

First, we will present the descriptive statistics of the task performance and measures of both the Go/No-Go task (the accuracy in %, response times in ms), and Eriksen Flanker task (accuracy in %, response times in ms, post-error response times in ms) and examine the differences using dependent t-test. Second, we will estimate the Pearson's correlations between the four ERPs. Finally, we will show four regression models for the relation of the four cognitive control ERPs (the N2, P3, ERN, and Pe) and four SRIDs: sensation seeking, impulsivity, ADHD symptoms, and proactiveness all controlling for age and gender.

3.3 Results

3.3.1 Descriptive statistics: behavioral and questionnaire data

First, we present the descriptive statistics of the questionnaire data. The mean scores (and standard deviations, SD) for the SRIDs are as follows: sensation seeking, impulsivity, ADHD symptoms, and proactiveness are 5.51 (SD=1.02), 4.40 (SD=0.77), 2.78 (SD=0.52), and 3,54 (SD=0.89), respectively. Second, a short overview of the task performance and behavioral measures for inhibitory control and error processing is presented in Table 3.1.

3.3.2 Event-Related Potentials

The ERPs in the present study were all significant. Within the Go/No-Go task, the No-Go N2 was significantly larger (more negative) than the Go N2 ($t_{df=132}$ = -3.64, p < .000), and the No-Go P3 was significantly larger than the Go P3 ($t_{df=132}$ = 13.18, p < .001). Within the Eriksen Flanker task, the ERN was significantly smaller in incorrect versus correct trials ($t_{df=132}$ = -17.46, p < .001), and the Pe was significantly larger in incorrect versus correct trials ($t_{df=132}$ = 19.04, p < .001).

3.3.3 Pearson's correlations and Regression analysis

Table 3.2 presents the correlation matrix between the four cognitive control ERPs (N2, P3, ERN, and Pe). It is essential to note that the ERPs are based upon the difference between No-Go minus Go trials and incorrect minus correct responses for the N2/P3 and ERN/Pe, respectively. We observe that there are significant but small correla-

tions between the ERN/Pe, and the N2/P3. Furthermore, there is a significant but small and positive correlation between the P3/Pe.[2]

Table 3.3 presents the results for the four linear regression analyses examining the relations between the cognitive control ERPs and the four SRIDs. We checked for multicollinearity by assessing the tolerance statistics, which were all above 0.2, suggesting no multicollinearity issues (Menard, 1995). There were no significant relations between the ERPs and sensation seeking, ADHD symptoms, and proactiveness ($p>0.05$). Only the relation between impulsivity and the P3 was significant ($p<0.05$). None of the four models showed a satisfactory fit.

Table 3.1
Task performance and measures of inhibitory control (Go/No-Go task) and error processing (Eriksen Flanker task).

Go/No-Go			
	Go	No-Go	t-stat (p-value)
Accuracy (%)	97% (4%)	67% (14%)	24.5 (p<.001)
Eriksen Flanker			
	Congruent	Incongruent	
Accuracy	95% (4%)	86% (8%)	17.8 (p<.001)
Response times (ms)	406 (34)	446 (37)	-27.8 (p<.001)
	Correct	Incorrect	
Accuracy (%)	91% (6%)	9% (6%)	
Response times (ms)	438 (36)	312 (58)	19.9 (p<.001)
	Post-correct	Post-error	
Response times (ms)	437 (17)	457 (34)	-8.3 (p<.001)

Note: standard deviations are in parentheses, N=133. The t-test has 132 degrees of freedom (df).

[2] Bivariate correlations between the ERPs and the SRIDs indicated no significant relations. The bivariate correlation matrix between the ERPs, behavioral data, and SRIDs is available on request from the corresponding author.

Table 3.2
Pearson's correlation matrix between the ERPs of inhibitory control (N2 and P3) and error processing (ERN and Pe)

	N2	P3	ERN	Pe
N2	1			
P3	.39**	1		
ERN	.12	-.09	1	
Pe	-.02	.30**	.19**	1

Note: The N2, P3, ERN and Pe are the ERPs measured in μV, and are based upon difference waveforms between No-Go minus Go and incorrect minus correct for the N2/P3 and ERN/Pe, respectively. ** p<.05. N =133.

Table 3.3
Regression analyses with self-reported individual differences (SRIDs) as dependent variables, and the ERPs as independent variables.

Regression models		Sensation Seeking	Impulsivity	ADHD symptoms	Proactiveness
ERPs	N2	-.004 (-.01)	.016 (.41)	-.03 (-1.36)	.003 (-.10)
	P3	.03 (1.38)	.048 (2.27)**	.02 (1.62)	.009 (.55)
	ERN	-.02 (-1.29)	-.005 (-.31)	.01 (.79)	-.007 (-.55)
	Pe	.01 (.56)	-.03 (-1.88)	.004 (.48)	.004 (.33)
Control variables	Gender	-.20 (-1.08)	.09 (.53)	-.205 (-2.19)**	-.084 (-.63)
	Age	.03 (1.03)	-.004 (-.16)	.01 (.67)	.029 (1.35)
	F-test	1.31	1.63	1.74	.57
		p = .26	p = .15	p = .12	p = .76
	Adj. R^2	.01	.03	.03	-.020
	N	133	133	133	133

Note: The N2, P3, ERN and Pe are the ERPs measured in μV and are based upon difference waveforms between NoGo minus Go and incorrect minus correct for the N2/P3 and ERN/Pe, respectively. Gender is a dummy variable with 0 = male. β-coefficients are presented with t-statistics between parentheses. The degrees of freedom for the F-test in all models are 6,126. ** p<.05. N=133.

3.4 Discussion

The present study was set up to investigate the functional significance of four electrophysiological indices of inhibitory control (N2/P3) and error processing (ERN/Pe). For this purpose, we related these ERPs to four self-reported individual differences (SRIDs) that are thought to reflect aspects of cognitive control. The SRIDs are sensation seeking, impulsivity, attention-deficit/hyperactivity disorder (ADHD) symptoms, and proactiveness. The second goal of this study was to investigate the correlations among the ERPs because previous research suggests that the ERPs may reflect similar aspects of cognitive control processes, and hence that these ERPs are, at least to some extent, correlated.

To start with the second goal of our study, as expected, the results of the Pearson's correlation analysis showed small correlations between the N2/P3 (inhibitory control), and the ERN/Pe (error processing). Interestingly, the results showed no correlation between the earlier ERPs, viz., the N2/ERN, but we did find a positive correlation between later ERPs, viz., the P3/Pe. These findings suggest that the ERPs of inhibitory control and error processing partly reflect similar aspects of cognitive control processes (especially the later ERPs, the P3 and the Pe).

We would like to discuss three aspects of the correlation analyses resulting from the second goal of the study. Our results were in line with earlier studies analyzing the correlations between these cognitive control processes. Specifically, Miyake et al. (2000) found moderate correlations between these cognitive processes, but they were still dissociable (Overbeek, Nieuwenhuis, & Ridderinkhof, 2005). *First*, we found a correlation between the ERN and Pe, which is in line with Riesel et al. (2013, p.381). Riesel et al. (2013, p. 383) suggested that the ERN and Pe originate from a common neural network, which drives the correlation between them. Similarly, we found a correlation between the N2 and P3, which in line Ramautar, Kok, & Ridderinkhof (2004), is also driven by a shared underlying neural network (Botvinick et al., 2001; Nieuwenhuis et al., 2003).

Second, as noted before, conflict monitoring is thought to be an important process underlying both the N2 associated with inhibitory control and the ERN associated with error processing (Luijten et al., 2014), which could drive the possible correlations among these ERPs. However, the current lack of an association between the N2 and ERN indicated that these ERPs reflect different processes. As previously suggested by

Larson et al. (2014) it may be that the ERN merely reflects a post-response conflict that is contingent upon the processing of an error, whereas the N2 represents pre-response conflict between the activation of multiple response options by a target stimulus (Dimoska et al., 2006; Larson et al., 2014; Yeung & Cohen, 2006). Therefore, Larson et al. (2014) suggested that the N2 and ERN reflect distinct, separable, and hence uncorrelated cognitive control processes.

Third, we observed, as expected, a significant, positive correlation between the P3 and Pe (Overbeek, Nieuwenhuis, & Ridderinkhof, 2005). Among others, Kaiser et al. (1997) suggested that both the P3 and Pe are associated with salience detection (Leuthold & Sommer, 1999; Nieuwenhuis et al., 2001; Ridderinkhof et al., 2009), which potentially drive the positive correlation between these ERPs. Altogether, the present results suggest that 'cognitive control' is an umbrella concept that reflects different aspects of cognitive processes that are only partly correlated.

The small or insignificant correlations between the ERPs allow for their use in verifying their functional significance in linear regressions on all four SRIDs. This is the first goal of our study. Our results indicated that there are no significant relations between the ERPs and SRIDs. These results are in line with previous studies (e.g., Brenner, Beauchaine, & Sylvers, 2005) that also failed to find an association between psychophysiological measures and SRIDs. Brenner, Beauchaine, & Sylvers (2005) concluded that SRIDs and psychophysiological measures may not always capture similar aspects of a phenomenon. We conclude that this is also the case in cognitive control processes and the SRIDs in our sample of 133 healthy young adults.

A possible limitation of our study is that its results may depend upon specific characteristics of the sample (i.e., higher educated participants) or the set up of the tasks, viz., multiple working memory components in the Go/No-Go tasks (Maguire et al., 2009, 2011). Moreover, two of the four SRIDs (impulsivity and ADHD symptoms) appeared to be less reliable, as witnessed by a low Cronbach's alpha. These limitations may lead to a bias in the results and need to be addressed in future studies.

These results and limitations open up ample room for future research. First, it is relevant to replicate the current study in a sample reflecting a more general population and to test more associations and consider whether the results generalize to other tasks reflecting cognitive control (e.g., stop-signal task, Stroop task, oddball task). Further-

more, future research should investigate to what extent the concept of 'cognitive control' drives the correlations between these ERPs. For future research it is important to investigate what aspects are measured in these psychophysiological measures as well as SRIDs of cognitive control and whether they complement or substitute each other (Kluger & Tikochinsky, 2001). It might well be that other aspects such as reward and punishment processing are reflected in these ERPs (i.e., P3, ERN, Pe).

In conclusion, the results showed small positive correlations between the N2/P3, ERN/Pe and P3/Pe but no correlation between the N2/ERN. In addition, we found no associations between these four ERPs and SRIDs in linear regressions on all four SRIDs. For future research, it is important to study the associations between similar and different ERPs and relate them to other relevant SRIDs to deepen our understanding of the functional significance of ERPs.

CHAPTER 4

Positive aspects of attention-deficit/hyperactivity disorder (ADHD) symptoms? The association between ADHD symptoms and self-employment

Based on Rietdijk, Block, Larsson, Verheul, Franken and Thurik (2015b)

Abstract

It has been claimed that attention-deficit/hyperactivity disorder (ADHD) symptoms is associated with the decision to become self-employed. Although attention-deficit/hyperactivity disorder (ADHD) symptoms are largely disadvantageous, some symptoms may have some advantageous aspects for the individual. To our knowledge, there is no systematic, epidemiological evidence to support this claim. Therefore, binary logistic regressions were used to examine the association between ADHD symptoms and the self-employment choice in a population-based sample from the STAGE cohort of the Swedish Twin Registry (N=7,208). We used a sample of Dutch students who participated in the Global University Entrepreneurial Spirit Students' Survey (GUESSS) for replication (N=13,112). In the Swedish sample, we found a positive association of both total ADHD symptoms [odds ratio (OR) 1.13; 95% confidence intervals (CI) 1.04-1.23] and hyperactivity symptoms [OR 1.19; 95% CI 1.08-1.32] with the self-employment choice, whereas this association could not be found for attention-deficit symptoms [OR 0.99; 95% CI 0.89-1.10]. The positive association between hyperactivity symptoms and the self-employment choice [OR 1.13; 95% CI 1.00-1.28] was replicated in the Dutch sample. Our results suggested that some aspects of ADHD symptoms, especially hyperactivity symptoms, may be advantageous for the individual and are associated with the decision to become self-employed.

4.1 Introduction

Prominent entrepreneurs have publicly credited their attention-deficit hyperactivity disorder (ADHD) symptoms as a driver of their decision to become self-employed in popular outlets, such as The New York Times and Forbes Magazine (Archer, 2014a, 2014b; Turner, 2003). Examples include, among others, Ingvar Kamprad (founder of IKEA) and Richard Branson (founder of the Virgin Group) (Archer, 2014a, 2014b). Furthermore, The Economist recently published a short article addressing the suitability of people with high levels of ADHD symptoms for self-employment (The Economist, 2012).

ADHD refers to a neurodevelopmental disorder characterised by attention-deficit and hyperactivity symptoms (Barkley, 1997; Cantwell, 1996; Conners, 2000). The onset of ADHD is typically during childhood (before the age of 12) and was therefore seen as a childhood disorder. However, follow-up studies that include children who are diagnosed with ADHD have shown a persistence of ADHD symptoms into early adulthood (Biederman, Petty, Evans, Small, & Faraone, 2010; Biederman, Petty, Monuteaux, et al., 2010; Cantwell, 1996; Larsson et al., 2013; Spencer, Biederman, & Mick, 2007), with 65% demonstrating a full syndrome or only a partial remission at the age of 25 (Faraone, Biederman, & Mick, 2006). Recently, there has been increased attention towards understanding the persistence of ADHD symptoms in individuals at older ages (Wilens, Faraone, & Biederman, 2004). For this reason, the recent DSM-5 facilitates the application of ADHD diagnosis across the lifespan and not only during childhood (Kooij et al., 2005).

Although research has been focusing on the negative consequences of ADHD for individual performance within the context of formal education and wage-employment (Biederman & Faraone, 2006; Kleinman, Durkin, Melkonian, & Markosyan, 2009; Kuriyan et al., 2013; Loe & Feldman, 2007; Raggi & Chronis, 2006), recent studies have highlighted positive aspects of ADHD, such as its association with resilience, well-being (Wilmshurst, Peele, & Wilmshurst, 2011), and close friendship (Glass et al., 2012). In the present study, we focus on a potential positive aspect of ADHD: self-employment as a career choice. Self-employment is essential for economic growth of modern societies (Audretsch & Thurik, 2001; Thurik et al., 2013) and can be used as a possible economic instrument in the business cycle (Koellinger & Thurik, 2011). Some

authors in the popular press have suggested that individuals with ADHD symptoms are able to break through inertia within organizations because of their ability to envision and create new 'realities' and (successfully) start their own firms (Archer, 2014a, 2014b; Shelley-Tremblay & Rosén, 1996; The Economist, 2012; Verheul et al., 2015). Allegedly, when individuals who 'suffer' from ADHD symptoms develop capabilities to cope with their 'weaknesses,' they are then able to exploit their talents and function just as well as or even better compared to the average wage-paid worker or self-employed individual (Archer, 2014b; Hartmann, 2002; Verheul et al., 2015). Nevertheless, empirical studies have found only circumstantial evidence that ADHD symptoms are associated with self-employment-related behaviour, linking ADHD to entrepreneurial intentions (Verheul et al., 2015), creativity (Flach, 1990; Healey & Rucklidge, 2006; White & Shah, 2011), risk-taking (Mäntylä et al., 2012), and proactiveness (Barkley, 1997). To our knowledge, there is no systematic, epidemiological evidence supporting a link between ADHD symptoms and the self-employment choice.

The present study was set up to examine the association between self-reported ADHD symptoms and the self-employment choice in a population-based sample of 7,208 participants taken from the STAGE cohort of the Swedish Twin Registry of the Karolinska Institute. We also attempted to replicate our findings in a sample of 13,119 students who participated in the Global University Entrepreneurial Spirit Students' Survey (GUESSS) 2012 in the Netherlands. Given the discussions in the (popular) literature and the above mentioned circumstantial evidence, we expected a positive association between ADHD symptoms and the decision to become self-employed (Archer, 2014a, 2014b; The Economist, 2012; Turner, 2003; Ingrid Verheul et al., 2015).

It is essential to emphasise that the present study does not focus on ADHD as a full-blown, psychiatric disorder. For our purpose, the self-reported psychiatric symptoms which are defined across a continuum: the level of symptoms range from none, hardly any, some problems to severe problems (Hesse, 2012). We focused on individuals with subclinical ADHD symptoms only.

4.2 Methods

4.2.1 Swedish Twin Registry: STAGE cohort

We used the STAGE (Swedish Twin Studies on Adults: Genes and Environment) cohort from the Karolinska Institute in Stockholm, Sweden, as the discovery sample. For a full account of the design and execution of the STAGE cohort and the details of the ADHD data, we refer to Lichtenstein et al. (Lichtenstein et al., 2006) and Larsson et al. (Larsson et al., 2013), respectively. The main characteristics of the STAGE cohort are described next. The STAGE cohort is part of the population-representative Swedish Twin Registry (STR) (Pearce, Checkoway, & Kriebel, 2007), which was established in the 1950s to study the effects of smoking and drinking on cancer and cardiovascular diseases (Lichtenstein et al., 2006). Nowadays, the STR contains rich data about biological and clinical markers together with the socio-economic background of twins living in Sweden (Lichtenstein et al., 2006).

All twins born between 1959 and 1985 were contacted with an invitation letter with information about the project. The mailing was done in four batches in May and June 2005. The total sample consisted of 42,582 twins. The total response rate was 59.6% (N=25,364, 56% female, M_{age}=41.56, SD_{age}=7.6). The entire questionnaire contained approximately 1,300 questions, and respondents answered 800-900 questions on average (Lichtenstein et al., 2006). Informed consent was obtained from all individual participants included in the study. The present project has been reviewed and approved by the ethics committee of the Karolinska Institute.

4.2.2 Self-employment measures

Within the questionnaire, participants were asked two questions about their self-employment choice. The first question was whether they were full-time self-employed (yes/no), and the second question was whether they were part-time self-employed (yes/no). No ambidextrous categories were included. In the analyses, we combined the two measures to form one measure of self-employment (yes or no); this measure was coded as 1 if the participant was part-time or full-time self-employed and 0 if not self-employed (but wage-employed or unemployed). In the STAGE cohort data 14,039 out of 25,364 participants (≈55%) filled out their self-employed status (yes or no). A total of 2,096 participants (14%) were self-employed, of whom 1,270 (9%) were full-time self-employed, and 826 (5%) were part-time self-employed. Three participants answered yes

to both part-time and full-time self-employed, indicating that they did not comprehend the questionnaire and were excluded from the analysis. In order to analyse the association between ADHD symptoms and self-employment, we randomly dropped one of the twin pairs for inclusion in the analysis. The final sample consisted of 7,802 participants (58% female, M_{age}= 43.9, SD_{age}= 6.7), of whom 897 (12%) were self-employed (full-time: 515, 7%; part-time: 382, 5%), which was similar to the total sample distribution.

4.2.3 Attention-deficit/hyperactivity disorder symptom measure

Adult ADHD symptoms were assessed using a self-reported questionnaire containing the 18 items reflecting the DSM-IV ADHD symptoms (Larsson et al., 2013), consisting of nine attention-deficit symptoms and nine hyperactivity symptoms. Each item had a three-point answer format (0='no'; 1='yes, to some extent'; and 2='yes'). The 18 DSM-IV items were slightly modified to be suitable for adults to measure the level of ADHD symptoms (Lichtenstein et al., 2006). As expected from a general healthy population sample, many participants reported having no/few ADHD symptoms. The symptoms were added to create a scale of total ADHD symptoms and two sub-scales of attention-deficit symptoms and hyperactivity symptoms (Larsson et al., 2013). Reliabilities (Cronbach's alpha) of the total ADHD symptoms, attention-deficit symptoms and hyperactivity symptoms scales were α = 0.84, 0.78, and 0.77, respectively (Larsson et al., 2013). The three scales were highly skewed: sample skewness[3] for total ADHD symptoms was equal to 1.66; for attention-deficit symptoms it was equal to 1.76; for hyperactivity symptoms it was equal to 1.71. The scales were log-transformed (Log10[x+1], where x is the initial value) to normalize their distributions: sample skewness after transformation for total ADHD symptoms was equal to -0.15; for attention-deficit symptoms it was equal to 0.26; for hyperactivity symptoms it was equal to 0.25 (Larsson et al., 2013).

[3] The sample skweness is measured by $M_3 M_2^{-3/2}$, where M is the mean of the initial value, and M_2 and M_3 are the unbiased estimators for the second, and third cumulants, respectively.

4.2.4 Control variables

In the STAGE cohort, to control for additional effects we included the following demographic variables: age, gender, and whether the participant attended university (0 = no, and 1 = yes).

4.2.5 GUESSS study: replication

We attempted to replicate the analysis associating ADHD symptoms to the self-employment choice in a sample of students from the Global University Entrepreneurial Spirit Students' Survey (GUESSS)[4] 2012 survey in the Netherlands. The GUESSS study is part of an international entrepreneurship research consortium that studies career objectives of students in higher education. Students at 14 universities and 24 universities of applied sciences in the Netherlands received a link to the online survey through email. After one month a reminder was sent. Two randomly drawn participants received an iPad 2.0 for their participation. To prevent self-selection of students with entrepreneurial intentions, the general theme of the survey was called future career paths. The GUESSS study was in line with the Erasmus Research Institute of Management review board standards and did not include clinical or patient data.

The GUESSS study had a response rate of 7.6% among the institutions that systematically recruit participants (Verheul et al., 2015) and consisted of 13,119 students (56% are female, M_{age}= 22.96, SD_{age}= 0.49), of whom 374 were student entrepreneurs, i.e., students who had their own business during their studies. Given that the GUESSS study consisted of only highly educated students (from universities and polytechnics), we only included age and gender as control variables in the model. In the GUESSS study, ADHD symptoms were measured using the 6 item ADHD Self-Report Symptom screener (ASRS-6 v1.1) developed by Kessler et al. (Kessler, Adler, & Ames, 2005; Kessler et al., 2007), which was based upon the 18 items DSM-IV criteria used in the STAGE study. Each item was answered on a 5-point Likert scale (1= never to 5= always). Although these measures were different, they were identified to be highly correlated (Kessler et al., 2005; Kessler et al., 2007). In the GUESSS study, the reliability coefficients (Cronbach's alpha) of the total ADHD symptoms, attention-deficit symp-

[4] For more information concerning the GUESSS study, we refer to: http://www.guesssurvey.org and http://www.eur.nl/ondernemerschap/research/guess_survey/.

toms and hyperactivity symptoms scales were 0.49, 0.53, 0.32, respectively, indicating that the scales had a low to moderate reliability. The three scales were only moderately skewed: sample skewness for total ADHD symptoms was equal to 0.42; for attention-deficit symptoms it was equal to 0.52; for hyperactivity symptoms it was equal to 0.55. These sample skewness measures indicated that log-transformation was not needed.

The ASRS-6 v1.1 screener of the GUESSS study is based upon the 18 item DSM-IV criteria used in the STAGE cohort (Kessler et al., 2005). This enabled us to replicate the analysis in the STAGE cohort using the 6 items from the ASRS-6 v1.1 screener and to compare the outcomes of both analyses.

4.2.6 Statistical analysis

To examine the association between ADHD symptoms and the self-employment choice, we estimated binary logistic regressions using STATA (version 12.0). First, in the STAGE cohort, we examined the association between the 18 item DSM-IV diagnostic criteria for the total ADHD symptoms, attention-deficit symptoms, hyperactivity symptoms, and the self-employment choice (part-/full-time). Second, in the GUESSS study we estimated the associations between the ASRS-6 v1.1 score of total ADHD symptoms, attention-deficit symptoms, hyperactivity symptoms and the self-employment choice. We included the effect sizes in terms of odds ratios (OR) and the associated 95% confidence intervals (95% CI). In the tables, we denote statistical significance (p-values at 5%, 1%, and 0.1% levels, respectively) using asterisks (*, **, and ***, respectively).

4.3 Results

4.3.1 STAGE cohort

In Table 1, we present the results of the binary logistic regressions of self-employment choice (part-/full-time) on the log-transformed score for the total ADHD symptoms, attention-deficit symptoms, and hyperactivity symptoms. Both total ADHD symptoms and the hyperactivity symptoms showed a positive association with the self-employment (part-/full-time) choice (OR 1.13; 95% CI 1.04-1.23, and OR 1.19; 95% CI 1.08-1.32, respectively), but no associations were found for the attention-deficit symptoms (OR 0.99; 95% CI 0.89-1.10).

In addition, as a robustness check we constructed two additional scores: a "*wide criteria*" score where the responses to the DSM-IV 18 items 1 and 2 ("yes", or "yes, to

some extent") are recoded to yes, and 3 ("no") is recoded to no, and a "*strict criteria*" score where 1 ("yes") is recoded to yes, and 2 and 3 ("yes, to some extent", or "no") are recoded to no. This was done to examine the association between the ADHD symptoms and the self-employment choice when we employed a stricter definition of ADHD that is closer to an actual psychiatric diagnosis (Larsson et al., 2013). We drew similar conclusions with respect to the association between ADHD symptoms and the self-employment choice using stricter criteria by which ADHD symptoms were measured.[5]

To summarise, in the STAGE cohort, we found a positive association between both total ADHD symptoms and the hyperactivity symptoms and the self-employment choice, whereas there was no association between attention-deficit symptoms and the self-employment choice.

[5] The results of the robustness checks are available on request from the corresponding author.

Table 4.1
STAGE cohort; Binary logistic regressions with self-employment (part-/full-time) as dependent variable and total ADHD symptoms, and the two sub-scales attention-deficit symptoms and hyperactivity symptoms as independent variables.

	(1)	(2)
Total ADHD symptoms	1.13 **	
	(1.04 -1.23)	
Attention-deficit symptoms		0.99
		(0.89 - 1.10)
Hyperactivity symptoms		1.19***
		(1.08 - 1.32)
N	7,208	7,208
Log-likelihood	-2599	-2597
df	4	5
Chi-square	209.2	222.7
Pseudo R-square	0.04	0.04

Note: the coefficients are odds ratios (ORs) and 95% confidence intervals (CI) are in parentheses; *** p<0.001, ** p<0.01, * p<0.05

Adjusted model: Both models are adjusted for age, gender, and university education (0= no and 1= yes).

4.3.2 GUESSS study: replication

Using the 2012 data from the Global University Entrepreneurial Spirit Students' Survey (GUESSS), we attempted to replicate the observed association between ADHD symptoms and the self-employment choice. The results of the binary logistic regressions are presented in Table 2. These results suggested that there was no association between total ADHD symptoms and the self-employment choice (OR 0.99; 95% CI 0.93-1.07). However, in a separate analysis, the attention-deficit symptoms were negatively associated with the self-employment choice (OR 0.89; 95% CI 0.79-1.00), whereas the hyperactivity symptoms were positively associated with the self-employment choice (OR 1.13; 95% CI 1.00-1.28).

Table 4.2

GUESSS study; Binary logistic regressions with self-employment (part-/full-time) as dependent variable and total ADHD symptoms, and the two sub-scales attention-deficit symptoms and hyperactivity symptoms as independent variables.

	(1)	(2)
Total ADHD symptoms	0.99	
	(0.93-1.07)	
Attention-deficit symptoms		0.89*
		(0.79-1.00)
Hyperactivity symptoms		1.13*
		(1.00 -1.28)
N	13,119	13,119
Log-likelihood	-3189	-3183
df	3	4
Chi-square	208.5	214.8
Pseudo R-square	0.07	0.07

Note: the coefficients are odds ratios (ORs) and 95% confidence intervals (CI) are in parentheses; *** p<0.001, ** p<0.01, * p<0.05

Adjusted model: Both models are adjusted for age, and gender.

To summarise, in the GUESSS study, we found a negative association between attention-deficit symptoms and the self-employment choice, a positive association between hyperactivity symptoms and the self-employment choice, and no association between total ADHD symptoms and the self-employment choice.

As a sensitivity analysis and to enable comparison of the results of the GUESSS study, we examined the associations between ADHD symptoms and the self-employment choice in the STAGE cohort using the 6 items from the ASRS-6 v1.1 instead of the 18 item ADHD score. We found no significant association between the self-employment choice and the total ADHD symptoms (OR 1.04; 95% CI 1.00-1.09), and no association was found for the attention-deficit symptoms (OR 0.97; 95% CI 0.9-1.03). However, in line with our previous analyses presented above, we found a positive

association between the hyperactivity symptoms, and the self-employment choice (OR 1.04; 95% CI 1.00-1.09).[6]

To summarise, we found that the association between the total ADHD symptoms and the self-employment choice was positive in the STAGE cohort but this association was insignificant in the GUESSS study. The association between the attention-deficit symptoms and self-employment choice was negative in the GUESSS study and insignificant in the STAGE cohort. The association between the hyperactivity symptoms and the self-employment choice was positive in both the STAGE cohort and the GUESSS study.

4.4 Discussion

The present study moved beyond the clinical view of treating ADHD as a pathological disorder and used its symptoms across the entire measurement spectrum to examine a positive aspect: its association with the self-employment choice. Hence, the aim of this study was not to diagnose individuals with ADHD and then examine the viability of self-employment as a career option. Instead, we investigated whether individuals who exhibit higher levels of ADHD symptoms – but who are not necessarily screened positive for ADHD in a clinical sense – have a good fit with self-employment (compared with other options, such as wage-employment). In line with previous research, special attention was paid to whether this fit concerns total ADHD symptoms or the separate hyperactivity or attention-deficit symptom dimensions (Acosta, Castellanos, & Bolton, 2008; Grizenko, Paci, & Joober, 2009; Hesse, 2012; Larsson et al., 2013; Miller, Nigg, & Faraone, 2007).

Two independent samples were used for the present analysis: Swedish adults (STAGE cohort) and Dutch students (GUESSS study). In the Swedish sample, we found a positive association of both the total ADHD symptoms and hyperactivity symptoms with the self-employment choice, whereas this association could not be found for the attention-deficit symptoms. The positive association between the hyperactivity symptoms and the self-employment choice was replicated in the Dutch sample.

[6] In line with Kessler et al. (Kessler et al., 2005; Kessler et al., 2007) the reliability coefficients (Cronbach's alpha) for total ADHD symptoms, attention-deficit symptoms and hyperactivity symptoms are 0.59, 0.58, and 0.50, respectively, indicating that the scales are moderately reliable.

ADHD is typically characterised by high energy levels, which express themselves as severe and persistent attention-deficit and hyperactivity that is essentially driven by behavioural 'disinhibition' or a lack of restraint (Nigg, 1999). Far less attention is paid to ADHD symptoms adult decision-making (Young, 2000) but it is generally recognised that high levels of attention-deficit and hyperactivity have negative consequences in the work place; individuals who experience such behaviours tend to show a low job performance and a high chance of becoming unemployed (Bozionelos & Bozionelos, 2013; Halleland et al., 2015; Halmøy, Fasmer, Gillberg, & Haavik, 2009). However, the present results show that ADHD symptoms, particularly hyperactivity, are associated with aspects that are beneficial for the individual and society at large.

The present study has implications for further research. Our results may be an initial step towards establishing a link between ADHD symptoms and career choices, such as self-employment. The outcomes of this study may help to 'destigmatise' ADHD as a disorder, in particular given the positive associations people feel with self-employment in view of its contribution to socio-economic life. Given the high occurrence of moderate psychiatric symptoms, it is plausible (from a Darwinian perspective) that psychiatric symptoms not only confer risks but can also be beneficial for the individual. For the field of psychopathology it is important to study the potential benefits of having a high level of ADHD symptoms (Glass et al., 2012; Panksepp & Scott, 2012; White & Shah, 2006, 2011) across the lifespan (Kooij et al., 2005; Shelley-Tremblay & Rosén, 1996; Spencer et al., 2007; Williams & Taylor, 2006). Such a focus on the value (rather than the cost) of ADHD is at the heart of a recent stream of literature in the field of psychiatry, i.e., Darwinian Psychiatry, arguing that the persistence of such mental 'disorders' serves a purpose (Brüne et al., 2012; Shelley-Tremblay & Rosén, 1996; Troisi & McGuire, 2002; Williams & Taylor, 2006). According to this research stream, psychiatric symptoms or genetic variations that are mostly or currently disruptive for an individual's work and private life can – under some circumstances or in mild forms – be beneficial for 'adaptation' or survival of the individual. Hence, (young) adults who experience mild to severe ADHD symptoms may benefit rather than suffer from them, provided they find ways to cope with the negative consequences. Benefits may be particularly salient when individuals with ADHD symptoms find a suitable work environment, such as self-employment, where the "disorder" is not harmful but instead can be valuable and

help them to function well in society (Glass et al., 2012; Shelley-Tremblay & Rosén, 1996; Williams & Taylor, 2006).

Although the present study is just a first contribution to the detection of possible positive aspects of ADHD symptoms, it highlights some promising avenues for future research. *First*, the current data do not enable us to examine the association between ADHD symptoms and the performance of self-employed individuals. The question that arises is whether self-employed individuals who score higher on ADHD symptoms also have better performing ventures (Rauch et al., 2009). *Second*, the decision to become self-employed may not be the only association with ADHD symptoms; this may also be the case for underlying entrepreneurial behaviours such as risk-taking and proactiveness. ADHD symptoms may also have 'positive' associations with other socio-economic behaviours for occupational choice, such as in the areas of management and consultancy positions (Thurik et al., 2013). *Third*, in order to generalise the results in this study, it is worthwhile to examine the association between ADHD symptoms and self-employment in other, preferably non-European, population-based cohorts. It is also important to distinguish between individuals with a different occupational status in the control group, including wage-employment and unemployment. For future research, it is important to make a distinction between these (alternative) occupations to effectively examine the association with different control groups.

To conclude, our results indicated that the positive association between ADHD symptoms and the self-employment choice hinges primarily on the hyperactivity symptoms of ADHD, whereas the overall association between ADHD symptoms and the self-employment choice is only significant in one of our two samples. For future research, it is important to understand how ADHD symptoms are associated with more specific self-employment behaviours, such as the level of risks taken or the performance in self-employment or as a business owner. This may enhance our understanding of the positive effects of ADHD symptoms or even "destigmatise" ADHD as a disorder that always deserves treatment.

CHAPTER 5

Attention-deficit/hyperactivity disorder (ADHD) symptoms and entrepreneurial orientation

Based on Rietdijk, Verheul Khedhaouria, Franken and Thurik (2015c)

Abstract

Recent studies associate attention-deficit/hyperactivity disorder (ADHD) symptoms to entrepreneurship-related behaviors, such as entrepreneurial intentions, choice and orientation. Although these studies uncover important insights into these associations, a potential limitation is that they do not distinguish between the two dimensions that constitute ADHD symptoms, viz., attention-deficit (AD) and hyperactivity (HD) symptoms. Therefore, we associate ADHD symptoms and the two dimensions separately to entrepreneurial orientation in two samples: a first sample of Dutch solo self-employed individuals (i.e., the Panteia/EIM study) and we re-analyze the data from a second sample of French small business owners (i.e., the Amarok study). Taken together the results of the present study and the findings in earlier studies, we conclude that the results show that there is some evidence for the positive association between ADHD symptoms and EO, but that this association is primarily driven by HD symptoms.

5.1 Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a psychiatric disorder characterized by attention-deficit and hyperactivity symptoms (American Psychiatric Association, 2013). Until recently ADHD was considered a childhood disorder that was usually diagnosed before the age of 12 (Barkley, 1997; Cantwell, 1996; Kooij et al., 2005). However, follow up studies find that ADHD symptoms persist into adulthood and bare consequences for many later life decisions (Biederman, et al., 2010; Biederman, et al., 2010; Spencer, Biederman, & Mick, 2007). Therefore, the DSM-5 enables the application of the diagnosis also during adulthood (American Psychiatric Association, 2013; Kooij et al., 2005) which led to an increased attention towards studying consequences of ADHD symptoms for later life decisions (Kooij et al., 2005).

In addition, psychiatry research usually focuses on the negative consequences of ADHD symptoms (Kooij et al., 2005), whereas only a few studies (in line with the Darwinian perspective of psychiatry) argue that these symptoms do not only carry risks, but may, under certain circumstances also have some beneficial value for the individual (Brüne et al., 2012; Shelley-Tremblay & Rosén, 1996). For this reason, some studies examine positive aspects of ADHD symptoms for later life consequences and decisions, such as close friendship (Glass et al., 2012), well-being (Wilmshurst et al., 2011) and entrepreneurship as an occupational choice compared to wage-paid employment (Rietdijk et al., 2015b; Verheul et al., 2015).

Initially, anecdotal evidence links ADHD symptoms to behaviors important for entrepreneurship, such as risk-taking, proactiveness, highly energetic and being able to 'creatively establish new businesses' (Archer, 2014a, 2014b; Hartmann, 2002; Shelley-Tremblay & Rosén, 1996; The Economist, 2012). Some first studies moved beyond the anecdotal level and examine the associations between these symptoms and three levels of entrepreneurship-related behaviors, viz., *entrepreneurial intentions* (Verheul et al., 2015), *entrepreneurial choice* (Rietdijk et al., 2015b) and *entrepreneurial orientation (EO)* Khedhaouria et al. (2014). In line with the 'job-person' fit perspective, these studies find positive associations and argue that entrepreneurship compared to wage-paid employment may be a more suitable working-environment for individuals that experience high level of ADHD symptoms (Kessler et al., 2009; Kristof-Brown, Zimmerman, & Johnson, 2005).

Khedhaouria et al. (2014) find a positive association between ADHD symptoms and EO in French small business owners. Although this study is an excellent starting point, there is a potential limitation. Recent studies suggest that ADHD symptoms consists of two separate dimensions, viz., attention-deficit (AD) and hyperactivity (HD) symptoms that are only partly correlated (Hesse, 2012). In line with these results, other studies identify AD and HD has different genetic and environmental risk factors (Grizenko et al., 2009).

The two separate dimensions have also shown to have different comorbid conditions such as separate AD symptoms are more associated with anxiety and depression, whereas the combined AD and HD symptoms are associated with externalizing problems (e.g. violent behavior) (Acosta et al., 2008; Hesse, 2012; Miller et al., 2007). More recently, Rietdijk et al. (2015b) find that also the association between ADHD symptoms and the choice to become self-employed is primarily driven by HD symptoms and not by AD symptoms. Khedhaouria et al. (2014) and Verheul et al. (2015) examine the association between ADHD and entrepreneurship-related behaviors but do not distinguish between AD and HD as separate dimensions.

Therefore, this study attempts to replicate the association between ADHD symptoms and EO in a sample of solo self-employed. In addition, we re-analyze the data of the Amarok study from Khedhaouria et al. (2014) to enable comparison of the results. Taken together, the results in both samples provide evidence that the strength and direction of the associations are similar in the two samples, while some of these associations are not significant in the Amarok study. In line with the two initial studies (Rietdijk et al., 2015b; Verheul et al., 2015), we conclude that the results show that there is indeed some evidence for the positive association between ADHD symptoms and EO and this positive association is primarily driven by HD symptoms.

5.2 Methodology

5.2.1 Panteia/EIM study: Dutch solo self-employed

In this study, we use data from the Panteia/EIM Panel of solo self-employed.[7] Solo self-employment is considered a type of entrepreneurial venture where one individual is in

7 Source: Panteia/EIM (2014). For details we refer to online documentation: https://easy.dans.knaw.nl/ui/datasets/id/easy-dataset:55814 (in Dutch).

charge of a venture (Burke, 2011; Carland & Hoy, 1984, p.356; Storey, 1994; Vesper, 1980) which plays an increasingly important role in modern economies (Arum & Müller, 2004; Burke, 2011, 2012; Rapelli, 2012), but receives little attention in research (Blanchflower, 2000, p.475; Kitching & Smallbone, 2012, p.75).

The data of the solo self-employed sample were collected during an Internet survey in December 2013. A total of 2,554 solo self-employed received an invitation to complete the online questionnaire, out of which 820 (32%) individuals participated. There was 5% item non-response in the sample of 820 individuals. The final sample consists of 779 solo self-employed (30% female, M_{age}= 51.39; SD_{age}= 9.35). Five randomly selected participants received a gift voucher of 50 Euros (about 65 Dollars) for their participation.

5.2.2 Measures

Entrepreneurial Orientation (EO)

We measure entrepreneurial orientation using the scale developed by Bolton & Lane (2012) and Bolton (2012), which consists of 10-items scoring on a 5-point Likert scale (1=completely disagree, to 5=completely agree), and each of these 10 items reflect one of the three dimensions of EO, viz., risk-taking (e.g., *I like to take bold action by venturing into the unknown*), proactiveness (e.g*., I usually act in anticipation of future problems, needs or changes*) and innovativeness (e.g., *I favor experimentation and original approaches to problem solving rather than using methods others generally use for solving their problems*). All ten separate items are available on request from the corresponding author, or can be found in the original study by Bolton (2012) and Bolton & Lane (2012). The Cronbach's alpha for the total EO scale is .82, and of the three separate dimensions is for risk-taking, proactiveness and innovativeness are 0.71, 0.70 and 0.73, respectively. This demonstrates that the EO provides sufficient internal reliability (Hinton, Brownlow, & McMurray, 2004). The sum scores of these items are taken into the analysis.

Attention-deficit/hyperactivity disorder symptoms

We measure the level of ADHD symptoms using the World Health Organization ADHD Self-Report Scale (ASRS-6 v1.1 screener) (Kessler et al., 2005; Kessler et al., 2007). Participants were asked to respond on a 5-point Likert scale (1=never, to 5=very often) how they felt over the past six months concerning the following six questions: (1) *How*

often do you have trouble wrapping up the final details of a project, once the challenging parts have been done?; (2) *How often do you have difficulty getting things in order when you have to do a task that requires organization?;* (3) *How often do you have problems remembering appointments or obligations?;* (4) *When you have a task that requires a lot of thought, how often do you avoid or delay getting started?;* (5) *How often do you fidget or squirm (move) with your hands or feet when you have to sit down for a long time?; and* (6) *How often do you feel overly active and compelled to do things, like you were driven by a motor?*

The internal reliability coefficient (Cronbach's alpha) of the ASRS-6 v1.1 in this sample is 0.7, suggesting sufficient internal reliability (Hinton et al., 2004). We take the sum score on the 6 items of the ASRS-6 as a proxy for ADHD symptoms. In addition, we construct two dimensions out of the ADHD symptoms in line with Hesse (2012) and Kessler et al. (2005), viz., AD symptoms and HD symptoms. First, items 1 through 4 cover AD symptoms, and items 5 and 6 cover HD symptoms. The reliability (Cronbach's alpha) of the AD symptoms (0.76) and HD symptoms (0.41) demonstrate to be high and low, respectively. The sum scores for the 4 and 2 measures of AD and HD are taken into the analysis, respectively.

Control variables

We control for the usual demographic variables of the solo self-employed: *Age*, *Gender (*female = 1), and *Level of education*. Furthermore, we include a control variable about the *job satisfaction* of the solo self-employed individual. Job satisfaction is asked on a 5-point Likert-scale (1 = very dissatisfied, 5 = very satisfied) and reflects six aspects of the job such as, income, hours/week, nature of the work, stress, utilization of skills, overall satisfaction with the job (Ybema et al., 2013). Moreover, we add another control variable of whether the solo self-employed produces mainly *goods or services*. Finally, sector dummies are included (10 levels, where the largest group, i.e., the B2B services serves as the reference category).

5.2.3 Amarok study: French small business owners

We re-analyze the data of from Khedhaouria et al. (2014) to enable the comparison between the results of both studies. Khedhaouria et al. (2014) use the same measure for ADHD, viz., the ASRS6 v1.1 measurement scale developed by Kessler et al. (2005) and Kessler et al. (2007) and use the entrepreneurial orientation measurement scales pro-

posed by Wales, Patel, & Lumpkin (2013). For a full account of the data we refer to the original study of Khedhaouria et al. (2014). We included age, gender, level of education, firm size and level of experience as control variables.

5.2.4 Statistical analysis

We will analyze the data of both data sets in a similar fashion. First, using ordinary least squares (OLS) regressions we analyze the association between ADHD symptoms and the complete entrepreneurial orientation, which consist of the three dimensions: risk-taking, proactiveness and innovativeness. Second, we will distinguish between the two dimensions of ADHD, viz., attention-deficit symptoms and hyperactivity symptoms and associate these to EO. Third, we will run similar analyses for the three dimensions that together constitute EO as dependent variables, viz., risk-taking, proactiveness and innovativeness.

5.3 Results

5.3.1 Dutch solo self-employed individuals: regression analysis

Table 5.1 presents the regression models of the association between ADHD symptoms, AD and HD symptoms and EO and its dimensions: risk-taking, proactiveness, and innovativeness. *First*, the EO model generally fits moderately with the ADHD symptoms ($F(15,763) = 4.09$, $p<.001$), as well as with the separate dimensions AD and HD symptoms as independent variables ($F(16,762) = 5.07$, $p<.001$). EO is not associated with ADHD symptoms ($\beta = .03$, $p>.05$), negatively associated with AD symptoms ($\beta = -.06$, $p<.01$), and positively associated with HD symptoms ($\beta = .19$, $p<.001$).

Second, the risk-taking model generally fits moderately with the ADHD symptoms as independent variables ($F(15,763) = 4.31$, $p<.001$), as well as with the separate dimensions AD and HD symptoms ($F(16,762) = 4.13$, $p<.001$). Risk-taking is positively and significantly associated with ADHD symptoms ($\beta = .02$, $p<.01$), and HD symptoms ($\beta = .04$, $p<.01$). There is no significant association between AD symptoms and risk-taking ($\beta = .04$, $p>.05$).

Third, the proactiveness model generally fits moderately with the ADHD symptoms as independent variables ($F(15,763) = 3.57$, $p<.001$), as well as with the separate dimensions AD and HD symptoms ($F(16,762) = 5.87$, $p<.001$). Proactiveness is negatively associated with ADHD symptoms ($\beta = -.03$, $p<.001$), and AD symptoms ($\beta = -.08$,

p<.001). Moreover, there is a positive significant association between proactiveness and HD symptoms (β = .07, p<.001).

Fourth, the innovativeness model generally fits moderately with the ADHD symptoms as independent variables (F(15,763) = 4.01, p<.001), as well as with the separate dimensions AD and HD symptoms (F(16,762) = 4.27, p<.001). Innovativeness is positively associated with ADHD symptoms (β = .03, p<.001), and HD symptoms (β = .07, p <.001). Moreover, there is no significant association between innovativeness and AD symptoms (β = .01, p>.05).

Taken together, in the solo self-employed data we observe the patterns that ADHD symptoms are associated with the three dimensions of EO, viz., risk-taking, proactiveness and innovativeness, and that in line with our expectations that HD symptoms usually show larger, more positive coefficients compared to AD symptoms in association with EO and the separate dimensions. In the solo self-employed data, the associations between HD symptoms and EO and its dimensions are significant, whereas there are mixed results for the association between AD and these dimensions.

5.3.2 French business owners: regression analysis

Table 5.2 presents the regression models of the association between ADHD symptoms, AD symptoms and HD symptoms and EO and its dimensions: risk-taking, proactiveness, and innovativeness. *First*, the EO model does not fit well with the ADHD symptoms as independent variables (F(5,300) = .61, p>.05), neither with the separate dimensions AD and HD symptoms (F(6,299) = .69, p>.05). EO is positive but insignificantly associated with ADHD symptoms (β = .02, p>.05), negative and insignificantly with AD symptoms (β = -.04, p>.05), and positive and insignificantly with HD symptoms (β = .04, p>.05).

Second, the risk-taking model does not fit well with the ADHD symptoms as independent variables (F(5,300) = 1.62, p>.05), neither with the separate dimensions AD and HD symptoms (F(6,299) = 1.49, p>.05). Risk-taking is positive and significantly associated with ADHD symptoms (β = .16, p<.05), positive but insignificantly with AD symptoms (β = .03, p>.05), and positive and significantly with HD symptoms (β = .11, p<.05).

Third, the proactiveness model does not fit well with the ADHD symptoms as independent variables (F(5,300) = 1.89, p<.05), neither with the separate dimensions

AD and HD symptoms ($F(6,299) = 1.79$, $p<.05$). Proactiveness is negative but insignificantly associated with ADHD symptoms ($\beta = -.1$, $p>.05$), negative but insignificantly associated with AD symptoms ($\beta = -.02$, $p>.05$), and negative but insignificantly associated with HD symptoms ($\beta = -.01$, $p>.05$).

Fourth, the innovativeness model does not fit well with the ADHD symptoms as independent variables ($F(5,300) = .53$, $p>.05$), neither with the separate dimensions AD and HD symptoms ($F(6,299) = .49$, $p>.05$). Innovativeness is positive but insignificantly associated with ADHD symptoms ($\beta = .003$, $p>.05$), negative but insignificantly associated with AD symptoms ($\beta = -.04$, $p>.05$), and positive but insignificantly associated with HD symptoms ($\beta = .02$, $p>.05$).

Taken together, the results of the Amarok provide less statistical significant results compared to the results in the solo self-employed sample. However, the coefficients for the associations between ADHD, AD and HD symptoms and EO in both samples show similar trends. More specifically, the strength, direction of the associations is comparable in both samples. For example, HD symptom coefficients are always more positive compared to AD symptoms and there are similar patterns in coefficients comparing the two samples.

Table 5.1 Solo self-employed: regression analysis

	EO			Risk-taking		
ADHD Symptoms		0.03			0.02**	
		(0.020)			(0.009)	
Attention-deficit symptoms			-0.06**			0.01
			(0.028)			(0.013)
Hyperactivity symptoms			0.19***			0.04**
			(0.043)			(0.020)
Observations	779	779	779	779	779	779
R-squared	0.07	0.07	0.10	0.07	0.08	0.08
F	4.24***	4.09***	5.07***	4.14***	4.31***	4.13***
df	(14,786)	(15, 763)	(16, 762)	(14,786)	(15, 763)	(16, 762)

table 5.1 (continued)

	Pro-activeness			Innovativeness		
ADHD Symptoms		-0.03***			0.03***	
		(0.008)			(0.009)	
Attention-deficit symptoms			-0.08***			0.01
			(0.012)			(0.012)
Hyperactivity symptoms			0.07***			0.07***
			(0.018)			(0.018)
Observations	779	779	779	779	779	779
R-squared	0.05	0.07	0.11	0.06	0.07	0.08
F	3.17***	3.57***	5.87***	3.39***	4.01***	4.27***
df	(14,786)	(15, 763)	(16, 762)	(14,786)	(15, 763)	(16, 762)

All models are adjusted for age, gender, level of education, goods/services, job satisfaction, industry (10 levels, 9 dummies). Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 5.2 Amarok study: Regression analysis

	EO			Risk-taking		
ADHD Symptoms		0.02			0.16**	
		(0.058)			(0.071)	
Attention-deficit symptoms (AD)			-0.044			0.026
			(0.058)			(0.071)
Hyperactivity symptoms (HD)			0.04			0.11**
			(0.039)			(0.048)
Observations	306	306	306	306	306	306
R-squared	0,012	0,012	0,016	0,012	0,028	0,03
F	0,7	0,61	0,69	0,89	1,62	1,49
df	(4,301)	(5,300)	(6,299)	(4,301)	(5,300)	(6,299)

table 5.2 (continued)

	Pro-activeness			Innovativeness		
ADHD Symptoms		-0,097			0,003	
		(0.076)			(0.083)	
Attention-deficit symptoms (AD)			-0,021			-0,039
			(0.076)			(0.083)
Hyperactivity symptoms (HD)			-0,01			0,023
			(0.052)			(0.056)
Observations	306	306	306	306	306	306
R-squared	0,031	0,037	0,04	0,01	0,01	0,011
F	1,94*	1,894*	1,79*	0,63	0,53	0,49
df	(4,301)	(5,300)	(6,299)	(4,301)	(5,300)	(6,299)

All models are adjusted for age, gender, level of experience, level of education and firm size. Standard errors in parentheses, *** p<0.001, ** p<0.05, * p<0.1

5.4 Discussion

The present study examines the association between ADHD symptoms and entrepreneurial orientation (EO). We examine this association in two samples. The first sample consists of Dutch solo self-employed individuals, i.e., the Panteia/EIM study. The results in this sample suggest that the positive association between ADHD symptoms and (the dimensions of) EO is primarily driven by the hyperactivity (HD) symptoms. Generally, the effect size of HD symptoms compared to attention-deficit (AD) symptoms is larger and more positive. This suggests that the positive association between ADHD and EO primarily hinges on HD.

Besides, we re-analyze the data from the second sample, which consists of French small business owners (Khedhaouria et al., 2014), i.e., the Amarok study. In this sample, we find less statistical significant results but we are able to observe similar trends in terms of strength and direction in the coefficients comparing the results of both samples. In particular, a trend is observed that HD symptoms are usually more positively related to (the dimensions of) EO compared to AD symptoms. A possible reason for the lack of statistical significance in the Amarok study may be due to the small sample size. However, given the trends in the coefficients for the associations between ADHD symptoms and EO in both samples, we conclude that there is indeed some evidence for a positive association but that is primarily driven by HD symptoms.

Our results are in line with earlier studies concerning the association of ADHD symptoms and entrepreneurship-related behaviors that suggest ADHD symptoms are positively associated with entrepreneurial intentions and choice (Rietdijk et al., 2015b; Verheul et al., 2015). The present study is in line with Rietdijk et al. (2015b) who found that ADHD and entrepreneurial choice are positively associated, but that this positive association is primarily driven by HD symptoms.

This study also has several limitations that open up ample room for future research. *First*, Khedhaouria et al. (2014) report a positive association between ADHD symptoms and EO, while the OLS regression results presented in this study show that this association is insignificant. The driver of this difference is the fact that Khedhaouria et al. (2014) conduct a confirmatory factor analysis to select the items from the ASRS-6 v1.1 that best fit the ADHD symptoms construct, using this approach Khedhaouria et al. (2014) dropped two questions. The different approach that is used in the present study is

following the standards of the ASRS-6 v1.1 set by Kessler et al. (2005) and include all 6 items disregarding their fit but fully reflecting the variety of ADHD symptom aspects. The advantage of the latter approach is the results are comparable to other studies in psychiatry (Halleland et al., 2015; Kessler et al., 2009) and entrepreneurship (Rietdijk et al., 2015b; Verheul et al., 2015).

Second, the results in the French business owner study suggest that although similar trends in the coefficients are visible compared to Dutch solo self-employed, we find no statistical significant associations. There are two potential drivers of these differences that need to be addressed in future research: limited sample size in the Amarok study and the use of different EO measurement scales used in the two samples. To exclude sample size as a possible driver of these differences it is important for future studies to replicate the present association between ADHD symptoms and EO in separate independent samples with larger sizes. Another possible driver is that in the solo self-employed individuals EO is measured using a scale developed by Bolton & Lane (2012) whereas the Amarok study measured EO using the scale of Wales et al. (2013). Although, these scales are conceptually measuring similar aspects of entrepreneurial orientation, we cannot exclude that there are differences that lead to the results we observed in this study. For future research it is important to understand whether these two measurement scales capture the same concepts and adequately reflect EO. Both issues need to be addressed in future research to fully reconcile the differences between the two samples and confirm the associations between ADHD symptoms and entrepreneurship-related behavior (Rietdijk et al., 2015b; Verheul et al., 2015).

Third, the present study uncovers the association between the third level of entrepreneurship-related behaviors, viz., EO. The present study fits within the scope of the other three studies that associated ADHD symptoms to entrepreneurial intentions (Verheul et al., 2015), choice (Rietdijk et al., 2015b) and orientation (Khedhaouria et al., 2014). For future research it is important to study the association between ADHD symptoms and entrepreneurial performance.

Finally, the present study is in line with the idea to 'destigmatize' psychiatric disorders and examine their associations with potential positive aspects such as entrepreneurship-related behaviors. The high prevalence of levels of psychiatric symptoms in the population suggests that it is important to understand the consequences of these

symptoms for daily life decisions. In addition, although the scope of the present study is limited to ADHD symptoms, there may be other (aspects of) psychopathologies that play a role in entrepreneurship-related behaviors, such as hypomania. Hypomania is a symptom of major depressive disorder that may under certain circumstances have a positive effect on creative thinking in individuals. In turn, creativity is seen as an important aspect of entrepreneurship (Flach, 1990; Furnham et al., 2008; Healey & Rucklidge, 2006; Johnson et al., 2012; Lloyd-Evans et al., 2006; White & Shah, 2006, 2011). However, the direct link between hypomania and entrepreneurship is to be uncovered.

To conclude, our results indicate that indeed there is some evidence that ADHD symptoms and EO are positively associated, but that this is primarily driven by the HD symptoms. For future research, it is important to understand how ADHD symptoms are associated with other entrepreneurship-related behaviors, such as the (financial) performance of entrepreneurs. This will contribute to our understanding of the associations between ADHD symptoms and economic decision-making and understand positive aspects of these symptoms.

CHAPTER 6

Temporal focus and entrepreneurial orientation of solo self-employed

Based on Rietdijk, Verheul, De Vries and Thurik (2015d)

Abstract

There is a growing literature that examines the temporal nature of managerial behavior and outcomes. Given the importance of attentional biases of CEOs for shaping strategic behavior, this study contributes by investigating the relation between temporal focus and Entrepreneurial Orientation (EO) in a sample of 783 solo self-employed individuals who have full managerial discretion. We find that both present and future temporal focus of these individuals are positively related to their EO, but that this relationship is stronger for future focus. We also test two competing hypotheses about how present and future focus interact with EO. Our findings suggest that these two foci are substitutes rather than complements in determining EO of solo self-employed individuals which may be explained by the resource constraints faced in solo self-employment.

6.1 Introduction

How we perceive time and its boundaries has important consequences for many daily decisions (George & Jones, 2000; Shipp et al., 2009). It is therefore not surprising to see a vast and ever growing amount of research focusing on temporal decisions, behavior and outcomes in different disciplines including psychology (Smallwood, Nind, & O'Connor, 2009), economics (Binswanger & Carman, 2012; Golsteyn et al., 2014; Ruffle & Tobol, 2014; Volk, Thöni, & Ruigrok, 2012), management (Das & Teng, 2001; Nadkarni, Chen, & Chen, 2015; Shi & Prescott, 2012; Souder & Bromiley, 2012; Van Doorn, Jansen, Van Den Bosch, & Volberda, 2013), leadership (Bluedorn & Jaussi, 2008; Bluedorn & Martin, 2008; Halbesleben & Buckley, 2004), organizational behavior (Mohammed & Harrison, 2013; Slocombe & Bluedorn, 1999) and entrepreneurship (Bluedorn & Martin, 2008; Lumpkin, Brigham, & Moss, 2010; Tumasjan, Welpe, & Spörrle, 2013).

Although everyone experiences the objective passage of time, individuals differ with respect to their (subjective) perception of, and focus on, different time periods including the past, present and future (Shipp et al., 2009; Soo, Tian, Cordery, & Kabanoff, 2013). This temporal focus influences a person's motivation, decisions and behavior (Ancona, Okhuysen & Perlow, 2001, p.518; Shipp, Edwards & Lambert, 2009) and has been linked with managerial behavior and outcomes such as resource management strategies (Bridoux, Smith, & Grimm, 2011), strategic change (West & Meyer, 1997), innovation (Nadkarni & Chen, 2014; Yadav, Prabhu, & Chandy, 2007) and team performance (Mohammed & Harrison, 2013). Sporadically, temporal focus has been related to entrepreneurial behavior (Foo et al., 2009; Lumpkin et al., 2010; Tumasjan et al., 2013).

Shrinking product and business model life cycles make future revenues increasingly uncertain and force companies to continuously search for, and invest in, new lines of business (Lumpkin & Dess, 2001). Firms may therefore benefit from the pursuit of an "entrepreneurial strategic orientation" to identify original business opportunities and launch new ventures (Lumpkin & Dess, 1996, 2001) by combining risk-taking, innova-

tive and proactive behavior (Miller, 1983; Miller, 2011).[8] Research shows that entrepreneurial orientation (EO) is important for firm performance in different ways: influencing performance (in-)directly (Kollmann & Stöckmann, 2012; Wiklund, 1999); acting as a mediator linking other factors to performance (Keh, Nguyen, & Ng, 2007; Rosenbusch, Rauch, & Bausch, 2011); or reinforcing performance as a moderator (Wiklund & Shepherd, 2003; Wales, Parida, & Patel, 2013). In addition, the relationship between EO and firm performance is found dependent upon factors internal and external to the company (Covin, Green, & Slevin, 2006; Khedhaouria, Gurău, & Torrès, 2015; Rauch, Wiklund, Lumpkin, & Frese, 2009; Stam & Elfring, 2008; Walter, Auer, & Ritter, 2006; Wiklund & Shepherd, 2005).

Given that time is seen as fundamental to the discovery and exploitation of entrepreneurial opportunities (Baron, 1998; Bird & West, 1997), the present study sets out to examine the temporal nature of EO, through linking it with present and future temporal focus. We examine the link between temporal focus and EO in a sample of 783 solo self-employed individuals, who run a business for their own account and risk and operate solo (without employing staff members)[9]. Despite the important role of self-employment in modern economies (Audretsch & Thurik, 2001; Thurik et al., 2013), knowledge of how solo operating self-employed individuals compete and run their business operations is still limited (Van den Born & van Witteloostuijn, 2013).

This study contributes in several ways. *First*, answering the call of Shipp et al., (2009, p.18) for more research into the role of temporal focus in determining organizational behavior, and in line with Nadkarni and Chen (2014) who point out the importance of CEO attentional biases in shaping strategic behavior, we study the relation between temporal focus and a (strategic) entrepreneurial orientation (EO). Next to examining the independent links of present and future temporal focus with EO, we take account of their combined effect as it is deemed important for those in charge of organi-

[8] The concept of EO is rooted in the work of Khandwalla (1977) and Mintzberg (1973), but Miller (1983) was the first to assess entrepreneurship by take into account risk-taking, proactiveness and innovativeness as entrepreneurial orientation behaviors.

[9] The term 'solo self-employed individuals' differs from that of 'self-employed persons' where the first operate solo and the latter may have employees. What we refer to as solo self-employed individuals in other studies is labeled as independent contractors (Davis-Blake & Uzzi, 1993), own-account workers (Earle & Sakova, 2000) or freelancers (Van den Born & van Witteloostuijn, 2013).

zational processes (e.g., managers, entrepreneurs) to satisfy current demands while at the same time preparing for future challenges (Gibson & Birkinshaw, 2004; Jansen et al., 2005). Assuming a combined temporal focus, we take a stand in the debate about the conceptualization and operationalization of the temporal focus construct, which by some scholars is seen as a fixed (predominant) orientation on one of the extremes (i.e., classifying people as either having a past, present or future focus) (Kabanoff & Keegan, 2009; Yadav et al., 2007; Zimbardo & Boyd, 1999), whereas others assert that focusing on one period does not preclude thinking about the other (Shipp et al., 2009, p. 2). Although scholars increasingly acknowledge the multidimensionality of the temporal focus construct (Nadkarni & Chen, 2014), there is still limited knowledge of its implications. We test for an interaction effect of present and future temporal focus and formulate two competing hypotheses: whether both present and future focus are *complements* or *substitutes* in determining EO.

Second, we contribute to the entrepreneurship literature by examining the temporal nature of EO. Although it is often proclaimed that the pursuit of an entrepreneurial strategy calls for leaders who are capable of anticipating on future outcomes (Foo et al., 2009) and adjusting their present behavior to take advantage of "unrealized potential" (West & Meyer, 1997), there is only a handful of studies focusing on the link between time orientation and EO. Zahra, Hayton, & Salvato (2004) tested the relation between EO and time orientation (proxied by the implementation of strategic or financial controls) in family and non-family firms. Lumpkin et al. (2010) discuss short-term and long-term perspectives of EO in relation to performance, and conclude that more research is needed including empirical studies that test the direct links between a company's time horizon for decision-making and EO, and focusing on the "individual time orientations of key decision-makers" (p.258).

Finally, we study temporal focus and the link with EO in a new empirical setting: that of solo self-employment, which is a type of entrepreneurial venture that has increased worldwide in the last two decades (Beck, 2000; Hipple, 2010)[10]. The context of solo self-employment allows us to examine the individual temporal orientation and

[10] Especially during a period of economic decline, individuals (involuntarily) leave organizations and become self-employed, thereby increasing the competition for work (Biehl, Gurley-Calvez, & Hill, 2014; Burke, 2011; Carrasco, 1999; Moore & Mueller, 2002; Müller & Arum, 2004).

the association with EO without the interference from team or organizational factors. Unlike small business owners or managers of large organizations, solo self-employed individuals have full 'managerial discretion' as there is no distinction between the owner and the business, and therefore there are no organizational constraints limiting the influence of managers on their business strategy and/or performance (Hambrick & Mason, 1984; Hambrick, 2007)[11].

6.2 Theory and hypothesis

6.2.1 The temporal nature of EO

Planning and action have long been considered two fundamental (but often contradictory) strategies in managing organizations. Mintzberg & Westley (2001), for example, distinguished between a rational ('think first') and an action-oriented ('act first') approach to decision-making[12]. There has also been quite some debate about the (relative) value of planning (requiring a long time horizon) and action (requiring a short time horizon) for successful entrepreneurship. In their meta-analysis, Brinckmann, Grichnik, & Kapsa, (2010) summarize the vivid debate about the importance of business planning for entrepreneurial performance. Emphasizing the action element in entrepreneurship, different scholars have explored the importance of improvisation for new venture performance (Baker, Miner, & Eesley, 2003; Hmieleski & Corbett, 2008). In her work Sarasvathy (2001) proposes that the future can not be predicted by writing plans, and that experienced entrepreneurs adopt an effectual (rather than a causal) approach and attempt to control the future by their own actions.

The distinction between short-term action and long-term planning appears essential for understanding the consequences of a present focus and a future focus, resp., for strategic decision-making. Based on the individual inclination to prefer one time period over the other, future oriented individuals can best be described as those who focus on (long-term) planning; who are driven by goals; and who take into account future consequences (Kabanoff & Keegan, 2009; Shipp et al., 2009). Present focused individuals, on

[11] According to Hambrick (2007, p. 335): "upper echelons theory offers good predictions of organizational outcomes in direct proportion to how much managerial discretion exists. If a great deal of discretion is present, then managerial characteristics will become reflected in strategy and performance".

[12] In addition, Mintzberg & Westley (2001) distinguish a third intuitive ('seeing first') approach.

the other hand, emphasize 'learning by doing' (or short-term planning); are motivated by feedback (prompted by behavior) (Kanfer & Ackerman, 1989); and have a preference for immediate rewards (Kabanoff & Keegan, 2009).

Thusfar, research did not explicitly link temporal focus and EO, but there have been studies that associated present and/or future temporal focus with separate dimensions of EO (risk-taking, proactiveness, innovativeness). In the remainder of this section we discuss these linkages in more detail and show what they have in common, which leads us to formulate a set of hypotheses linking temporal focus to EO.

Risk-taking, defined as the extent to which managers in companies follow new strategies and support projects with uncertain returns (Venkatraman, 1989), involves taking bold (instead of cautious) actions such as venturing into unknown markets, and extensive resource investments, to achieve set goals (Lumpkin & Dess, 2001). Irrespective of its precise definition, it appears that risk-taking involves foreseeing future outcomes together with taking action in the present that may or may not produce these outcomes, e.g., individuals may be willing to take monetary risks in the present in exchange for financial gains in the future (Shipp et al., 2009; Stewart & Roth, 2001).

Proactiveness, "an opportunity-seeking, forward looking perspective involving the introduction of new products and services ahead of competitors and acting in anticipation of future demand to create change and shape the environment" (Lumpkin & Dess, 2001, p. 431), has been related to (new venture) managers' future orientations, i.e., their preferential orientation toward events in the future (Sarasvathy, 2001), and their capability of "visualizing, comprehending, and grasping the distant future" (Das, 1987, p.205). Foo, Uy, & Baron (2009) argue that a future temporal focus fosters proactive behavior that takes place in the present. Grant & Ashford, (2008, p.9) conceptualized such proactive behaviors as "future focused," "mindful," and "acting in advance with foresight about future events before they occur".

Innovativeness can be defined as: "the tendency to engage in and support new ideas, novelty, experimentation, and creative processes that may result in new products, services, or technological processes" (Lumpkin & Dess, 1996, p. 142). Yadav, Prabhu & Chandy (2007) find that a CEO's temporal attention is an important antecedent of innovation outcomes. The more managers are focused on the future, the better the innovation outcomes in terms of the speed of detecting new technological opportunities and

developing new products, as well as the deployment breadth of innovations. Kabanoff & Keegan (2009) find that top teams' future orientation is positively associated with their strategic focus on innovation. Emphasizing radical innovation outcomes, Chandy & Tellis (1998, p. 479) assert that managers with a future market focus are better informed about new and emerging technologies, making them less concerned with past investments in current technology, and less inert. Innovativeness of firms with a short-term perspective is more likely incremental in nature (Lumpkin et al., 2010). Finally, Nadkarni & Chen (2014) show that in firms operating in stable environments innovative performance is stimulated by a high present focus and low future focus, whereas in dynamic markets new products are introduced faster if managers have both a high present and future focus.

To summarize, the three dimensions of EO appear to share their temporal nature; i.e., they require both a focus on what happens in the present and on what might happen in the future. Indeed, research shows that entrepreneurs are generally endowed with the capability to integrate the distant future and the present in their goal setting and behavior (Bird, 1988; Bird, 1992; West & Meyer, 1997), which is an important condition for achieving venture success (Bird & West, 1997). We formulate the following hypothesis:

Hypothesis 1: Present and future temporal focus are both positively associated with EO

It is nonetheless argued that a future temporal focus is preferred for setting a strategic direction and keeping managers alert to new technologies, competitors and innovations (Foo, Uy, & Baron, 2009; Kabanoff & Keegan, 2009; Yadav, Prabhu, & Chandy, 2007). Because individuals with a present focus prefer to act instead of deliberate, strategic decision making (promoting an entrepreneurial strategy) fits better with individuals whose future orientation (i.e., greater temporal distance) allows them to see the 'big picture' (Mohammed & Harrison, 2013). We hypothesize the following:

Hypothesis 2: Future temporal focus is more strongly associated with EO than present temporal focus

6.2.2 Interaction present and future

There are two contrasting perspectives on how people distribute their attention to different time periods (i.e., past, present, future). According to the first perspective temporal focus is seen as a single construct where present focus is located at one end of the

continuum and future temporal focus on the other. Here it is argued that individuals focus on one time period and can be classified accordingly (Harber, Zimbardo & Boyd, 2003; Holman & Silver, 1998; Laverty, 1996; McGrath & Rotchford, 1983; McKay et al., 2012). In a more 'liberal' scenario, individuals are assumed to focus *predominantly* but *not exclusively* on one of these time periods. The alternative view argues that present and future temporal foci are unrelated and that individuals are able to shift their attention among different time periods (Shipp et al., 2009; Shipp & Jansen, 2011). This allows for the focus on multiple periods (Kabanoff & Keegan, 2009; Shipp & Jansen, 2011; Yadav, Prabhu, & Chandy, 2007) and thus the combination of a high present focus with a high future focus. Given the current state of the literature, we believe that the argument for a strict separation between time orientations (i.e., that individuals are either future-focused or present-focused) does not hold. Therefore, we argue that temporal temporal focus involves the allocation of varying degrees of attention to different time periods (Shipp et al., 2009; Zimbardo & Boyd, 1999). Below we formulate two competing hypotheses on how present and future temporal focus may interact in relation to EO.

Substitution effect

Within the field of management the dilemma of intertemporal choice often involves options that are good in the short run, but not beneficial or even harmful in the long run (Laverty & Laverty, 1996, p. 828). Consistently, Marginson & Mcaulay, (2008, p. 273) define a present focus as "a preference for actions in the near term that may have detrimental consequences for the long term". The other way around, a "tendency to prioritize long range implications and impact of decisions and actions that come to fruition after an extended period of time" (Lumpkin, Cogliser, & Schneider, 2009, p. 56) can have negative consequences in the short run if it puts pressure on the organization or streamlining of daily operations. Within the context of the present study combining a present focus (with an emphasis on daily activities) with a future focus (with an emphasis on planning) may restrict the level of EO. For example, building on current knowledge and thinking within existing paradigms is expected to restrict creativity and 'out-of-the-box thinking', which may produce incremental improvements and stifle innovativeness in the long run (Finkelstein, 2005; Hambrick, Finkelstein, & Mooney, 2005; Yadav et al., 2007). In addition, individuals who are distracted by ongoing business will find it hard to come up with viable new ideas to pursue future opportunities (Hambrick, Finkelstein,

& Mooney, 2005, p. 504). Alternatively, adopting a long time horizon may reduce the flexibility that is needed to initiate timely action to benefit from new opportunities (Finkelstein, 2005; Khurana, 2002; Leonard-Barton, 1993; Tripsas & Gavetti, 2000; Yadav et al., 2007). To test for a trade-off between present and future focus in explaining EO, we hypothesize the following:

Hypothesis 3a: Present focus and future focus are substitutes in determining EO

Complementary effect

The contextual ambidexterity literature proposes that company performance benefits from combining a focus on current business operations with an emphasis on new business opportunities (Jansen et al., 2005; March, 1991; O'Reilly & Tushman, 2011). Within this context, day-to-day operations may actually benefit from taking a long-term perspective in terms of learning, e.g., with respect to efficiency of operations. Efficient operations subsequently allow for freeing up resources for discovering and entering new markets or developing new lines of business. Similarly, combining a present with a future temporal focus may facilitate EO. Several scholars emphasize that anticipating and profiting from future entrepreneurial opportunities (requiring a future focus) depends on the current initiation of activities to pursue these opportunities (requiring a present focus) (Bird & West, 1997; Foo et al., 2009). Moreover, several studies show that a present and a future focus can be complementary. For example, having a long term perspective and engaging in planning helps individuals to take action and reach their goals (Gollwitzer & Brandstätter, 1997). Delmar & Shane (2003) show that business planning fosters venture organizing activity by turning abstract plans in concrete operational steps. The other way around, it can be argued that a focus on the future should be combined with knowledge of the present, indicating how the desired (future) outcome can best be reached (Bird & West, 1997). To test for synergies between present and future focus in explaining EO, we hypothesize the following:

Hypothesis 3b: Present focus and future focus are complements in determining EO

6.3 Methodology

6.3.1 Data

To test our hypotheses, we use data from the Panteia/EIM Panel of solo self-employed individuals in the Netherlands.[13] Data were collected by way of an Internet survey in December 2013. A total of 2,554 solo self-employed individuals were invited by e-mail to fill out the online questionnaire, of whom 820 (32%) participated. In the sample of 820 participants, the item non-response for our variables of interest is 4.51%. The final sample consists of 783 solo self-employed individuals (27% female, M_{age} = 49.02; SD_{age} = 10.54). The participants took on average 12.6 minutes (SD = 5.2 minutes) to complete the questionnaire that consisted of 95 questions. Five randomly selected participants received a gift voucher of 50 Euro (about 65 US Dollars) for their participation.

6.3.2 Measures

Entrepreneurial orientation (EO)

In line with early studies (Covin & Slevin, 1989; Miller, 1983), we treat EO as a single construct. Although there are different ways of conceptualizing and measuring EO, the three-component, unidimensional view of EO has been the predominant one (Covin & Wales, 2012; Rauch et al., 2009). Furthermore, because self-employed individuals without personnel have full 'managerial discretion' (Hambrick, 2007) and are solely responsible for setting the strategic directions of their company, we measure EO at the individual level. We use a 10-item instrument developed by Bolton & Lane (2012), based on EO variables and definitions proposed by Lumpkin & Dess (1996) and Lumpkin et al. (2009) and adapted to the individual level. The measure was tested in a large student sample (N=1,102) and found to be internally consistent and fulfilling the criteria of internal and external validity (Bolton & Lane, 2012, p. 227/8). Unlike studies based on Covin & Slevin (1989) that make use of a semantic difference scale to assess EO, our measurement instrument consists of Likert-based questions. The problem of acquiescence (e.g., Friborg, Martinussen, & Rosenvinge, 2006) is expected to be negligible given that the EO items are not necessarily considered positive.

[13] Source: Panteia/EIM (2014). For technical details we refer to online documentation: https://easy.dans.knaw.nl/ui/datasets/id/easy-dataset:55814 (in Dutch).

Solo self-employed respondents were presented with the following information: "Individuals who score high on entrepreneurship may perform better in (solo) self-employment. Please indicate to what extent you agree to the following statements on your entrepreneurial attitude and functioning". Respondents assessed 10 items on a 5-point Likert scale (1= completely disagree to 5= completely agree). Sample items include: "I tend to act 'boldly' in situations where risk is involved" (risk-taking); "I usually act in anticipation of future problems, needs or changes" (proactiveness); and "In general, I prefer to use unique, one-of-a-kind approaches rather than revisiting tried and true approaches used before" (innovativeness). We employed confirmatory factor analysis (CFA) to examine the validity of the EO construct. The fit indices showed that the measurement model does not fit the data ($\chi 2 = 867{,}90$, $p < .001$; CFI = 0.79, NNFI = 0.73, RMSEA = 0.19, SRMR = 0.11), but all the items have significant standardized loadings that are not equally large. The Cronbach's alpha for the EO measure is 0.82[14], which still represents a high level of internal consistency. Despite the lack of fit of the items with the EO construct, we follow our prior hypothesis that these 10 items measure EO and use their average score in further analysis. The main reason is to enable a comparison of the present results with those reported in the initial studies that have developed this measurement scale (Bolton, 2012; Bolton & Lane, 2012).

Present and future temporal focus

Temporal focus is measured using the measurement scale proposed by Shipp, Edwards & Lambert (2009). For the present study, we include two dimensions (present and future temporal focus)[15] measured by four items each, which are answered using a 7-point Likert scale (1=completely disagree to 7= completely agree). Sample items include: "I think about where I am today", "I live my life in the present" (belonging to the present temporal focus dimension) and "I think about what my future has in store", "I focus on my future" (belonging to the future temporal focus dimension). The Cronbach's alphas (0.85 and 0.89) indicate a strong internal consistency for both present and future temporal focus dimensions, respectively (Hinton et al., 2004).

[14] Note that Cronbach's alpha for the three dimensions of EO (i.e., risk-taking, proactiveness, innovativeness) amount to 0.71, 0.79 and 0.76, respectively.

[15] Our literature review suggests these are most relevant to examine in the context of entrepreneurship (or EO).

Control variables

We control for demographic variables: age, gender (female=1) and level of education (including primary education; lower vocational education; medium-level vocational education; higher level vocational education; and university (of applied science)). We also include a set of venture-related variables including whether the solo self-employed individuals sells goods or services, and ten industry dummies[16].

6.3.3 Statistical analysis

We analyze the data in two steps. First, we present the bivariate correlations between the main variables of interest (see Table 1). Second, we perform a series of OLS regressions, and regress EO on (1) the controls; (2) present and future temporal focus together with the control variables (Hypotheses 1 and 2); and (3) present and future temporal focus, interaction between the two temporal foci with the control variables (Hypotheses 3a & 3b).

6.4 Results

6.4.1 Correlation matrix

Table 6.1 presents the descriptive statistics (i.e., mean, standard deviation and bivariate correlations) of the main variables of interest. The bivariate correlations are significant and positive between EO and both present focus ($r=0.2$, $p<0.05$) and future focus ($r=0.42$, $p<0.05$).

[16] Industry dummies include agriculture, manufacturing, construction, trade, transport, ICT, healthcare/wellness, education, B2B services and other services.

6.4.2 Regression analysis[17]

Table 6.2 presents the OLS regression analyses of both present and future temporal focus together with their interaction on EO. We find no multicollinearity issues as the tolerance statistics are in excess of 0.2 (Menard, 1995). In line with Hypothesis 1, we find that both present and future temporal focus are positively associated with EO (see Model 2 in Table 2). In addition, we find that future temporal focus has a stronger relation with EO ($\beta = 0.64$, $p<0.01$) than present temporal focus ($\beta=0.20$, $p<0.01$). This provides support for Hypothesis 2. Furthermore, to test whether present focus and future focus act as substitutes or complements in determining EO, we examine the interaction effect of the two temporal foci (see Model 3 in Table 2). We find that the interaction term is significant and negative ($\beta = -0,10$, $p<0.05$), indicating that the two temporal foci are substitutes rather than complementary factors (Hayes, 2013) with respect to EO.

Table 6.1 Pearson's correlation matrix

	Mean	SD	1	2	3	4	5	6	7
1 EO	10,5	1,9	1						
2 Present Temporal Focus	5,1	1,2	0.2**	1					
3 Future Temporal Focus	5,2	1,1	0.42**	0.24**	1				
4 Age	49,0	10,5	0,06	0,04	0	1			
5 Gender	0,3	0,4	-0.12**	0.13**	-0,03	-0,07	1		
6 Level of Education	2,3	1,4	-0,05	0,02	0,02	0,02	-0.19**	1	
7 Goods/Services	0,2	0,4	0	-0,05	0	-0,05	-0.08**	0.09**	1

Note: N = 783; *p<.05.

[17] In line with the view that the dimensions of EO can vary independently from each other (Lumpkin & Dess, 1996) and may therefore differ in terms of their temporal nature, we also performed the regression analyses separately for each of the dimensions of EO (i.e., risk-taking, proactiveness and innovativeness). These results can be obtained from the authors on request. Summarizing, we find that the results are quite similar, except that we do not find evidence for an effect of present temporal focus and the interaction term on risk-taking. Although Shipp et al. (2009) find that present temporal focus is strongly related to risk-taking, the focus in Shipp et al. (2009) is on short-term thrill-seeking aspects of risk-taking (Jackson, Hourany, & Vidmar, 1972), whereas we argue that within the specific context of solo self-employment risk-taking is associated with future returns and taking calculated risks to build up a sustainable long-term venture rather than with a focus on short term gains (Das & Teng, 1997).

Table 6.2 Regression analysis for Entrepreneurial Orientation (EO)

	Entrepreneurial Orientation		
	(1)	(2)	(3)
Present temporal focus		0.20***	0.71***
Future temporal focus		0.64***	1.14***
Present*future			-0.10***
Age	0.01	0.01	0.01
Gender	-0.54***	-0.53***	-0.53***
Level of education	-0.08	-0.10*	-0.09*
Goods/services	0.06	0.06	0.09
Agriculture#	-0.66**	-0.41	-0.42
Manufacturing	-0.23	-0.18	-0.17
Construction	-0.51	-0.52*	-0.49*
Trade/hospitability/repair	-0.35	-0.17	-0.14
Transport/storage/communications	-0.23	0.05	0.08
ICT	-0.42	-0.02	-0.04
Healthcare/wellness	-0.45*	-0.36	-0.36
Education/training	-0.27	-0.14	-0.13
Other services	-0.05	0.12	0.14
Constant	10.65***	6.22***	3.62***
R-squared	0.03	0.22	0.23
F-test	2.00**	14.16***	13.90***

Note: Standard errors in parentheses, N=783, *** p<0.01, ** p<0.05, * p<0.1.

B2B services (category 7) is the reference category.

6.5 Discussion and conclusions

Because modern economies increasingly pressure companies and enterprising individuals to pursue an entrepreneurial strategy, in turn demanding a balance between present and future goals (O'Reilly & Tushman, 2004), the present study sets out to examine the temporal nature of EO, through linking it with present and future temporal focus. Our findings indicate that both present and future temporal focus are positively related to EO, but that the relationship of future focus with EO is stronger[18]. Thus, we provide evidence that the pursuit of an entrepreneurial strategy requires a strong future focus (at least within the context of solo self-employment). Arguing that individuals can allocate their attention to different time periods (in line with Shipp et al., 2009) and are therefore able to combine a high present focus with a high future focus, we tested two competing hypotheses with respect to how present and future focus interact in relation to EO. The negative interaction term indicates that present and future temporal focus act as substitutes in determining the EO of solo self-employed individuals. This substitution effect may be explained by the limited resources (e.g., time, energy, attention, money) solo self-employed individuals are able to allocate to the present and future of their enterprise. Therefore, they run the risk of investing too little in *both* the present and future of their enterprise to create an impact in terms of EO. Indeed, Hyytinen & Ruuskanen (2007) demonstrate that self-employed individuals perceive more time constraints than employees within organizations.

6.5.1 Theoretical implications

Consistent with the perspective of different scholars (Shipp, Edwards, & Lambert, 2009; Wales, Patel & Lumpkin, 2013; Nadkarni & Chen, 2014) that temporal focus is a cognitive factor of interest to management scholars, we explore the link between temporal focus and EO. In doing so, we contribute to the literature stressing the importance of cognitive factors in explaining entrepreneurship-related phenomena[19]. Despite the fact

[18] In order to test the hypothesis that present temporal focus ($\beta = 0{,}20$) and future temporal focus ($\beta = 0{,}64$) were statistically significantly different we calculated the wald test, which indicated that future temporal focus was indeed stronger associated with entrepreneurial orientation than present temporal focus ($F_{1,767} = 25.92$; $p<.001$).

[19] The cognitive approach to entrepreneurship emphasizes differences between individuals in terms of their mental structures that aid them in perceiving and assessing opportunities, and making decisions regarding the pursuit of these opportunities (Amabile et al., 1996; Baron, 2007, 1998; Mitchell et al., 2002).

that cognitive studies within the context of entrepreneurship gain momentum, research focusing on the relation between cognitions and EO remains scarce (Wales, Patel & Lumpkin, 2013). The context of solo self-employment allows us to directly translate individual level (temporal) cognition into organizational behavior (Hambrick & Mason, 1984; Hambrick, 2007).

Furthermore, the results contribute to our understanding of the implications of the temporal focus construct (Kreiser et al., 2013; Shipp, Edwards, & Lambert, 2009; Shipp & Jansen, 2011) and their associations with entrepreneurial orientation (Lumpkin & Brigham, 2011). Specifically, in line with previous studies that stress the importance of a future temporal focus in determining life time (Golsteyn et al., 2014) and organizational outcomes (Kabanoff & Keegan, 2009; Yadav, Prabhu, & Chandy, 2007), we find that future temporal focus is more strongly related to EO than present temporal focus. Our study thus contributes by demonstrating the relative importance of a future orientation within a specific context: that of EO.

Finally, the finding that future focus and present focus act a substitutes in determining EO fits with the notion that it is considered difficult to maintain current operations and simultaneously keep track of future business opportunities (O'Reilly & Tushman, 2004), in particular in a small-scale setting. We note that there appears to be a discrepancy between what is advocated by research and what happens in practice. While in the modern work environment there is a tendency to focus on short-term events (requiring a high present focus) (Hamermesh & Lee, 2007; Laverty & Laverty, 1996; Prahalad & Hamel, 1994; The Economist, 2014), research emphasizes the importance of anticipating possible future outcomes (requiring a high future temporal focus) (Golsteyn, Grönqvist & Lindahl, 2014).

6.5.2 Practical implications

The present study has important implications for how the solo self-employed individuals manage their businesses. The substitution effect of present and future temporal focus on EO suggests that solo self-employed individuals lack a critical mass (scale) to simultaneously pursue short-term and long-term entrepreneurial goals and should either focus on one of the two, or increase their scale through the cooperation with other self-employed individuals or companies. With respect to the former, our findings indicate that solo self-employed individuals may be better off focusing on the future (than on the

present), given that we find that the link with EO is stronger for future focus than for present focus. Thus, solo self-employed individuals could benefit from having a clear vision and invest in the realization of that vision rather than having day-to-day routines absorb the bulk of their resources. Indeed, research shows that solo self-employed individuals involved in future-oriented activities such as innovation processes, benefit from cooperation with other organizations (De Vries & Koster, 2013). Several benefits of cooperation exist, yet for successful innovation the key benefit is access to new resources and knowledge. Therefore, broadening the scope of the enterprise by cooperating with self-employed who bring in complementary skills and competences (scope effects) leads to higher (long term) performance than working together with solo self-employed individuals involved in similar activities (scale effects) (Koster & De Vries, 2011).

As solo self-employed individuals have full managerial discretion, it is important for them to become aware of the importance of having a future temporal focus for EO. As a cognitive characteristic, individuals' temporal focus may be malleable and reinforced by training (Golsteyn, Grönqvist, & Lindahl, 2014; Cacioppo & Petty, 1982). Solo self-employed individuals may benefit from following error management training that enhances their meta-cognitive abilities (Keith & Frese, 2005), enabling them to effectively focus on the future, while attending to the (minimum) needs of the present.

6.5.3 Future research

Our study highlights ample opportunities for future research. First, given our finding that present and future focus act as substitutes in determining EO for solo self-employed individuals, it would be interesting to find out to what extent the scale of business operations facilitates a complementary effect, and what happens if organizational factors start to play a role in determining EO. If indeed the scale of operations and available resources matter for present and future focus to act as complements or substitutes, future studies could examine the temporal nature of EO in different contexts including self-employed with employees, entrepreneurial teams, small and medium-sized enterprises (SMEs), and large multinational companies. Since managerial discretion declines within these contexts, it is then important to operationalize EO at the organizational level.

Second, although the results suggest that temporal focus is associated with EO, we have not been able to examine the link with entrepreneurial success. Given the link

between EO and performance (Lumpkin & Dess, 1996, 2001; Rauch et al., 2009), temporal focus may also be associated with entrepreneurial performance and new venture development.

Third, as suggested in several studies (Lumpkin & Dess, 1996; 2001; Richard et al., 2004), the associations between cognitions of entrepreneurs and EO may enrich our understanding of entrepreneurship. Special attention should be devoted to different contingencies underlying the relation between temporal focus and entrepreneurship-related phenomena (Wales, Patel & Lumpkin, 2013). Possible moderators may include cognitive factors that interfere with having a long-term strategic perspective, such as a dynamic business environment or perceived time pressure.

Finally, future research may contribute by studying concepts such as organizational ambidexterity (Benner & Tushman, 2003; Jansen, Volberda, & Van Den Bosch, 2005) and effectuation versus causation (Sarasvathy, 2001) from a temporal focus perspective.

6.5.4 Limitations

The present study may suffer from two potential biases. *First*, our results results may suffer from common method bias (Conway & Lance, 2010; Podsakoff & Organ, 1986). To assess the level of common method variance in our dataset we employed Harman's single-factor test (Podsakoff & MacKenzie, 2003). From the 33 individual items we used in our regressions, we extracted 14 factors that account for 72 percent of the variance in our dataset. The first extracted factor has an eigenvalue of 5.42 and accounts for 16.45 percent of the variance in our dataset. We conclude that the extent of common method variance in our dataset is low and reduces the likelihood of common method bias (Podsakoff & MacKenzie, 2003).

Second, a potential limitation of the present study is the EO construct based on the measurement scale of Bolton & Lane (2012). This scale consists of 10 items reflecting the three dimensions of EO, viz., risk-taking, proactiveness and innovativeness. The confirmatory factor analysis shows that these 10 items do not load well on one latent construct (i.e., EO). It may well be that EO consists of three separate dimensions that vary independently of each other and should be separated rather than taken together in one construct. For this reason, we also analyzed the associations between the temporal foci and the three separate dimensions of EO. These results were similar to those for the

overall construct of EO, which makes us believe that the results presented in this study are reliable and not driven by one of the dimensions. It is for future research to uncover whether EO is a first-order construct, a second order construct and/or to what extent these dimensions are able to vary independently of each other (Lumpkin & Dess, 1996, 2001).

Summary

‘What makes an entrepreneur?’ This is an important question for many researchers in the past three decades. Although important factors are identified in previous research, these factors provide usually incomplete and uncertain answers to this question. Thus, it is of imperative importance to study novel factors that may explain entrepreneurship better. Therefore, this thesis takes entrepreneurship as a starting point to investigate the associations with two new potential cognitive factors, viz., neurocognitive measures on the one hand and self-reported psychiatric symptoms and individual differences on the other hand. Chapter 1 introduces how the five chapters fit in the conceptual model this thesis builds upon and discusses its main motivation and contribution. Chapter 2 and 3 examine the internal consistency and functional significance of important neurocognitive measures. The results provide guidelines for future research and suggest that more research is needed to fully understand what these neurocognitive measures reflect. Chapter 4 and 5 investigate the association between attention-deficit/hyperactivity (ADHD) symptoms and entrepreneurial choice and orientation. The findings suggest that there is a positive association that is primarily driven by hyperactivity symptoms. Finally, Chapter 6 studies the association between present and future temporal focus and entrepreneurial orientation in a sample of solo self-employed individuals. The results suggest that for these individuals a future focus is more important compared to present focus for the entrepreneurial orientation and that a focus on both temporal foci simultaneously comes at the expense of their entrepreneurial orientation. Taken together, this thesis presents initial results associating new potential cognitive factors that may explain entrepreneurship and opens up ample room for research in this direction.

Samenvatting (Summary in Dutch)

‘Wat is een ondernemer?’ Dit is een belangrijke vraag die veel onderzoekers al zo’n 30 jaar bezighoudt. Alhoewel er belangrijke factoren zijn geidentificeerd in vorig onderzoek, geven de meeste factoren onvolledige en onzekere antwoorden op deze vraag. Voor toekomstig onderzoek is het dus belangrijk om te zoeken naar nieuwe factoren die ondernemerschapsgedrag beter kunnen verklaren. Deze thesis neemt ondernemerschap als startpunt en onderzoekt de associaties met twee nieuwe cognitieve factoren, namelijk neurocognitieve metingen aan de ene kant en zelf-gerapporteerde psychiatrische symptomen en individuele verschillen aan de andere kant. Hoofdstuk 1 introduceert hoe de vijf studies passen binnen het conceptuele model in deze thesis and bediscussieerd wat de belangrijkste motivatie en bijdrage zijn. Hoofdstuk 2 en 3 bestuderen de interne consistentie en functionele significantie van vier belangrijke neurocognitieve metingen. De resultaten geven richtlijnen voor verder onderzoek, en suggereren dat er nog meer onderzoek nodig is om goed uit te zoeken wat deze neurocognitieve metingen precies reflecteren. In hoofdstuk 4 en 5 associëren we de symptomen van een attentie-deficiet/hyperactiviteits stoornis (ADHD) met twee belangrijke ondernemerschapsgedragingen: de ondernemerschapskeuze, en -oriëntatie. De resultaten suggereren dat ADHD symptomen, en in het bijzonder hyperactiviteit een positieve rol spelen bij de cognitie van een ondernemer. Ten slotte, hoofdstuk 6 presenteert een studie naar de associatie tussen temporeel bewustzijn en ondernemerschapsoriëntatie. De resultaten suggereren dat vooral een toekomst perspectief belangrijk is voor zelfstandige zonder personeel (ZZP’ers), en dat een gecombineerde focus op het heden en toekomst ten kosten gaat van de ondernemerschapsoriëntatie. Concluderend, deze thesis presenteert intiële resultaten voor de associatie tussen cognitieve factoren die mogelijk een rol spelen bij ondernemerschap, en ook opent deze thesis de mogelijkheid om meer studies in deze richting uit te voeren.

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Wim J.R. Rietdijk (1988) attended the Erasmus University and graduated with a Master degree in Business Administration and Master degree in Epidemiology. In 2010 he started his PhD with Erasmus Research Institute of Management. In his research, Wim attempts to build a relationship between economics and (cognitive) psychology. He co-authors several papers regarding the associations between cognitive factors, psychiatric symptoms and economic behavior that fit within the conceptual model of the present thesis. Furthermore, he presented his work at various international conferences including American Accounting Association, management accounting section in Orlando (USA) and NeuroPsychoEconomics conference in Bonn (Germany). He also visited the University of Michigan (Ross School of Business/Department of Psychology) as a visiting scholar for seven months in 2013. Currently, Wim is on the job market outside academia.

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THE USE OF COGNITIVE FACTORS FOR EXPLAINING ENTREPRENEURSHIP

SOME EMPIRICAL RESULTS

'What makes an entrepreneur?' This is an important question for many researchers in the past three decades. Although important factors are identified in previous research, these factors provide usually incomplete and uncertain answers to this question. Thus, it is of imperative importance to study novel factors that may explain entrepreneurship better. Therefore, this thesis takes entrepreneurship as a starting point to investigate the associations with two new potential cognitive factors, viz., neurocognitive measures on the one hand and self-reported psychiatric symptoms and individual differences on the other hand. Chapter 1 introduces how the five chapters fit in the conceptual model this thesis builds upon and discusses its main motivation and contribution. Chapter 2 and 3 examine the internal consistency and functional significance of important neurocognitive measures. The results provide guidelines for future research and suggest that more research is needed to fully understand what these neurocognitive measures reflect. Chapter 4 and 5 investigate the association between attention-deficit/hyperactivity (ADHD) symptoms and entrepreneurial choice and orientation. The findings suggest that there is a positive association that is primarily driven by hyperactivity symptoms. Finally, Chapter 6 studies the association between present and future temporal focus and entrepreneurial orientation in a sample of solo self-employed individuals. The results suggest that for these individuals a future focus is more important compared to present focus for the entrepreneurial orientation and that a focus on both temporal foci simultaneously comes at the expense of their entrepreneurial orientation. Taken together, this thesis presents initial results associating new potential cognitive factors that may explain entrepreneurship and opens up ample room for research in this direction.

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