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Rules are made to be broken! The role of rule-breaking in entrepreneurship - evidence from behavioural, cognitive and neuroscience approaches

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Summary

Complex problems require innovative solutions. Current humanity challenges (e.g., inequality, climate change, pandemics, wars, migration and scarcity of natural resources) calls for individuals with an entrepreneurial mindset. In other words, we require individuals who intend to perform entrepreneurial activities and feel capable of doing so to develop innovative ideas to combat these challenges either (a) independently by creating communities and enterprises or (b) within organisations by spreading the enterprises to other services or venues. In this dissertation, I aimed to understand the intraindividual antecedents of entrepreneurial mindset, by focusing on entrepreneurial intention and entrepreneurial self-efficacy. Within these antecedents, I revealed and evaluated the role of deliberative rule-breaking tendencies, defined as carefully deciding whether to break or follow a rule according to the consequences and self-interests therein. To this purpose, I used a multi-source approach to conduct two experiments. In the first study, I collected data from questionnaires, as well as from 'actual' behaviour, reaction times and mouse movements in a computerised task. In the second study, I gathered information from questionnaires, as well as 'actual' behaviour, reaction times, electroencephalogram and eye and mouse movements.

In Chapter 1, I established the motivation, construct definitions and the punctual research questions of this dissertation. In Chapter 2, I outlined the content of Chapters 3, 4 and 5. In Chapter 3, using the data obtained from the first experiment, I investigated deliberative rule-breaking from a cognitive perspective. Here, I standardised a computerised task that discriminated against individuals who tend to deliberatively break rules from those

who tend to follow rules. Using this task, I also found that rule-breakers experienced more pronounced cognitive conflict (measured via reaction times and mouse movements) than rule-followers, especially when the type of consequences was negative – if following the rule. In particular, this cognitive conflict was expressed more when rule-breakers violated norms and when rule-breaking was more frequent, recurrent and early. In Chapter 4, using the data obtained from the first experiment, I found that individuals who have an open personality towards new experiences and less moral idealism are prone to high entrepreneurial intention when they tend to break rules to obtain benefits, such as increasing pay-off. In Chapter 5, I demonstrated that an individual's cognitive-conflict-capacity is essential for deliberative rule-breaking tendencies, which, when combined with low behavioural inhibition personality, precedes entrepreneurial self-efficacy. This cognitive capacity is characterised by slow responses, complex and large mouse trajectories, numerous eye-fixations, slow saccades and low delta bandpower in frontocentral and parietal electrodes. In Chapter 6, I discussed the results, theoretical implications, practical implications and possibilities for future studies. The present dissertation contributes to the theory in the following ways:

1. I provide cognitive science and management research communities with a standardised novel methodology to evaluate deliberative rule-breaking tendencies, cognitive conflict and cognitive-conflict-capacity.
2. I introduce deliberative rule-breaking tendencies as a behavioural precursor of entrepreneurial mindset (quantified by recording actual 'behaviour' in a computerised task) and their interplay with personal characteristics that favour the formation of the entrepreneurial mindset.
3. I provide a neurocognitive foundation for the antecedents of entrepreneurial mindset and especially those of entrepreneurial self-efficacy.

Besides the theoretical contributions, this dissertation also has the following practical implications:

1. My findings on the intraindividual antecedents of entrepreneurial mindset are of benefit to recruiters because they improve their hiring strategies.
2. My research also helps practitioners to recognise personal characteristics and incorporate individualised support into the design of entrepreneurship training throughout an individual's career or for teams within an enterprise.
3. My dissertation can be a springboard to an early step in the process of using new technologies for entrepreneurship training (e.g., neurofeedback).
4. This work can benefit both entrepreneurs and individuals involved in modern occupations as recognising the antecedents of entrepreneurial mindset described in my research can help individuals to proactively navigate economic, social and technological shifts in their jobs.

This dissertation *highlights the importance of* and *adds to the study of* the intraindividual antecedents of entrepreneurship at the individual level. This empirical work sheds light on the use of original neurocognitive methodologies in the management and entrepreneurship communities.

Zusammenfasung

Komplexe Probleme erfordern innovative Lösungen. Die aktuellen Herausforderungen für die Menschheit (z. B. Ungleichheit, Klimawandel, Pandemien, Kriege, Migration und Verknappung der natürlichen Ressourcen) erfordern Menschen mit unternehmerischem Denken. Mit anderen Worten: Wir brauchen Menschen, die die Absicht haben und sich in der Lage fühlen, unternehmerisch tätig zu sein und innovative Ideen zu entwickeln, um diese Herausforderungen zu bekämpfen und zwar entweder (a) eigenständig durch die Gründung von Gemeinschaften und Unternehmen oder (b) innerhalb von Organisationen durch die Ausweitung der Unternehmen auf andere Dienste oder Orte. In dieser Dissertation wollte ich die intraindividuellen Antezedenzien des unternehmerischen Denkens verstehen, indem ich mich auf die unternehmerische Absicht und die unternehmerische Selbstwirksamkeit konzentrierte. Innerhalb dieser Antezedenzien habe ich die Rolle der Tendenz zum absichtlichen Regelbruch aufgedeckt und bewertet, d. h. die sorgfältige Entscheidung, ob eine Regel unter Berücksichtigung der Konsequenzen und des Eigeninteresses gebrochen oder befolgt werden soll. Zu diesem Zweck habe ich zwei Experimente mit einem Multi-Source-Ansatz durchgeführt. In der ersten Studie sammelte ich Daten aus Fragebögen sowie aus dem "tatsächlichen" Verhalten, den Reaktionszeiten und den Mausbewegungen in einer computerisierten Aufgabe. In der zweiten Studie sammelte ich Informationen aus Fragebögen sowie aus dem "tatsächlichen" Verhalten, den Reaktionszeiten, dem Elektroenzephalogramm und den Augen- und Mausbewegungen.

In Kapitel 1 habe ich die Motivation, die Konstruktdefinitionen und die punktuellen Forschungsfragen dieser Dissertation dargelegt. In Kapitel 2 habe ich den Inhalt der Kapitel 3,

4 und 5 dargelegt. In Kapitel 3 untersuchte ich anhand der Daten aus dem ersten Experiment das deliberative Regelbrechen aus kognitiver Sicht. Dazu habe ich eine computerisierte Aufgabe standardisiert, die Personen, die dazu neigen, Regeln absichtlich zu brechen, von denen unterscheidet, die dazu neigen, Regeln zu befolgen. Mit dieser Aufgabe fand ich auch heraus, dass Regelbrecher einen ausgeprägteren kognitiven Konflikt (gemessen über Reaktionszeiten und Mausbewegungen) erlebten als Regelbefolger, insbesondere wenn die Art der Konsequenzen negativ war, wenn die Regel befolgt wurde. Dieser kognitive Konflikt war vor allem dann ausgeprägter, wenn Regelbrecher gegen Normen verstießen und wenn der Regelbruch häufiger, wiederholter und früher erfolgte. In Kapitel 4 habe ich anhand der Daten aus dem ersten Experiment herausgefunden, dass Personen, die eine offene Persönlichkeit gegenüber neuen Erfahrungen haben und weniger moralisch-idealistisch sind, zu einer hohen unternehmerischen Absicht neigen, wenn sie dazu neigen, die Regeln zu brechen, um Vorteile zu erlangen, wie z. B. die Erhöhung ihrer Gewinne. In Kapitel 5 habe ich gezeigt, dass die kognitive Konfliktfähigkeit eines Individuums wesentlich für die Tendenz zum bewussten Regelbruch ist, die in Verbindung mit einer Persönlichkeit mit geringer Verhaltenshemmung der unternehmerischen Selbstwirksamkeit vorausgeht. Diese kognitive Kapazität ist gekennzeichnet durch langsame Reaktionen, komplexe und große Mausbewegungen, zahlreiche Augenfixierungen, langsame Sakkaden und niedrige Delta-Bandstärken in frontozentralen und parietalen Elektroden. In Kapitel 6 diskutiere ich die Ergebnisse, theoretische und praktische Implikationen sowie zukünftige Studien. Die vorliegende Dissertation trägt auf folgende Weise zur Theorie bei:

1. Ich stelle der Kognitionswissenschaft und der Managementforschung eine standardisierte neue Methodik zur Verfügung, um die Tendenz zum bewussten Regelbruch, den kognitiven Konflikt und die kognitive Konfliktfähigkeit zu bewerten.

2. Ich führe deliberative Regelbruchtendenzen als Verhaltensvorläufer der unternehmerischen Denkweise ein (quantifiziert durch Aufzeichnung des tatsächlichen

"Verhaltens" in einer computergestützten Aufgabe) und ihr Zusammenspiel mit persönlichen Merkmalen, die die Ausbildung der unternehmerischen Denkweise begünstigen.

3. Ich liefere eine neurokognitive Grundlage für die Vorläufer des unternehmerischen Denkens, insbesondere für die unternehmerische Selbstwirksamkeit.

Neben den theoretischen Beiträgen hat diese Dissertation die folgenden praktischen Implikationen:

1. Meine Erkenntnisse über die intraindividuellen Antezedenzien der unternehmerischen Denkweise kommen Personalverantwortlichen zugute, indem sie ihre Einstellungsstrategien verbessern.

2. Meine Forschung hilft auch Praktikern, persönliche Merkmale zu erkennen und individuelle Unterstützung in die Gestaltung von Entrepreneurship-Trainings während der gesamten Karriere eines Einzelnen oder für Teams innerhalb eines Unternehmens einzubauen.

3. Meine Dissertation kann ein sehr früher Schritt in diesem Prozess bei der Nutzung neuer Technologien für das Unternehmertraining sein (z. B. Neurofeedback).

4. Diese Arbeit kann Unternehmern und Personen, die in modernen Berufen tätig sind, zugute kommen, da das Erkennen der in meiner Forschung beschriebenen Antezedenzien des unternehmerischen Denkens dem Einzelnen helfen kann, proaktiv mit den wirtschaftlichen, sozialen und technologischen Veränderungen an seinem Arbeitsplatz umzugehen.

Diese Dissertation unterstreicht die Bedeutung der Untersuchung der intraindividuellen Antezedenzien des Unternehmertums auf individueller Ebene und trägt zu deren Erweiterung bei. Diese empirische Arbeit wirft ein Licht auf den Einsatz neuartiger neurokognitiver Methoden in den Bereichen Management und Unternehmertum.

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Chapter 1: Introduction and research questions

"Breaking the rules and challenging convention is in the DNA of every successful entrepreneur. Doing things differently and solving problems with new, innovative and fresh approaches are the very reason many start-ups are able to compete and sometimes outpace the established market leaders" – *Richard Brason, billionaire and founder of the Virgin Group.*

Entrepreneurship is a primary force in the world's economies (Pacheco et al., 2010; Studdard et al., 2013; Thompson et al., 2011). The current reality presents many challenges, such as inequality, climate change, pandemics, wars, migration and scarcity of natural resources (Becker et al., 2019; Bruton et al., 2021; da Silva & Neto, 2021; Jakob, 2022; Rawtani et al., 2022). These challenges' complexity and entanglement require highly innovative solutions, i.e., entrepreneurial thinking. Societal success, thus, relies on individuals who face crises and intend and feel able to perform entrepreneurial activities that develop innovative ideas in order to combat current challenges either (a) independently by creating communities and enterprises or (b) within organisations by spreading their enterprises to other services or venues. In other words, we need individuals to develop entrepreneurial intention and entrepreneurial self-efficacy. Career researchers, practitioners, educators and policymakers are interested in understanding the individual antecedents of entrepreneurial intention and self-efficacy because of the growing influence of the entrepreneurial mindset on career development. To place suitable individuals into central positions in politics and economics

and to further develop their abilities, we need to understand the qualities that make some individuals more prone to developing an entrepreneurial mindset than others (Memon et al., 2019), i.e., the intraindividual antecedents of the entrepreneurial mindset.

Even though rule-breaking tendencies have previously been associated with entrepreneurship, their role as an antecedent of the entrepreneurial mindset has been overlooked (Obschonka et al., 2013; Watt, 2016a; Zhang & Arvey, 2009). In this dissertation, I propose that the rule-breaking associated with entrepreneurship is deliberative. This kind of rule-breaking means deciding carefully whether or not to follow or break a rule depending on the consequences and personal interests (Arend, 2016; Cubillos-Pinilla & Emmerling, 2022). Individuals with deliberative rule-breaking tendencies violate norms if the expected consequence is advantageous and concordant with their personal goals. Importantly, these tendencies can be observed spontaneously, i.e., without an individual having been explicitly informed that they can choose to break the rule in the first place (Arend, 2016; Cubillos-Pinilla & Emmerling, 2022; Gross et al., 2018; Pfister et al., 2019). Deliberative rule-breaking tendencies are relevant for studying entrepreneurial mindset because these tendencies endorse characteristics required for entrepreneurship. These characteristics include proactivity, innovation, opportunity recognition, prioritisation of personal goals, increased perception of control over surroundings and risk tolerance.

Although in management research the use of questionnaires has been "ritualised", they are prone to social desirability and retrospective biases, especially when it comes to evaluating rule-breaking tendencies in entrepreneurship (Alvesson & Sandberg, 2013; Brice & Spencer, 2007; Donaldson & Grant-Vallone, 2002; Rutter et al., 1998; Schyns & Schilling, 2013b; Vigil-Colet et al., 2012). In self-report questionnaires, individuals tend to report less rule-breaking behaviour than is actually committed because rule-following is appreciated as more trusted, kind and attractive (Everett et al., 2016; Forsyth, 1980; Paunonen et al., 2006). This effect is intensified in individuals interested in entrepreneurship since they usually aspire

to social prestige even when facing financial and psychological risk (Timothy et al., 2011; Treviño et al., 2006). To study deliberative rule-breaking in entrepreneurship, there is a need for a methodology that avoids these external biases. Moreover, the kind of cognitive mechanism associated with the tendency for breaking the rules rather than with the tendency to follow them has not yet been described. It is important to understand the cognitive mechanism underlying these tendencies in order to increment them. I propose that the cognitive mechanism is cognitive conflict, resulting from the simultaneous suppression of the rule-following action plan alongside the intended action plan to break the rule (Botvinick et al., 2001; Pfister, 2013; Schröger et al., 2007). If this is true, I would expect that individuals expressing deliberative rule-breaking tendencies also exhibit and tolerate higher cognitive conflict than those who tend to follow the rules.

Moreover, previous research has indicated personality to be a strong predictor of behaviours in individuals that conform or violate rules (e.g., criminal behaviour, pedestrian train crossing violation, pro-social rule-breaking, counterproductive behaviour at school, aggression). For example, individuals who tend to break the rules are inclined to be extroverts (Atindanbila & Gyamfua-Danquah, 2012), grandiose narcissistic (Finkelman & Kelly, 2011), have a propensity to risk (Freeman & Rakotonirainy, 2015; Morrison, 2006; Obschonka et al., 2013; Reiter et al., 2019; Zhang & Arvey, 2009), disagreeable (Carvalho et al., 2020; Fiddick et al., 2016; Hartmann & Müller, 2022; Hopwood et al., 2009; Jackson et al., 2010; Jensen-Campbell et al., 2002; Reardon et al., 2015) and impulsive (e.g., low behavioural inhibition, high goal-oriented motivation and sensation seeking; Janoff-Bulman, 2009; Maneiro et al., 2017; Rhodes et al., 2013; Sijtsema et al., 2010). Therefore, it seems worth investigating the link between these personality traits (using psychometric measures) with the behavioural and the cognitive characteristics of rule-followers and rule-breakers, especially when evaluating these characteristics using a computerised task. Therefore, my first, second and third research questions are:

Research question 1: *How can we measure 'actual' deliberative rule-breaking tendencies avoiding biases associated with self-report measurements?*

Research question 2: *Does "cognitive conflict" underlie deliberative rule-breaking behavioural tendencies?*

Research question 3: *Which personality traits relate to deliberative rule-breaking tendencies?*

In this project, I aim to study the role of deliberative rule-breaking tendencies and the interplay of the intraindividual antecedents of entrepreneurial mindset by focusing on entrepreneurial intention and self-efficacy. The former is defined as the psychological state of a person with the desire, optimism and aspiration to initiate a new business or create a new value extension within a current company (Guerrero et al., 2008; Peng et al., 2012; Shahab et al., 2019; Wu & Wu, 2008). The latter is defined as individuals' confidence in their ability to perform the different roles and tasks of innovative thinking and entrepreneurship (Balven et al., 2018; Chen et al., 1998; Orlitzky et al., 2011; Shahab et al., 2019; Siegel et al., 2004; Waldman et al., 2001). Notably, research on the antecedents of entrepreneurial intention and self-efficacy is grounded in different theoretical backgrounds. While the antecedents of entrepreneurial intention are investigated based on the theory of planned behaviour (Buchholz & Rosenthal, 2005; Clarke & Aram, 1997; Dlugosch et al., 2018; Kaptein, 2019; Payne & Joyner, 2006), the antecedents of entrepreneurial self-efficacy are investigated based on the theories of agency and social cognition (Newman et al. (2019).

Drawing on the theory of planned behaviour, attitudes and subjective norms that position entrepreneurship as an attractive career choice appear to predict entrepreneurial intention effectively (Yang, 2013). However, which general individual characteristics drive these attitudes and norms is less clear. A way to work around this gap is to take a

psychological perspective that focuses on personality and morality as basic human characteristics shaping those attitudes and norms and thus, entrepreneurial intentions (Buchholz & Rosenthal, 2005; Clarke & Aram, 1997; Dlugosch et al., 2018; Kaptein, 2019; Payne & Joyner, 2006). Moreover, despite the relevance of rule-breaking tendencies in entrepreneurship, the role of deliberative rule-breaking tendencies on the relationships that personality and morality have with entrepreneurial intention has yet not been described (Obschonka et al., 2013; Watt, 2016; Zhang & Arvey, 2009). Thus, the fourth research question of this dissertation is:

Research question 4: *Which personal characteristics interplay as the intraindividual antecedents of entrepreneurial intention?*

Even though previous work has painted a picture of the antecedents essential for the formation of entrepreneurial self-efficacy, it has not, however, so far focused on the underlying cognitive and neurophysiological mechanisms. To truly understand the antecedents of entrepreneurship concepts, such as entrepreneurial self-efficacy, we should rely on a brain-mind model. Brain-mind models represent a constructive approach to integrating disciplines aimed at studying individuals' psychological processes at different levels of analysis (Westbrook & Braver, 2015). Brain-mind models include the following levels of analysis: a neurocognitive mechanism (e.g., cognitive capacities), behavioural tendencies (e.g., deliberative rule-breaking tendencies) and complex psychological processes (e.g., personality; Connors & Halligan, 2014; Montag & Panksepp, 2020; Shiffrin et al., 2020; Zmigrod & Tsakiris, 2021).

These models are helpful for management and entrepreneurship research because they

(a) link unobservable mental constructs and behavioural tendencies (e.g., cognitive capabilities with respect to decision-making) through new technologies (Kotchoubey et al., 2016; Lerner, 2020; Shinnar et al., 2014; Waldman & Balthazard, 2015),

(b) explain previously unexplained variance by traditional methods in entrepreneurship-related variables (Korpysa, 2020),

(c) are widely use for the study of psychological constructs that are relevant for entrepreneurship such as self-efficacy (Lewis et al., 2020; Stone, 2018; Utami et al., 2020),

(d) indicate how rational and emotional aspects of an entrepreneur's decision-making are related to the functioning of the entrepreneur's brain (Nicolaou & Shane, 2013),

(e) integrate several neurocognitive methods (e.g., psychophysics, eye-tracking, electroencephalography), giving optimal convergent validity to the assessment strategies of often abstract mental constructs (Carlson & Herdman, 2010; Kotchoubey et al., 2016; Schweizer, 2012) and

(f) inform the design and standardisation of computerised tasks that can measure antecedents of the entrepreneurial mindset.

Despite the growing body of literature suggesting that a combination of neurocognitive science with entrepreneurship research can be fruitful (Gielnik et al., 2012; Korpysa, 2020; Lin et al., 2022; Waldman et al., 2019; Waldman et al., 2011b), there is still no empirical research addressing the precursors of entrepreneurial self-efficacy from a neurocognitive perspective. We should therefore investigate the intraindividual antecedents of entrepreneurial self-efficacy through a brain-mind model that includes behavioural tendencies, personality and a neurocognitive mechanism.

Regarding the behavioural tendencies, I propose investigating the role that deliberative rule-breaking tendencies have on entrepreneurial self-efficacy since these tendencies are linked to entrepreneurship. Moreover, according to the theories of agency and the social cognition, self-efficacy beliefs evolve through behavioural tendencies such as deliberative

rule-breaking (Gecas, 1989; Newman et al., 2019; Wilson et al., 2018). Yet behavioural tendencies are more likely to form such beliefs when individuals exhibit certain personality traits (Farrukh et al., 2017; Gielnik et al., 2012; Jordaan, 2014; Kamerdze et al., 2014; Schmutzler et al., 2018). Personality-wise, I propose investigating behavioural inhibition. Behavioural inhibition is defined as the personality that evokes responses of prevention or repudiation when approached with anxiety-associated cues like punishment, non-reward and unfamiliarity (Fowles, 1988; Fowles, 1980; Gray, 1987; McNaughton & Gray, 2000) and it bias own perception to increase the focus on possible threats. This personality type is worth investigating as an antecedent of entrepreneurial self-efficacy, because previous research has unravelled its negative relationship with entrepreneurship due to the demanding challenges associated with the uncertainties surrounding entrepreneurial activities (Geenen et al., 2016).

The cognitive mechanism I propose for developing a brain-mind model is named cognitive-conflict-capacity. This capacity is described as the cognitive system's capacity to tolerate, respond and disentangle cognitively demanding situations due to uncertain, inconclusive or challenging information. This capacity means that individuals can handle cognitive conflict. Cognitive-conflict-capacity can be measured with neurocognitive methods such as psychophysics, mouse-tracking, eye-tracking and electroencephalography. Following this line of thought, the fifth and sixth research question are:

Research question 5: *Which personal characteristics interplay as the intraindividual antecedents of entrepreneurial self-efficacy?*

Research question 6: *How is a brain-mind model of the intraindividual antecedents of entrepreneurial self-efficacy?*

In summary, there is a need to understand the intraindividual antecedents that make individuals more prone to exhibiting an entrepreneurial mindset than others. One aspect that

should be studied as an antecedent of this mindset is deliberative rule-breaking tendencies because it has been shown that these broadly relate to entrepreneurship. These tendencies and their cognitive mechanism should be accessed by methodologies that avoid biases associated with self-report measurements. Moreover, when studying the antecedents of the entrepreneurial mindset, I focused on studying the antecedents of entrepreneurial intention and entrepreneurial self-efficacy. Building on previous literature, I aimed to empirically unravel the role of deliberative rule-breaking tendencies preceding the entrepreneurial mindset and the interplay of its antecedents. Despite previous literature suggesting that novel technologies favour the assessment of mental constructs associated with personal characteristics that precede the entrepreneurial mindset from a neurocognitive perspective, this proposition has not yet been empirically tested by means of a brain-mind model.

Chapter 2: Research approach

This dissertation comprises two different experiments with the collection of data from two different samples. Chapter 3 and Chapter 4 of this dissertation used data collected in an experiment carried out at the same time point. Notably, the purpose and analyses of the data substantially differ from one chapter to the other. Chapter 5 of this dissertation used data collected at a different time point from a different sample. The following three chapters answer the research questions above in an empirical and quantitative manner.

Chapter 3[1] is grounded in a cognitive science approach and answers the first, second and third research questions. The chapter reveals the adaptation, design and standardisation of a computerised task to measure interindividual differences in deliberative rule-breaking tendencies. The study records individuals' rule-breaking behaviour and classifies it into two groups – those who tend to break the rules and those who tend to follow the rules. The cognitive mechanism associated with this behaviour–cognitive conflict–is measured via psychophysics and mouse-tracking during the computerised task. The study analyses the relationship of cognitive conflict with the intraindividual and interindividual differences in rule-breaking behaviour. Furthermore, various personality traits are assessed using self-report

[1] The study reported in this chapter is based on a published paper by Cubillos-Pinilla, L. & Emmerling, F., currently published in PloS one. Please cite as: *Cubillos-Pinilla, L., Emmerling, F.(2022). Taking the chance!–Interindividual differences in rule-breaking. PloS one, 17(10), e0274837*

questionnaires and correlated with rule-breaking tendencies and cognitive conflict. The findings of this study are framed in an established model of cognitive science literature (the Decision-Implementation-Mandatory Switch-Inhibition model) and discussed as regards their originality and limitations in the field of cognitive science. These findings shed light on the relevant aspects of the computerised task for evaluating rule-breaking tendencies and cognitive conflict, which paves the way for their measurement in the following chapters of this dissertation.

Chapter 4[2] answers the fourth research question. This study analyses the interplay of individual characteristics that motivate a person to start a business or to perform entrepreneurship-like activities. More specifically, I propose that rule-breaking tendencies shape the relationship between personality and morality with entrepreneurial intention. Individuals who are high in openness or low in idealism, who tend to deliberatively break rules, should not only exhibit the cognitive processes and preferences that are relevant for the formation of entrepreneurial intention, but also have the intention to act entrepreneurially. This study proposes that entrepreneurial intention is likely to develop in individuals (a) high in openness–a personality type–because they are likely to have attitudes that are positively related to entrepreneurial activities; and (b) low in idealism–a morality type–because they are inclined to prefer social norms that counter entrepreneurship. With an open personality and high rule-breaking tendencies, they likely can recognise (due to openness) and are ready to exploit (due to rule-breaking tendencies) opportunities. Similarly, with low idealistic morality and high rule-breaking tendencies, they likely recognise novel ways to overcome problems (due to low idealism) and intend to act on their ideas even if this requires acting against the rules.

[2] The study reported in this chapter is based on a working paper by Cubillos Pinilla, L., Hubner-Benz, S. & Emmerling, F., currently submitted to *Applied Psychology*.

This study employs a computerised task to evaluate 'actual' rule-breaking tendencies and a set of questionnaires to evaluate personality traits and entrepreneurial intention. This chapter contributes to entrepreneurship research by (a) integrating research on the theory of planned behaviour with research on personality and morality to provide a more comprehensive perspective on the antecedents of entrepreneurial intention, (b) introducing deliberative rule-breaking tendencies as an antecedent of entrepreneurial intention and their interplay with other individual antecedents of entrepreneurial intention and (c) featuring a novel methodological approach to study the antecedents of entrepreneurial intention. This study can assist entrepreneurship educators in recognising personal characteristics, incorporating individualised support into the design of entrepreneurship training and by helping the recruitment process in enterprises that need individuals with an entrepreneurial mindset.

Chapter 5[3] answers the fifth and sixth research questions. This study investigates the individual antecedents of entrepreneurial self-efficacy by means of a brain-mind model. Drawing on the theory of agency and social cognition, this study proposes that a cognitive mechanism (i.e., cognitive-conflict-capacity) be associated with deliberative rule-breaking tendencies that, combined with a low behavioural inhibition personality type, precede entrepreneurial self-efficacy. This study administers questionnaires and a computerised task, during the course of which I recorded individuals' behaviour, reaction times, brain electrical activity, eye and mouse movements. This work contributes to and empirically tests an integrative model with a neurophysiological basis to the antecedents of entrepreneurship to the field. The study has practical implications for recruitment, entrepreneurial education and navigating socioeconomic shifts in current occupations. This chapter highlights the broad

[3] The study reported in this chapter is based on a working paper by Cubillos Pinilla, L., Emmerling, F., Peus. C., currently submitted to *Personnel Psychology*.

potential of brain-mind models for use in the study of the antecedents of management and entrepreneurship at the individual level.

Chapter 3: Taking the chance! – Interindividual differences in rule-breaking

Abstract

While some individuals tend to follow norms, others, in the face of tempting but forbidden options, tend to commit rule-breaking when this action is beneficial for themselves. Previous studies have neglected such interindividual differences in rule-breaking. The present study fills this gap by investigating cognitive characteristics of individuals who commit spontaneous deliberative rule-breaking (rule-breakers) versus rule-followers. We developed a computerised task, in which 133 participants were incentivised to sometimes violate set rules which would – if followed – lead to a loss. While 52% of participants tended to break rules to obtain a benefit, 48% tended to follow rules even if this behaviour led to loss. Although rule-breakers experienced significantly more cognitive conflict (measured via response times and mouse movement trajectories) than rule-followers, they also obtained higher payoffs. In rule-breakers, cognitive conflict was more pronounced when violating the rules than when following them and mainly during action planning. This conflict increased with frequent, recurrent and early rule-breaking. Our results were in line with the Decision-Implementation-Mandatory switch-Inhibition model and thus extend the application of this model to the interindividual differences

in rule-breaking. Furthermore, personality traits such as extroversion, disagreeableness, risk propensity, high impulsiveness seem to play a role in the appreciation of behaviours and cognitive characteristics of rule-followers and rule-breakers. This study opens the path towards the understanding of the cognitive characteristics of the interindividual differences in responses towards rules and especially in spontaneous deliberative rule-breaking.

Keywords: rule-breaking, rule-following, cognitive conflict, recency, latency, decision-making.

1. Introduction

Humans tend to follow norms because this action is reinforced by peers, superiors and society (Gozli, 2019; Gross and De Dreu, 2020; Guzmán and Frasser, 2017; Baron et al., 2009; Van Wye et al., 2020; Wang et al., 2015) . Even seemingly simple behaviours such as verbal communication are grounded in surprisingly complex rules with respect to grammar and pragmatics (de Diego Balaguer et al., 2007; Gow and Nied, 2014) . Most of the time, human agents effortlessly follow such regulations as these norms define behaviours that are allowed and expected in specific social situations (Blass and Schmitt, 2001; Cialdini and Goldstein, 2004; Searle, 2010) . Rule-following can, furthermore, be favourable for individual agents because rule-followers are perceived as more reliable social partners (Foerster et al., 2013; Vlachos et al., 2013; Baum and Locke, 2004) The described advantages seem to solidify rule-following behaviour as a default mode for cultural evolution (Hoffman, 1981; Bushmakin, 2017) .

Despite rule-following advantages, humans also show a tendency to break rules when established conventions thwart their attempts to succeed. Although rule-following is the dominant behavioural action plan, rules are broken if the value of the expected outcome following this action is sufficiently large (e.g., increased reward, increased social desirability,

expedited task completion; Gross and De Dreu, 2020; Bushmakin, 2017; Forsyth, 1982; Pfister et al., 2019). Interestingly, some individuals tend to follow rules regardless of the consequences (Kyrlitsias and Michael-Grigoriou, 2018; Neyret et al., 2020; Salomons et al., 2018) while others tend to make an effort to break them specifically to obtain benefits (Pfister et al., 2019; Dignath et al., 2014; Gross et al., 2018; Wirth et al., 2016; Pfister, 2013) . These interindividual differences seem to be more palpable in individualistic cultures in which individuals are more prompted to commit rule-breaking in comparison to collectivistic cultures (Sims, 2007) . This study investigates cognitive and personality characteristics of these interindividual differences in spontaneous deliberative rule-breaking (rule-followers versus rule-breakers) in an individualistic culture and results cannot be generalised to collectivistic settings. Notably, this research focuses on general norms rather than on social, legal or moral norms. That is, we investigate individuals' reaction towards the connotation of framing a simple but otherwise arbitrary statement as a norm (e.g., the rule is to put a ball in the blue area)."

1.1 Interindividual differences in rule-breaking

Although some people tend to break norms when the rewards of following them are limited, others always follow them regardless of the cost (Bushmakin et al., 2017; Greve et al., 2019) . However, in previous studies, unconditional rule-followers (i.e., participants who usually followed rules) were either excluded for further analyses (Pfister et al., 2019; Gross et al., 2018), or participants were directly instructed to follow or break rules (i.e., non-spontaneous rule-breaking behaviour; Wirth et al., 2016; Pfister, 2013; Jusyte et al., 2017; Jusyte et al., 2019; Pfister et al., 2014; Pfister et al., 2016a; Wirth et al., 2018) . Thus, cognitive research on rule-breaking has rarely focused on this interindividual variability (Pfister et al., 2019; Gross et al., 2018). Importantly, studying rule-breaking with in one individual is valuable and has been well studied (Jusyte et al., 2017; Jusyte et al., 2019; Pfister et al., 2014; Pfister et al., 2016a; Wirth et al., 2018), but distinct from a line of research that includes interindividual differences in rule-

breaking. This gap is partly rooted in the challenge to design a paradigm in which participants show variable behaviour. On the one hand, the population divides into different groups with different tendencies towards imposed rules (i.e., rule-followers, rule-breakers; (Pfister et al., 2019; Gross et al., 2018)). Hence, it is difficult to study the natural inclinations of rule-following and rule-breaking within one individual. On the other hand, in a laboratory setting, it is difficult to induce spontaneous rule-breaking, which is not explicitly instructed and, thus, ecologically (Dignath et al., 2014; Wirth et al., 2016; Pfister, 2013; Jusyte et al., 2017; Jusyte et al., 2019;Pfister et al., 2016a; Pfister et al., 2016b; Sheperd, 2012; Wirth et al., 2019) . In tasks in which rule-breaking is not instructed, rule-breaking behaviour is substantially rare and it is, thus, hard to achieve the statistical power required to draw inferences on the comparison between breaking versus following rules. Research is needed to identify and describe the individuals' natural inclinations towards rule-breaking and to uncover their cognitive characteristics.

1.2 Spontaneous deliberative rule-breaking

One of the ways to motivate spontaneous deliberative rule-breaking in the laboratory is to introduce economic rewards (Pfister et al., 2019; Dai et al., 2018; Fischbacher and Föllmi-Heusi, 2013; Gächter and Schulz, 2016; Geven et al., 2020; Hobson et al., 2020; Lin and Suárez, 2020) so that participants are motivated to either increase their payoffs or to prevent losses (Schindler and Pfattheicher, 2017). In most studies, participants are encouraged to continuously break a rule (Dai et al., 2018; Fischbacher and Föllmi-Heusi, 2013; Gächter and Schulz, 2016; Hobson et al., 2020; Lin and Suárez, 2020). However, in real-world situations, breaking a rule is not necessarily constant but merely sometimes optimal (Van der Steen, 2012). In many cases, rule-following might be beneficial and practical (Pfister et al., 2016b; Sheperd, 2012; Zawadzka et al., 2016), while in other instances, rule-breaking may be the more advantageous option (Arend, 2016; Clegg et al., 2017). Here, the self-interests of the individuals following or

breaking the rules are key. That is individuals' self-interests defined by an initial behaviour (i.e., the *a priori* behaviour expressed without an external constraint;Bobadilla-Suarez et al., 2022; Dong et al., 2021; Gordon, 2021; Oosterhoff and Palmer, 2020; Rische and Komarova, 2016). In some individuals, this initial behaviour persists after a rule is present (Gross et al., 2018). As rules limit or threat specific behavioural freedoms, individuals' psychological reactance might motivate to commit rule-breaking to pursue these self-interests (Petegem et al., 2015).They opt for committing rule violations only when the outcome is positive (e.g., leads to greater earnings or benefits), which is when it is aligned with their interests. For example, car drivers do not cross red traffic lights to reach their destination faster because someone or something commanded them to go for it (Cinnamon et al., 2011). This spontaneous and deliberative form of rule-breaking, i.e., the form of rule-breaking in which individuals carefully and meticulously decided whether to follow or break rules in particular situations based on consequences and own interests, is the one that is worth studying. However, research on this kind of spontaneous deliberative rule-breaking is rare and yet we need to comprehend the underlying cognitive mechanisms.

1.3 Cognitive conflict in rule-breaking

Previous literature on instructed rule-breaking elucidate the understanding of the cognitive characteristics of intentionally behaving contrary to what is commonly acknowledged as appropriate (Pfister, 2013; Wirth et al., 2018; Hayes et al., 1989). In these instructed rule-breaking tasks, when the individuals are asked to follow a rule, the rule retrieval automatically facilitates the agent's behaviour to obey the rule. Simultaneously, actions that are inconsistent with following the rule are suppressed. In contrast, when individuals are asked to break the rule, the individual must make the effort to reactivate covert actions or to look for alternative actions filling in for the behavioural option to follow the rule. Therefore, rule-breaking consists of resolving the cognitive conflict resulting from the simultaneous suppression of the rule-

following action plan, alongside the intended action plan to break the rule (Pfister, 2013; Botvinick et al., 2001; Schröger et al., 2007). The mere connotation of rule *violation* makes a response harder to carry out (e.g., take more time to complete) than an identical response that is labelled with a more neutral term, such as rule *inversion*, even if both actions require the same cognitive and motor operations (Pfister et al., 2016b; Sheperd, 2012; Wirth et al., 2016).

Cognitive conflict can be measured and quantified by analysing reaction times and parameters of mouse trajectories such as Maximum Absolute Distance (MAD) and Area Under the Curve (AUC) in computerised tasks. For instance, if individuals have to choose between two options starting from a central point, then their mouse trajectory towards these options could determine the uncertainty towards one option or another (Wirth et al., 2018). Thereby, larger reaction times and larger trajectory parameters indicate larger cognitive conflict. Such measures are valuable because they (a) are sensitive to specific response options towards rules (Freeman and Ambady, 2009; McKinstry et al., 2008; Song and Nakayama, 2009), (b) identify the temptation towards behavioural alternatives whilst probing for self-control (Dignath et al., 2014) and (c) reflect internal representations such as anticipated action consequences (Pfister et al., 2014; Pfister et al., 2016b; Wirth et al., 2015).

Pfister et al. (2019) and Wirth et al. (2018) have suggested that, in instructed rule-breaking tasks, planning versus executing an action rely on separate cognitive processes. In typical conflict tasks, participants have to continuously react to task-relevant stimuli while ignoring task-irrelevant information. Responses are typically fast and correct but deteriorate once alternative responses are required (Egner and Hirsch, 2005; King et al., 2010; Prével et al., 2021; Sundvall and Dyson, 2022). However, with increasing frequency of alternative responses, participants' performance recovers (Prével et al., 2021; Sundvall and Dyson, 2022; Logan and Zbrodoff, 1979; Ullsperger et al., 2005). Different from typical cognitive conflict tasks, the performance does not recover completely in instructed rule-breaking tasks (Poboka

and Karayanidis, 2014). Mainly, the time spent for planning rule-violations and not the execution of them remains unaffected by the frequency of the alternative responses (rule-breaking behaviour) and their recency (i.e., how often rule-breaking is immediately followed by further rule-breaking; Wirth et al., 2018). This suggests that planning to violate norms is likely to involve persistent cognitive conflict. Evidence implies, thus, that planning and execution of rule-breaking build upon different mental sources and processes (Liefgreen et al., 2020; Pennycook et al., 2015).

Recent research has shown that cognitive conflict relates not only to instructed rule-breaking, but also to spontaneous deliberative rule-breaking that requires to be an unsolicited but incentivised rule violation (Pfister et al., 2019; Dignath et al., 2014; Geven et al., 2020). Like in instructed rule-breaking, Pfister et al. (Dignath et al., 2014) observed that spontaneous deliberative rule-breaking relates to larger cognitive conflict than rule-following and that this conflict was correlated with fewer decisions in favour of violating rules. Thus, individuals chose to violate norms even if it had a high cognitive cost. Nonetheless, few studies have examined cognitive conflict in spontaneous deliberative rule-breaking (Pfister et al., 2019; Dignath et al., 2014), while several studies have examined this conflict in instructed rule-breaking (Wirth et al., 2016; Pfister, 2013; Jusyte et al., 2017; Jusyte et al., 2019; Pfister et al., 2014; Pfister et al., 2016a; Wirth et al., 2018). Further studies are needed to evaluate this conflict in various tasks to confirm that this conflict is neither task specific nor due to the fact that this norm violation is instructed. In another spontaneous deliberative rule-breaking study, Arend (2016) registered the frequency (i.e., how many times rule-breaking occurs in a given behavioural task to obtain a gain), latency (i.e., how early rule-breaking occurs in a given behavioural task to obtain a gain) and recency (i.e., how often rule-breaking is immediately followed by further rule-breaking resulting in a gain) of rule-breaking behaviour in a task. While latency was interpreted as individuals' alertness towards the recognition of opportunities, recency dictated the

individuals' aggressiveness of their reaction towards positive feedback. However, Arend [45] did not explicitly consider cognitive conflict. He was not interested in the effect of the frequency, latency and recency of rule-breaking behaviour on cognitive conflict, but on entrepreneurial status. Although frequency and recency of rule-breaking have been shown to impact the cognitive conflict during the execution but not the planning of rule violations in instructed rule-breaking tasks (Wirth et al., 2018), how such results transfer to spontaneous deliberative rule-breaking remains unknown. Likewise, evidence on the influence of rule-breaking latency on cognitive conflict in spontaneous deliberative rule-breaking has been neglected.

In summary, research on instructed and spontaneous deliberative rule-breaking tasks has shown that rule-breaking involves cognitive conflict. This conflict is larger when breaking rules than when following them and it can be measured via reaction times and mouse trajectory parameters. However, few studies have investigated this conflict in spontaneous deliberative rule-breaking in comparison to instructed rule-breaking. Moreover, the effect of frequency, latency and recency on cognitive conflict in spontaneous deliberative rule-breaking has not been addressed.

1.4 DIMI Model

Previous rule-breaking studies have mainly focused on instructed rule-breaking behaviour (Pfister, 2013; Jusyte et al., 2019; Pfister et al., 2014; Pfister et al., 2016a; Pfister et al., 2016b; Wirth et al., 2019; Fischbacher and Föllmi-Heusi, 2013). Based on these studies, Wirth *et al.* (2018) postulated the Decision-Implementation-Mandatory switch-Inhibition (DIMI) model, an adaptation of the two-step activation model (Wirth et al., 2016). The DIMI model assumes:

1. The following and breaking of norms are two distinct task sets, even when co-occurring in the same block. However, both task sets always co-occur (Wirth et al., 2018).

2. By default, humans follow rules. Therefore, the task set for rule-following is always accessible and partially pre-implemented. This is evident because when participants obey norms, they take less time to complete this action.

3. When a rule-breaking task set is implemented, interference arises from the two task sets' competition (rule-breaking and rule-following) and triggers cognitive conflict (e.g., slower reaction times, complex and longer mouse movements). Here, the rule-following task set is only temporarily suppressed or inhibited because the rule-breaking task set cannot exist independently.

4. The selection for the task set (i.e., rule-following versus rule-breaking) usually occurs mainly during its planning as it is evident due to slow reaction times (Wirth et al., 2018). On top of that, implementation of the task set is not necessarily complete by the end of its planning (i.e., initiation time, e.g., the time in which stimuli are displayed), but can continue even during the action execution (i.e., movement time, e.g., time in which participants perform movements to complete the task set), as it is evident due to slower reaction times in comparison to rule-following (Scherbaum et al, 2010).

The DIMI model has been framed to explain instructed rule-breaking but has yet to conceptualise spontaneous deliberative rule-breaking. As cognitive conflict has already been observed in spontaneous deliberative rule-breaking behaviour (Pfister et al., 2019; Wirth et al., 2016; Pfister, 2013), we expect the DIMI model to cover this behaviour as well. Empirical evidence for this hypothesis, however, still needs to be provided. Furthermore, the DIMI model has so far exclusively considered behaviours or task sets exclusively performed by the same individual. Although there are visible interindividual differences in rule-breaking (Pfister et al., 2019; Gross et al., 2018), previous research has not investigated the cognitive underpinnings of these differences for the challenges mentioned above (see *1.1 Interindividual differences*).

Thus, the fit of interindividual differences in the DIMI model has not yet been explored. Since the model's assumptions do not exclude individuals who tend to follow the rules or commit spontaneous rule-breaking, we expect that the model applies to understand these interindividual differences. This hypothesis is yet subject to empirical support. If true, the model could contribute even more to the understanding of spontaneous deliberative rule-breaking because it would enable differentiation of the cognitive scheme in individuals that tend to commit rule-breaking from those who do not.

1.5 Personality in rule-breakers and rule-followers

Personality describes reasonably constant patterns of behaviour, thoughts and emotions (McCrae and Costa, 2003; Parks-Leduc et al., 2015) and accounts for a high amount of variance in various behavioural and cognitive processes (Becht et al., 2016; Rammstedt et al., 2018; Virge et al., 2014). However, the influence of personality on behaviours and cognitive processes has not been yet explored among rule-breakers and rule-followers in a controlled setting. For instance, personality could (a) facilitate low cognitive cost in rule-followers, (b) enhance the frequency of rule-breaking behaviour in rule-breakers and (c) facilitate better coping with high cognitive costs due to spontaneous deliberative rule-breaking behaviour in rule-breakers.

Moreover, previous research has indicated personality to be a strong predictor of behaviours in individuals that conform or violate rules (Becht et al., 2016; Atindanbila and Gyamfua, 2012). For example, individuals that tend to conform to rules tend to be introverts (Atindanbila and Gyamfua, 2012). In contrast, individuals who are inclined to break rules (e.g., criminal behaviour, pedestrian train crossing violation, pro-social rule-breaking, counterproductive behaviour at school, aggression) tend to be grandiose narcissistic (Finkelman and Kelly, 2011), propense to risk (Freeman and Rakotonirainy, 2015; Morrison, 2006; Obschonka et al., 2013; Reiter et al., 2019; Zhang and Arvey, 2009), disagreeable (Carvalho et

al., 2020; Fiddick et al., 2016; Hartmann and Müller, 2022; Hopwood et al., 2009; Jackson et al., 2010; Jensen-Campbell et al., 2002; Reardon et al., 2015) and impulsive (e.g., low behavioural inhibition, high goal-oriented motivation and sensation seeking; Janoff-Bulman, 2009; Maneiro et al., 2017; Rhodes et al., 2013; Sijtsema et al., 2010). Therefore, it seems worth to investigate the link of these personality traits (using psychometric measures) with the behavioural and the cognitive characteristics of rule-followers and rule-breakers, especially when evaluating these characteristics in a controlled setting.

1.6 Research goals

The present study aims to fill the outlined gaps by addressing the following five research goals:

1. As previous studies have rarely examined differential characteristics of rule-followers versus rule-breakers, in this study we implement and validate a computerised task that identifies interindividual differences in rule-breaking. While rule-followers tend to follow rules, rule-breakers tend to violate rules when the consequences of following them are negative and tend to follow them when the consequences are positive. Rule-breakers pursue their self-interests as their initial behaviours persist even after external rules are imposed. This is important because we improve the characterisation of individual variations in responses towards rules and spontaneous deliberative rule-breaking as we appraise how individuals who commit this behaviour are distinct from others.

2. We aim to evaluate cognitive conflict in (a) rule-breakers versus rule-followers and (b) spontaneous deliberative rule-breaking versus rule-following in rule-breakers. This is important because (a) we improve the characterisation of individual variations in rule-breaking as we appraise how rule-breakers are distinct from others and (b) we can specifically attribute conflict to spontaneous deliberative rule-breaking instead of instructed behaviour or the task in which this behaviour is tested.

3. Moreover, it is still unknown whether or not the factors such as frequency, latency and recency of rule-breaking impact cognitive conflict in spontaneous deliberative rule-breaking. In this line, we investigate to what extent this conflict is affected by them.

4. In the interest of providing a broad perspective on interindividual differences in rule-breaking, we investigate the relationships between personality, behaviour and cognitive processes in rule-followers and rule-breakers.

5. In order to know whether the DIMI model extends (a) from instructed rule-breaking behaviour to spontaneous deliberative rule-breaking within and between individuals and (b) from behaviours (rule-following versus rule-breaking) within an individual to behavioural tendencies (rule-followers versus rule-breakers) between individuals, we aim to discuss the extent to which this model fits our results. Framing our results in this model contributes to the conceptualisation of spontaneous deliberative rule-breaking.

2. Method

2.1 Sample and procedure

The study was conducted in either German or English in the Laboratory of Experimental Research in Economics at the Technical University of Munich. Once participants arrived at the laboratory, they signed a written informed consent and sat in individual cubicles to complete the computerised task and questionnaires. The entire experiment took about one hour to complete and at the end of the experiment participants were paid between 8 to 14 euros for compensation. All procedures were approved by the Ethics Commission of Technical University Munich (project number: 64/19 s).

A final sample of 133 participants (61 females, i.e., 45.9%; M_{age} = 25, SD_{age} = 7) were included in the analysis. In terms of outlier analysis, first, we excluded practice trials, trials

that took longer than 5000 ms or shorter than 250 ms (Becker et al., 2016; Cassotti et al., 2012; Rogers and Monsell, 1995) and outlier values of the reaction times and mouse trajectory parameters during the "rule" part of the task, which resulted in the exclusion of .07% of trials. Second, following the main resistance rule by Hoaglin *et al.* (1986), we performed an outlier analysis on the mean of the reaction's times and mouse trajectory parameters of the trials of all participants in the blocks where rules were shown, which led to the exclusion of one participant (for further details on outlier analysis and excluded participant see supplementary material).

2.2 Rule-breaking task

To measure rule-breaking behaviour, we implemented a computerised task adapted from an established paradigm (Wirth et al., 2016) See *Figure 1.* for task design and an animation in .GIF format of the whole task can be found in the supplementary material.

2.2.1 Technical specificities. Viewing distance was unconstrained at approximately 65 cm. Stimuli were presented on a 19-inch CRT monitor (1440 x 900 pixels, 75-Hz vertical refresh rate) and enhanced pointer precision in mouse settings was deactivated to obtain an accurate measurement of participants' mouse trajectory parameters (13-14Hz refresh rate). E-Prime 3.0 (Psychology Software Tools, Pittsburgh, PA) was used to implement the computerised experimental task.

2.2.2 Instructions. At the beginning of the task, participants were informed that they would receive 8 Euro for participation at the end of the experiment and that this amount would increase proportionally to the number of stocks they earned during the task. We read the initial instructions and asked the participants to reread these on the screen before they proceeded with the task. In addition, participants were instructed to execute smooth movements and were

encouraged to ask questions to ensure that they understood the task. Experimenters were present in the room during the whole procedure.

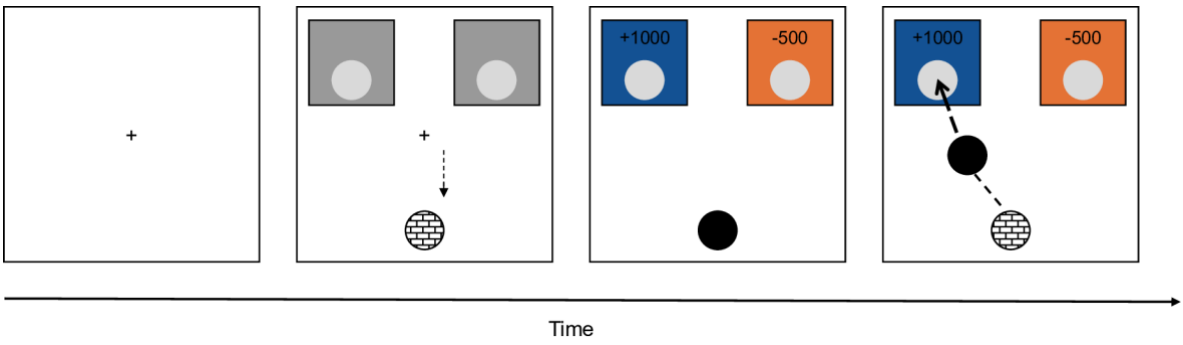
2.2.3 General task procedure. In the experiment, the participants decided how to allocate balls between two areas: a blue and an orange box. Each box was associated with a different number of stocks for each trial (see *Figure 1A.*). Participants earned the number of stocks that they selected. Participants' decisions throughout the task led to real financial consequences because the final sum of chosen stocks translated into additional compensation.

2.2.4 Trial Structure. Figure 1A summarises the trial procedure. Trials commenced with a fixation cross of 500-700 ms duration (jittered randomly in steps of 20 ms). Afterwards, the following objects were presented on the screen: a brick black-white texture circle (diameter: 2 cm) in the lower part of the screen, a cross-shaped cursor (diameter = 2 cm) situated in the screen centre, two grey boxes located on the superior part of the screen that were separated horizontally by 16 cm and had inside a circular light grey hole (diameter = 2,2 cm) (see *Figure 1A*). In each trial, the cursor had to be dragged to the home-area (brick black-white texture circle) to pick up a black ball (diameter = 2 cm), which subsequently displayed at the respective cursor coordinates. At the same time, each box turned into either blue or orange and a specific number of stocks appeared above the grey hole. The time spent in the home area while seeing the amounts of stocks displayed on the screen was registered as the initiation time (i.e., action planning). Then, the participants dragged the ball into one of the grey holes located in the boxes to complete the trial, which meant that they selected the number of stocks displayed above the chosen box. The time between when the ball was dragged out of the home-area and dropped into a hole was registered as the movement time (i.e., action execution). If participants took more than 1000 ms to complete this action, a message, *"Please try to leave the home-area as quickly as possible!",* would appear on the screen so that participants became faster and remained focused throughout the task. The assignment of colours to each of the boxes was

randomised across trials. The use of blue versus orange ensured that all participants recognised them as two different colours, even if they were colour-blind. For further information about the stimuli location on the screen see supplementary material.

2.2.5 Block structure. The task consisted of two parts: an initial "rule-free" part and a subsequent "rule" part, both preceded by five practice trials (see *Figure 1B*.). The "rule-free"

A. Trial structure



B. Block structure

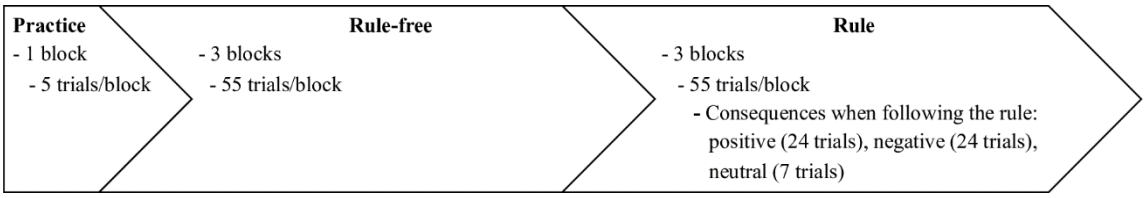


Figure 1. A. Trial structure. Following a fixation cross (500-700 ms), participants moved the mouse cursor to the home-area in the bottom-centre of the screen. Once they reached the home-area, the cursor transformed into a black ball. Simultaneously, the screen displayed the coloured boxes and the stock values for each box (the time prior to cursor pick-up while stock values were already displayed was measured as initiation time; i.e., action planning). Subsequently, participants dragged the ball from the home-area towards either of the boxes and, therewith, earned/lost the stocks associated with the chosen box (the time of the cursor movement was measured as movement time; i.e., action execution). For further information about the stimuli location on the screen see supplementary material. B. Block structure. The task included a "rule-free" and a "rule" part, preceded by practice trials. After each block, participants received feedback on the total amount of stocks they accumulated. In "rule-free" blocks, participants were instructed to freely choose the number of stocks they wanted to keep for themselves. In the "rule" blocks, participants were instructed to select a specific colour, irrespective of the associated stocks. The type of consequences when following the rule in the "rule" part were fully randomised. The experiment comprised 335 trials in total.

part included three blocks in which the participants freely chose the box they preferred. The "rule" part involved three blocks and introduced a simple colour-based rule that was displayed on screen (e.g., "The rule is to put each ball in the blue/orange area") at the beginning of each block. The colour indicated in this rule was counterbalanced across participants. Rule-breaking did not have any additional consequence apart from receiving or losing the number of stocks associated with the chosen box. Each block included 55 trials. When following the rule during the "rule" part, 7 trials led to neutral (i.e., getting the same number of stocks), 24 to positive (i.e., getting the greatest number of stocks) and 24 to negative (i.e., getting the lowest number of stocks) consequences. The trial sequence within each block was fully randomised. An additional diagram about the block structure can be found in the supplementary material.

2.2.6 Decision consequences. In each trial, dragging the ball to either the blue or the orange box led to the following consequences in terms of stock amounts: −5000, -3000, −1000, −500, 0, 500, 1000, 3000, 5000. Participants were confronted with combinations of these stocks across the two boxes within each block (see supplementary material for further details of these combinations). The distribution of stocks was arranged in a way that unconditional rule-followers earned a maximum of 39000 stocks in the "rule" part, while rule-breakers always opting for the most beneficial option - despite the consequence when following the rule - could earn a maximum of 171000 stocks. This potential earning was implemented to increase the motivation to break rules.

2.3 Questionnaires

After participants completed the main task, personality traits were assessed via psychometric measurements. We evaluated narcissism using the Narcissistic Personality Inventory (cronbach's alpha: .62; Gentile et al., 2013, 13 items, literature cronbach's alpha = .73), risk propensity (cronbach's alpha: .68; Antoncic et al., 2016 , 2 items, literature cronbach's alpha =

.75), impulsiveness - behavioural inhibition and activation systems (cronbach's alpha = .7; Carver and White, 1994 and the Big Five personality traits (cronbach's alpha = .45; (Rammstedt and John, 2007), 10 items, literature cronbach's alpha = .75), for further details see supplementary material.

2.4 Data analyses

2.4.1 Classification of rule-breakers versus rule-followers

All data analysis is based on classification of participants into two groups. Participants were classified as either rule-breakers or rule-followers based on the distribution of the percentage of rule-breaking behaviour that led to a gain. Participants who always follow the rule and who were within the first quantile (25%) of the distribution in individuals who broke at least once the rule were labelled as rule-followers and the rest were labelled as rule-breakers. Thus, we opted for a conservative criterion regarding the inclusion of participants as rule-followers, by including within rule-followers individuals who never broke the rule and those who might have mistaken on breaking the rule (i.e., those in the first quantile). Importantly, including only those who always followed the rule led to the same results. In addition, we controlled that rule-breakers followed the rules in more than 95% of trials in which the consequences of following them were positive.

2.4.2 Statistical analyses. Mouse trajectory parameters were extracted from the raw movement trajectories during the movement time by using a custom-coded MATLAB (MATLAB 2019a, The MathWorks, Natick, 2019) based on Wirth *et al.* (2018). All data was processed in R version v3.1.2. and statistical analyses were performed in in IBM SPSS Statistics (Version 27). General linear models (2-tailed, sig. .05) were employed.

3. Results

3.1 Classification of rule-breakers versus rule-followers

Participants who never broke the rule or that broke the rule in less than or equal to 13.8% (first quantile cut-off; see also method section) were classified as rule-followers (N = 63, 30 females, i.e., 49.2%; M_{age} = 25.4, SD_{age} = 7.7), while the rest were labelled as rule-breakers (N = 70, 31 females. i.e., 44.3%. M_{age} = 25, SD_{age} = 6.4). Importantly, most of the rule-followers always followed the rules regardless of the consequences (78.6%). Results were stable when using other cut-offs (0%, 5%, 10%, 15%, 20%, 55%)[1]. As assessed via manipulation checks, all participants reported that they recognised and remembered the rule in the "rule" part of the task, as well as had no previous experience with similar tasks. All rule-breakers explicitly reported that they sometimes broke the rules.

3.2 Rule-breaking task

3.2.1 Decision-making in the "rule-free" and "rule" part. Participants optimised their earnings in 97% of the trials in the "rule-free" part (rule-breakers = 97%; rule-followers = 95%), which shows that their intrinsic interest was to maximise their earnings. Participants were slower and exhibited longer and more complex trajectories in the "rule-free" part than in the "rule" part. This suggests that participants learnt to master the task after the "rule-free" part (see supplementary material for details). Furthermore, rule-breakers' and rule-followers' reaction times and mouse trajectories exclusively differed significantly in the "rule" part of the task (see supplementary material for details).

3.2.2 Reaction times and mouse trajectories across the type of consequences when following the rule and across interindividual differences in rule-breaking.

Multiple independent mixed 3 x 2 ANOVAs with the type of consequence when following the rule (i.e., positive, negative, neutral) as a within group factor and the behavioural tendency (i.e., rule-followers versus rule-breakers) as a between group factor were computed

to examine whether there were significant differences in participants' behaviour (i.e., reaction times, mouse trajectory parameters) (see *Figure 2*). These tests revealed an interaction between the type of consequences and the behavioural tendency with respect to reaction times and mouse trajectory parameters ($F_{total(2,130)} = 33.23$, $\eta^2 = .34$, $p < .001$; $F_{initiation\ (2,\ 130)} = 18.65$, $\eta^2 = .22$, $p < .001$; $F_{movement\ (2,\ 130)} = 18.6$, $\eta^2 = .22$, $p < .001$; $F_{MAD\ (2,\ 130)} = 34.95$, $\eta^2 = .35$, $p < .001$; $F_{AUC\ (2,\ 130)} = 35.68$, $\eta^2 = .35$, $p < .001$). Rule-breakers were significantly slower, displayed longer and more complex mouse trajectories across all type of consequences when following the rule as compared to rule-followers (see *Table 1, Figure 2*). Trials associated with negative consequences resulted in significantly slower reactions, as well as longer and more complex mouse trajectories than those associated with positive and neutral consequences (see *Table 1, Figure 2*). Further post-hoc analyses with Bonferroni adjustment revealed that rule-breakers' reactions were characterised by longer total, initiation and movement time in trials associated with negative consequences as compared to when those associated with positive consequences (see *Table 1, Figure 2*). Mouse trajectories were longer and more complex in rule-breakers in trials associated with negative consequences as compared to when those associated with positive or neutral consequences (see *Table 1, Figure 2*). In rule breakers, mouse trajectories were longer and more complex in trials associated with neutral consequences than with those associated with positive consequences (see *Table 1, Figure 2*). No significant differences were found in reaction times and mouse trajectory parameters among rule-followers across the type of consequences when following the rule (see *Table 1, Figure 2*).

Since we are interested in the interindividual differences of responses towards rules, we reported the results based on the dichotomous distinction between rule-followers and rule-breakers. Exploratory analyses that examined the continuous (versus dichotomous) effect of rule-breaking frequency on reaction times and mouse trajectory parameters revealed the same results. All reported results remain stable after bootstrap analyses with 1000 permutations.

3.2.3 Rule breakers

3.2.3.1 Reaction times and mouse trajectories when following and breaking the rules associated with negative consequences. Multiple independent paired-sample t-tests were performed to examine the influence of the response towards the rule (i.e., rule-breaking behaviour versus rule-following behaviour) on cognitive conflict measurements (i.e., reaction times, mouse trajectory parameters) exclusively in those rule-breakers who sometimes broke and sometimes followed the rule in trials associated with negative consequences (N = 59, 4 rule-breakers were excluded for this analysis as they always broke the rule in these trials). We found that rule-breakers were slower when they broke the rule (M_{total} = 1183.3 ms, $M_{initiation}$ = 614.5 ms, $M_{movement}$ = 568.7 ms) than when they followed the rule (M_{total} = 1028.8 ms, $M_{initiation}$ = 517.3 ms, $M_{movement}$ = 511.4 ms, $t_{total\ (56)}$ = -4.15, η^2 = -.55, p < .001; $t_{initiation\ (56)}$ = -4.1, η^2 = -.58, p < .001; $t_{movement\ (56)}$ =-4.4, η^2 = -.28, p < .05). Notably, the effect is more pronounced for initiation than for movement time. Mouse trajectories were longer and more complex when breaking the rule (M_{MAD} = 26 px; M_{AUC} = 6549.3 px^2) than when following the rule (M_{MAD} = 76.5 px, M_{AUC} = 17016.8 px^2, $t_{MAD\ (58)}$ = -5.61, p < .001; $t_{AUC\ (58)}$ = -5.37, p < .001; see *Figure 3*). Further analyses showed that reaction times are longer, as well as mouse trajectories are longer and more complex, when participants broke the rule in the current trial after following the rule in the previous trial, in comparison to trials were participants either followed the rule consecutively or followed the rule in the current trial after violating it in the previous trial (see supplementary material for details).

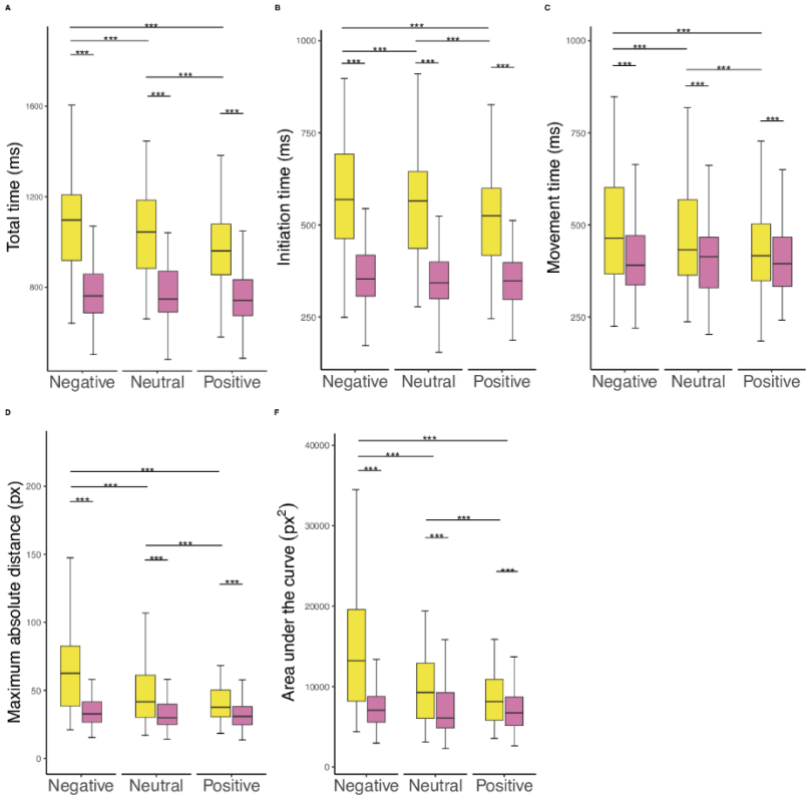


Figure 2. Reaction times and mouse trajectories across interindividual differences in rule-breaking and type of consequences when following the rule. Yellow = rule-breakers, Pink = rule-followers. Significance: *** = p <.001. The top and bottom whiskers are set to the highest/lowest value of the dataset that are included in the 1.5IQR range.

Table 1. Descriptive values and post-hoc results of reaction times and mouse trajectory parameters across behavioural tendency and type of consequences when following the rule (i.e., neutral, positive, negative)

Descriptive analyses

	Type of consequences											
	Negative				**Neutral**				**Positive**			
	Rule-breakers		**Rule-followers**		**Rule-breakers**		**Rule-followers**		**Rule-breakers**		**Rule-followers**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total time (ms)	1098.1	219.3	787.7	168.6	1044	196.2	780	164	970	168.9	765.7	156
Initiation time (ms)	576.1	170.5	361.5	85.8	559.1	153.2	353.7	81.2	523.1	134.8	351.2	71.5
Movement time (ms)	522	216.2	426.1	134.5	484.8	198	426.3	133.9	446.9	168.6	414.4	128.7
MAD (px)	69.4	40	38.4	22.7	52.1	34.4	36.7	21.2	43.1	24.5	35.7	19.2
AUC (px^2)	15439.6	9223.4	8817.5	6776.5	11245.3	7910.4	8971.9	7054.1	9743.3	6613.9	8197.6	6091.6

Post-hoc analyses

		Mean difference	**Std. Error**	***p***	**95% Confidence interval**	
					Lower bound	**Upper bound**
Total time (ms)						
Behavioural tendencies						
Rule-breakers	Rule-Followers	259.56*	29.99	0	200.24	318.9
Type of consequences						
Negative	Positive	75.04*	7.75	0	56.25	93.84
	Neutral	30.89*	8.47	0	10.34	51.44
Positive	Neutral	-44.154*	5.22	0	-56.81	-31.5
Behavioural tendency: Type of consequence						
Rule-breakers: Negative	Rule-followers: Positive	332.44*	31.15	0	240.45	424.42
	Rule-followers: Negative	310.45*	31.15	0	218.47	402.44

	Rule-followers: Neutral	318.07*	31.15	0	226.09	410.06
	Rule-breakers: Positive	128.1*	31.96	0	33.73	222.48
	Rule-breakers: Neutral	54.16	31.96	1	-40.22	148.53
Rule-breakers: Positive	Rule-followers: Positive	204.33*	31.15	0	112.35	296.32
	Rule-followers: Negative	182.35*	31.15	0	90.36	274.34
	Rule-followers: Neutral	189.97*	31.15	0	97.98	281.96
	Rule-breakers: Neutral	-73.95	31.96	.32	-168.32	20.43
Rule-breakers: Neutral	Rule-followers: Positive	278.28*	31.15	0	186.29	370.26
	Rule-followers: Negative	256.3*	31.15	0	164.31	348.28
	Rule-followers: Neutral	263.92*	31.15	0	171.93	355.9
Rule-followers: Negative	Rule-followers: Positive	21.98	30.32	1	-67.55	111.52
	Rule-followers: Neutral	7.62	30.32	1	-81.91	97.15
Rule-followers: Positive	Rule-followers: Neutral	-14.36	30.32	1	-103.89	75.17
Initiation time (ms)						
Behavioural tendencies						
Rule-breakers	Rule-Followers	197.27*	20.34	0	157.04	237.5
Type of consequences						
Negative	Positive	31.67*	4.56	0	20.6	42.74
	Neutral	12.42*	4.77	.03	0.87	23.98
Positive	Neutral	-19,250*	3.25	0	-27.12	-11.38
Behavioural tendency: Type of consequence						
Rule-breakers: Negative	Rule-followers: Positive	224.87*	20.92	0	163.09	286.65
	Rule-followers: Negative	214.51*	20.92	0	152.73	276.29
	Rule-followers: Neutral	222.38*	20.92	0	160.6	284.17

	Rule-breakers: Positive	52.98	21.46	.21	-10.41	116.37
	Rule-breakers: Neutral	16.97	21.46	1	-46.42	80.36
Rule-breakers: Positive	Rule-followers: Positive	171.89*	20.92	0	110.1	233.67
	Rule-followers: Negative	161.53*	20.92	0	99.74	223.31
	Rule-followers: Neutral	169.4*	20.92	0	107.62	231.18
	Rule-breakers: Neutral	-36.01	21.46	1	-99.4	27.37
Rule-breakers: Neutral	Rule-followers: Positive	207.9*	20.92	0	146.12	269.68
	Rule-followers: Negative	197.54*	20.92	0	135.76	259.32
	Rule-followers: Neutral	205.41*	20.92	0	143.63	267.2
Rule-followers: Negative	Rule-followers: Positive	10.36	20.36	1	-49.77	70.5
	Rule-followers: Neutral	7.88	20.36	1	-52.26	68.01
Rule-followers: Positive	Rule-followers: Neutral	-2.49	20.36	1	-62.62	57.65
Movement time (ms)						
Behavioural tendencies						
Rule-breakers	Rule-Followers	62.3*	28.06	.03	6.79	117.8
Type of consequences						
Negative	Positive	43.37*	5.37	0	30.36	56.38
	Neutral	18.47*	5.88	.01	4.2	32.73
Positive	Neutral	-24,904*	4.22	0	-35.14	-14.66
Behavioural tendency: Type of consequence						
Rule-breakers: Negative	Rule-followers: Positive	107.57*	28.69	0	22.83	192.31
	Rule-followers: Negative	95.95*	28.69	.01	11.21	180.68
	Rule-followers: Neutral	95.69*	28.69	.01	10.95	180.43
	Rule-breakers: Positive	75.12	29.44	.17	-11.82	162.06
	Rule-breakers: Neutral	37.19	29.44	1	-49.75	124.13
Rule-breakers: Positive	Rule-followers: Positive	32.45	28.69	1	-52.29	117.18

	Rule-followers: Negative	20.82	28.69	1	-63.91	105.56
	Rule-followers: Neutral	20.57	28.69	1	-64.17	105.31
	Rule-breakers: Neutral	-37.93	29.44	1	-124.87	49.01
Rule-breakers: Neutral	Rule-followers: Positive	70.38	28.69	.22	-14.36	155.12
	Rule-followers: Negative	58.76	28.69	.62	-25.98	143.5
	Rule-followers: Neutral	58.5	28.69	.63	-26.24	143.24
Rule-followers: Negative	Rule-followers: Positive	11.62	27.93	1	-70.86	94.1
	Rule-followers: Neutral	-.25	27.93	1	-82.73	82.22
Rule-followers: Positive	Rule-followers: Neutral	-32.45	28.69	1	-117.18	52.29
Maximum absolute distance (px)						
Behavioural tendencies						
Rule-breakers	Rule-Followers	17.91*	4.37	0	9.26	26.56
Type of consequences						
Negative	Positive	14.46*	1.6	0	10.59	18.33
	Neutral	9.49*	2.16	0	4.25	14.72
Positive	Neutral	-4,971*	1.5	0	-8.61	-1.33
Behavioural tendency: Type of consequence						
Rule-breakers: Negative	Rule-followers: Positive	38.8*	5.92	0	21.32	56.28
	Rule-followers: Negative	36.12	5.92	0	18.65	53.61
	Rule-followers: Neutral	38.28*	5.92	0	20.8	55.76
	Rule-breakers: Positive	31.34*	6.07	0	13.4	49.27
	Rule-breakers: Neutral	20.39*	6.07	.01	2.46	38.33
Rule-breakers: Positive	Rule-followers: Positive	7.46	5.92	1	-10.02	24.94

	Rule-followers: Negative	4.79	5.92	1	-12.69	22.27
	Rule-followers: Neutral	6.93	5.92	1	-10.54	24.42
	Rule-breakers: Neutral	-10.94	6.07	1	-28.88	6.99
Rule-breakers: Neutral	Rule-followers: Positive	18,41*	5.92	.03	0.93	35.89
	Rule-followers: Negative	15.73	5.92	.12	-1.75	33.21
	Rule-followers: Neutral	17,88*	5.92	.04	0.4	35.36
Rule-followers: Negative	Rule-followers: Positive	2.68	5.76	1	-14.34	19.69
	Rule-followers: Neutral	2.15	5.76	1	-14.86	19.16
Rule-followers: Positive	Rule-followers: Neutral	-0.53	5.76	1	-17.54	16.49
Area under the curve (px^2)						
Behavioural tendencies						
Rule-breakers	Rule-Followers	3647.04*	1207.32	0	1258.68	6035.41
Type of consequences						
Negative	Positive	3158.11*	351.04	0	2306.81	4009.42
	Neutral	2269.96*	533.89	0	975.21	3564.71
Positive	Neutral	-888.17	367.27	.05	-1778.84	2.52
Behavioural tendency: Type of consequence						
Rule-breakers: Negative	Rule-followers: Positive	8356.54*	1548.78	0	3782.6	9223.37
	Rule-followers: Negative	7756.63*	1548.78	0	3182.69	9223.37
	Rule-followers: Neutral	8071.96*	1548.78	0	3498.02	9223.37
	Rule-breakers: Positive	6727.4*	1589.02	0	2034.64	9223.37
	Rule-breakers: Neutral	4769.46*	1589.02	.04	76.69	9223.37
Rule-breakers: Positive	Rule-followers: Positive	8356.54*	1548.78	0	3782.6	9223.37
	Rule-followers: Negative	7756.63*	1548.78	0	3182.69	9223.37
	Rule-followers: Neutral	8071.96*	1548.78	0	3498.02	9223.37

	Rule-breakers: Neutral	4769.46*	1589.02	.04	76.69	9223.37
Rule-breakers: Neutral	Rule-followers: Positive	3587.08	1548.78	.32	-986.86	8161.03
	Rule-followers: Negative	2987.17	1548.78	.82	-1586.77	7561.12
	Rule-followers: Neutral	3302.5	1548.78	.50	-1271.45	7876.44
Rule-followers: Negative	Rule-followers: Positive	599.91	1507.47	1	-3852.04	5051.86
	Rule-followers: Neutral	315.33	1507.47	1	-4136.62	4767.28
Rule-followers: Positive	Rule-followers: Neutral	-284.58	1507.47	1	-4736.53	4167.37

Between and within subject factor main post-hoc results of the ANOVA 3x2 assuming independent groups. Post-hoc results remain when assuming dependence of the group, see supplementary material. Additional post hoc results comparing all conditions (Behavioural tendency: Type of consequence) after performing a one-way ANOVA, see supplementary material). Std. = standard.

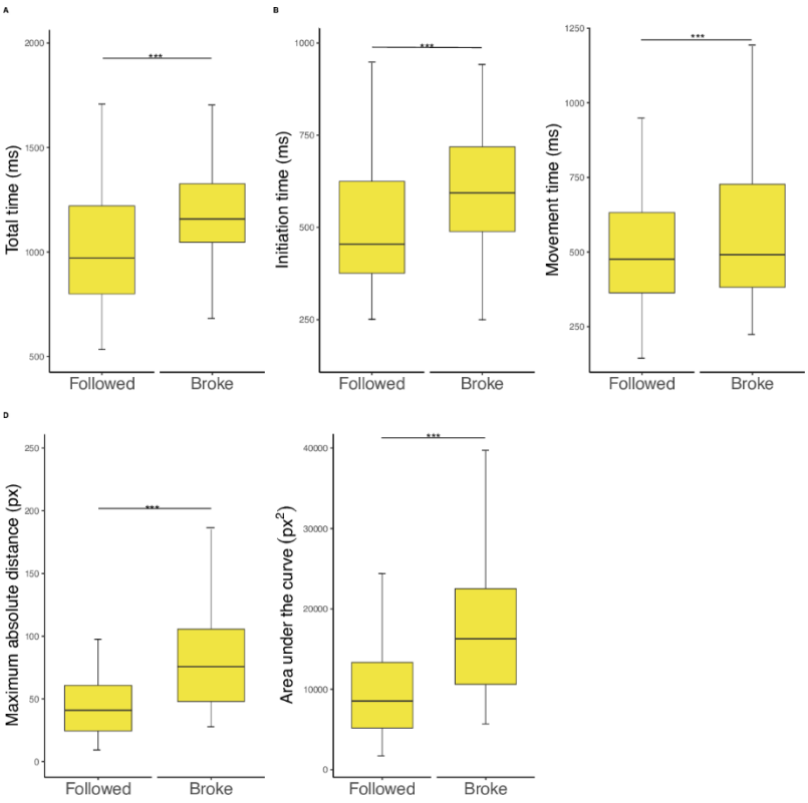


Figure 3. Reaction times and mouse trajectories across responses to rules in rule-breakers. Significance: * = p < .05, ** = p < .01, *** = p <.001. The top and bottom whiskers are set to the highest/lowest value of the dataset that are included in the 1.5IQR range.

All reported results remain stable after bootstrap analyses with 1000 permutations (see supplementary material for details).

3.2.3.2 Effect of the frequency, latency and recency on spontaneous deliberative rule-breaking behaviour in the "rule" part. In order to investigate the effect of frequency (percentage of number of trials rule-breaking occurs in a given behavioural task to obtain a gain), recency (percentage of rule-breaking occurring immediately followed by further rule-breaking resulting in a gain) and latency (number of trials preceding first rule-breaking to obtain a benefit) of rule-breaking behaviour on cognitive conflict, we performed multiple regression analyses on the independent impact of latency, recency and frequency rule-breaking behaviour on reaction times and mouse trajectory parameters of rule-breakers during the "rule" part, see Table 2. Low latency, high recency and high frequency of rule-breaking behaviour were positively related to longer reaction times, $p < .001$ and particularly recency and high frequency

of rule-breaking related to longer initiation time, $p < .001$, see Table 2. In addition, low latency related to longer and more complex mouse trajectories, $p < .001$, see Table 2. When exploring the same analyses only in trials in which rules were associated with negative consequences, the same pattern was observed (see supplementary material for details). In trials associated with negative consequences in which participants broke rules to obtain a benefit no significant differences were found (see supplementary material for details). All reported results remain stable after bootstrap analyses with 1000 permutations (see supplementary material for details).

3.3 Questionnaires

3.3.1 Rule-breakers versus rule-followers. In order to investigate whether or not certain personality is associated to "rule-followers" versus "rule-breakers", we performed Pearson correlations. Rule-breakers were more positively associated to grandiose narcissism, than rule-followers (see Table 3). No additional significant results were found.

3.3.2 Rule-followers. In order to provide a broad perspective on interindividual differences in rule-breaking we correlated personality traits and rule-breaking task related variables (e.g., reaction times and mouse trajectory parameters; see supplementary material for correlation tables). In rule-followers, introversion was related to slow movement. Likewise, sensation seeking (sub-scale of the behavioural activation system) was negatively related to the total time, initiation time and movement time per trial.

3.3.3 Rule breakers. In rule breakers, disagreeableness, goal orientation (sub-scale the behavioural activation system) and sensation seeking (a scale of the behavioural activation system) were related to larger payoffs, frequency of rule-breaking and recency. Moreover, risk propensity tended to inversely affect movement time and mouse trajectory parameters. Furthermore, low behavioural inhibition was inversely related to initiation time. When we correlated the same variables exclusively in trials in which the consequences of following rules

were negative, results remained in line with these findings (see *Table 3*). When correlating the outlined variables in trials in which the consequences of following rules were negative and participants broke these to increase their earnings, the effect of risk propensity on movement time and mouse trajectory parameters disappeared (see supplementary material).

4. DISCUSSION

In order to investigate the individual default tendencies towards norms, we implemented and validated a rule-breaking task sensitive to distinguish rule-breakers from rule-followers. Because rule-breakers are characterised by deliberatively violating norms that match their interests, they exclusively broke rules when these actions led to higher payoffs. Rule-breakers obtained higher earnings and exhibited higher cognitive conflict (i.e., slower responses, longer and complex mouse trajectories), compared to rule-followers. Rule-breakers also exhibited higher cognitive conflict when the consequences of following the rules were negative than when they were either neutral or positive. In those trials associated with negative consequences (i.e., following the rules leads to limited rewards or losses), rule-breakers experienced more cognitive conflict when they broke the rules compared to when they followed them. Notably, cognitive conflict during action planning of rule-breaking behaviour was more pronounced than during action execution. In the "rule" part and in trials associated with negative consequences, the cognitive conflict experienced during action planning by rule-breakers was enhanced by low latency, high frequency and high recency of rule-breaking. However, this effect

Table 2. **The influence of frequency, recency and latency of rule-breaking on reaction times and mouse trajectory parameters in the rule-part (rule-breakers, N = 63).**

	Std. coeff.	*Std. error*	*Beta coeff.*	*t*	*p*	***95% Confidence interval***		R^2	R^2 *adjusted*
						Lower bound	*Upper bound*		
Percentage of rule-breaking									
Total time (ms)	3.26	.72	.5	4.53	0	1.82	4.69	.25	.24
Initiation time (ms)	2.05	.61	.39	3.34	0	.82	3.27	.16	.14
Movement time (ms)	1.21	.83	.18	1.45	.15	-.46	2.88	.03	.02
MAD (px) (ms)	.2	.15	.17	1.31	.2	-.11	.51	.03	.01
AUC (px^2) (ms)	41.80	39.86	.13	1.05	.3	-37.91	121.5	.02	0
Recency									
Total time (ms)	2.61	.66	.45	3.94	0	1.28	3.93	.2	.19
Initiation time (ms)	1.68	.55	.36	3.04	0	.58	2.79	.13	.12
Movement time (ms)	.12	.14	.11	.88	.38	-.16	.4	.01	0
MAD (px) (ms)	.12	.14	.11	.88	.38	-.16	.4	.01	0
AUC (px^2) (ms)	22.81	35.77	.08	.64	.53	-48.71	94.32	.01	0
Latency									
Total time (ms)	-4.82	1.6	-.36	-3.01	0	-8.03	-1.61	.13	.12
Initiation time (ms)	-3.04	1.32	-.28	-2.3	.03	-5.68	-.4	.08	.07
Movement time (ms)	-1.78	1.74	-.13	-1.02	.31	-5.26	1.7	.02	0
MAD (px)	-.73	.31	-.29	-2.35	.02	-1.35	-.11	.08	.07
AUC (px^2)	-168.9	80.32	-.26	-2.10	.04	-329.51	-8.29	.07	.05

Note: All analyses remained significant after bootstrapping with 1000 permutations (see supplementary material). Std = standard, coeff. = coefficient.

Table 3. **Main correlation findings of rule-followers versus rule-breakers and personality and across individuals in these two groups during the "rule" part**

Variables	1	2	3	4	5	6	7	8	9
Rule-followers versus rule-breakers [b]	-.13*	-.06	.06	-.09	-.05	-.03	.05	.09	.02
Rule-followers									
Total pay-off	-.08	-.1	-.05	-.04	-.13	.08	.04	-.03	-.08
Total time (ms)	-.11	-.13	.12	-.12	-.01	-.04	.31*	.2	.09
Initiation time (ms)	-.18	.08	.06	.14	.16	-.04	.22	.2	.1
Movement time (ms)	-.14	.11	.1	-.24*	-.11	-.03	.25*	.13	.05
AUC (px^2)	-.14	.08	.11	-.04	-.14	-.02	-.17	-.17	-.15
MAD (px)	.13	-.05	.12	-.07	-.16	.01	-.13	-.14	-.15
Rule-breakers									
Total pay-off	-.18	-.36	-.21*	-.2	-.21*	.19	.28*	.29*	.24
Total time (ms)	0	-.36*	-.21	-.15	-.2	-.17	.27*	.26*	.18
Initiation time (ms)	.02	0	.07	.16	.13	.02	-.19	-0.16	-.08
Movement time (ms)	-.02	-.38*	-.19	-.13	-.16	-.14	.25*	.24*	.2
AUC (px^2)	.03	-.16	.2	.06	-.24	-.16	-.1	.14	.01
MAD (px)	.04	-.05	-.04	-.02	-.01	-.26*	.04	.07	-.01

Note: 1 Grandiose narcissism, 2 Agreeableness, 3 Conscientiousness, 4 Extraversion, 5 Risk propensity, 6 BAS drive, 7 BAS fun seeking, 8 BAS reward, 9 BIS. AUC = area under the curve, MAD = Maximum absolute distance, [b] 1 = rule-followers. 2 = rule-breakers. Correlation significance is at the .05 level (2 – tailed) represented with asterisk (*). Descriptive of the variables and further correlation analyses can be found in the supplementary material (Tables S19-S23).

disappeared when analyses were focussing trials in which rule-breakers violated rules. Moreover, in rule-followers, introversion and sensation seeking were associated with fast responses. In contrast, in rule-breakers, disagreeableness, sensation seeking and goal-oriented motivation were associated with higher payoffs, frequency and recency of rule-breaking. In parallel, in rule-breakers, risk propensity and behavioural inhibition were associated with fast planning and execution of the actions in the "rule" part of the task.

4.1 Broading the Decision-Implementation-Mandatory Switch-Inhibition model

Studies in which the DIMI model has been applied (Wirth et al., 2018) focused on instructed rule-breaking and intraindividual differences (i.e., rule-breaking and rule-following within a single individuum). However, our investigation evaluated spontaneous deliberative rule-

breaking, intraindividual differences (i.e., rule-breaking versus rule-following in rule-breakers) and interindividual differences (i.e., rule-breakers versus rule-followers). Although our study approach towards studying rule-breaking differs from previous work, our results fit and, thus, extend the DIMI model. Based on our results, the DIMI model explains (a) instructed as well as *spontaneous deliberative rule-breaking* and (b) intraindividual as well as *interindividual differences*. In the following paragraphs we explain how our results strongly support the assumptions of the DIMI model.

First and second assumptions: Rule-following and rule-breaking responses rely on two distinct task sets and the rule-following task set is partially pre-implemented.

These assumptions are supported by our findings because, in our task, rule-breakers switched between rule-breaking and rule-following task sets within the same block. Rule-followers were faster than rule-breakers and the latter were faster when following rules than when breaking them. Therefore, the rule-following task set is different from the rule-breaking task set, but the former was partially pre-implemented – independent of whether both behaviours are displayed by one single or distinct agents.

Third assumption: cognitive conflict occurs due to interference from the simultaneous activation of the two task sets

Our results support this assumption as cognitive conflict was more pronounced (a) in rule-breakers when comparing rule-breaking to rule-following in trials associated to negative consequences (i.e., intraindividual differences) and (b) in rule-breakers versus rule-followers (i.e., interindividual differences). Different from instructed rule-breaking tasks, rule-breakers in our task switched between task sets spontaneously (i.e., without explicitly giving them this instruction). Hence, they made this switch deliberatively to pursue an internal motive (i.e., to increase their earnings). In contrast, rule-followers constantly presented less cognitive conflict

because they continuously practiced rule-following and, thus, did not need to handle both task sets concurrently. Our data demonstrate that rule-following is associated with less cognitive conflict than spontaneous deliberative rule-breaking – independent of whether both behaviours are displayed by one single or distinct agents.

Fourth assumption: (a) The selection of the task set occurs during action planning, (b) the implementation of the task set starts with action planning and lasts till action execution

The idea that the selection of a task set occurs early in the decision process is braced by electroencephalography research in instructed rule-breaking, in which the cognitive conflict present in the selection of the task set (rule-following versus rule-breaking) is reflected by a delayed and attenuated P300 component (Pfister et al., 2016a). According to our data, the complex decision of choosing between rule-breaking versus rule-following task sets occurring during action planning took more cognitive effort and consequently more time than the subsequent action execution in rule-breakers. Therefore, the selection of the task set occurred early and recruited more cognitive sources than the execution of the action. The fourth assumption of the DIMI model is considered a signature of instructed rule-breaking. We can now extend this assumption to spontaneous deliberative rule-breaking.

Alternatively, the fourth assumption of the DIMI model applies to cognitive motor-control tasks. Kaiser *et al.* (2019) found that cognitive conflict was more pronounced in action planning than in action execution during a motor-control task; this finding was mirrored by lower midfrontal theta brain waves. The authors specify that this effect is due to the selection of motor responses and that this effect is specific to cognitive motor control and does, for instance, not apply to attentional control. In typical cognitive-motor control tasks, participants repetitively perform a motor response (e.g., clicking a key repetitively) and inhibit this response when a signal is displayed on the screen. In our task, when participants committed rule-

breaking, they inhibited the motor response that corresponds to rule-following. Thus, this inhibition process that appears in rule-breaking tasks seems similar to typical motor-control tasks.

How early, often and recent rule-breaking occurred increased the cognitive conflict during the action planning, while no impact of these variables was observed on action execution in our data. This increment was observed when there was a switch between rule-following and rule-breaking task sets and not when examining exclusively trials in which rule-breakers opted for the rule-breaking task set. Intuitively, one would expect that lower latency, higher frequency and higher recency ameliorate the cognitive conflict related to this switching (Prével et al., 2016; Vandierendonck et al., 2012). However, these factors have shown, in instructed rule-breaking, to decrease cognitive conflict during action execution in rule-breaking, but not in action planning (Wirth et al., 2018). Therefore, cognitive conflict during action planning, seems to be more resistant to low latency, high frequency and high recency of rule-breaking – most probably due to the selection of the task set.

The fourth assumption also advocates that the implementation of the task sets prolongates to its execution which indicates that cognitive conflict is present during action execution, but in a lower degree than in action planning. This assumption matches our results because during action execution cognitive conflict was more intense in (a) rule-breakers than in rule-followers and (b) in rule-breaking than in rule-following within rule-breakers. In contrast to previous research in instructed rule-breaking, the cognitive conflict related to action execution was not reversed by the recency and frequency of rule-breaking (Wirth et al., 2018). The absence of this effect in our study might be explained by limited frequency and recency of rule-breaking behaviour. The necessary threshold to ameliorate the costs of cognitive conflict in the execution of the task sets was probably not reached in our computerised task (Pfister et

al., 2019; Prével et al., 2021; Vandierendonck et al., 2012). Further studies should evaluate spontaneous deliberative rule-breaking with paradigms optimized for the observation of frequency and recency. For instance, future studies might increase the number of blocks in the "rule" part or increase the number of chances per block in which breaking the rule leads to gain.

4.2 Personality traits underlying interindividual differences in rule-breaking

The current study provides a broad perspective on the interindividual differences in rule-breaking by investigating how personality links with behaviours and cognitive processes in rule-breakers and rule-followers. Analogous to previous literature, we found that grandiose is more pronounced in rule-breakers than rule-followers (White et al., 2018). Grandiose narcissism is characterized by self-importance, feelings of superiority, as well as exhibitionism (Gentile et al., 2013; Emmons, 1987). Indeed, narcissistic leaders are susceptible to violate norms as they are more likely to be innovative, but also to engage in unethical rule-breaking (Finkelman and Kelly, 2011). Moreover, grandiose narcissism has also been related to pro-social rule-breaking because individuals who are narcissists have the psychological need for grandiose fantasy, sacrificing, self-enhancement and devaluing rules (White et al., 2018). Narcissistic individuals believe that there are no limits to achieve their goals and that they are in control of their destiny, which makes them more prompt to violate norms to benefit themselves (Mathieu and St-Jean, 2013; Adams et al., 2014; Yu et al., 2020). Grandiose narcissism has been shown to predict self-report measurements of proactive and reactive aggression, as well as actual aggressive behaviours (Lobbestael et al., 2014). Narcissists likely feel entitled to break rules when rules don’t benefit them (Mathieu and St-Jean, 2013). Therefore, our results match previous theory, suggesting that narcissism is more likely to be associated with rule-breakers rather than with rule-followers.

Regarding rule-breakers, disagreeableness was associated with frequent and repetitive infractions, consistent with previous research (Fiddick et al., 2016; Nofal et al., 2020; Settles et al., 2012; Wood and Eagly, 2002). A reason for this finding is that disagreeable individuals tend to break rules because they are less likely to regulate themselves, which deters them from recruiting attentional resources to obey the rules and ignore their natural impulses (Jensen-Campbell et al., 2002). For instance, trait agreeableness has been positively associated to the adherence to rules for prevention of COVID-19 during the first 1.5 years of the pandemic. Individuals might adhere to the COVID-19 preventive rules because they tend to care for others and avoid conflicts, even when they believe that the danger of this disease is exaggerated (or even faked). This suggests that agreeableness might be a critical personality trait in mitigating the effect of a negative attitude towards the preventive measures and, thus, enhancing actual preventive behaviour.

Moreover, sensation seeking and goal-orientation in rule-breakers were related to recurrent and frequent norm violation. These characteristics might enhance the ability of rule-breakers to cope with the "cognitive pain" associated with the violation of norms, allowing them to break the rules more often (Maneiro et al., 2017; Sijtsema et al., 2010; Karjalainen et al., 2016; Serrano-Ibánez et al., 2019). In contrast, sensation seeking in rule-followers was associated with fast responses, which suggests that they experienced low cognitive conflict. This is not surprising because rule-followers prefer to obey norms and generally conform rapidly (Murray and Schaller, 2012). Moreover, introvert rule-followers were faster in their responses than extrovert rule-followers. This was expected as introverted individuals tend to agree faster with others' opinions than extroverted individuals (Atindanbila and Gyamfua, 2012).

Additionally, our results showed that low behavioural inhibition in rule-breakers was associated with time-consuming action planning (i.e., more cognitive conflict during action planning). Low behavioural inhibition associates with sensitivity to punishment (Pickering and Gray, 1999). In our task, following the rules could constantly lead to loss of earnings; as such rule-breakers characterised by behavioural inhibition might effortfully choose to violate norms based on their aversion to losing (Liefgreen et al., 2020; Kwak et al., 2015). Upon action planning, rule-breakers decreased their cognitive conflict, which favoured smooth action execution. In our study we found that rule-breakers who are prone to risk execute their actions rapidly. This is in line with previous research, as individuals who are more propense to risk seem to have the advantage of decreasing their cognitive conflict as exhibited by fast responses during the execution of their actions, which in turn makes them more susceptible to commit rule-breaking (Freeman and Rakotonirainy, 2015; Morrison, 2006; Obschonka et al., 2013; Reiter et al., 2019; Zhang and Arvey, 2009). Interestingly, entrepreneurial status has been associated with individuals who are propense to risk and commit moderate rule-breaking (i.e., delinquency, offences in family and school) and not extreme rule-breaking (i.e., breaking an official contact, drug use and crime). As entrepreneurs tend to face moral dilemmas in their work (e.g., choosing between overpromise or telling the truth of the current financial condition of their enterprise to convince investors, employees and customers to support their endeavour), it is possible that having high risk propensity declines their cognitive conflict for committing rule-breaking, so they can afford to go around these dilemmas.

Overall, our findings advance the understanding of interindividual differences in rule-breaking. Our study exhibits how personality relates to the cognitive and behavioural characteristics of rule-breakers and rule-followers. Future research needs to explore these relationships in various rule-breaking tasks to further understand whether these findings

transfer to other tasks, so to comprehend the mindset favouring conformism to rules or attenuating the cognitive conflict associated with spontaneous deliberative rule-breaking.

4.3 Limitations

While the evaluation of spontaneous deliberative rule-breaking is more ecologically valid than instructed rule-breaking, it comes with its own pitfalls. First, the distinction between participants intentionally violating rules versus error could be called into question. Even if participants reported intentional rule-breaking, this testimony is nothing but retrospective. We aimed at minimizing this issue by implementing a task with low difficulty for participants to avoid errors (Gross et al., 2018; Benikos et al., 2013). What is more, rule-breakers broke the rule mostly when following the rule involved negative consequences and explicitly report their intention to break rules to obtain benefits. Therefore, we are confident that participants committed indeed intentional rule violations rather than simple slips or errors. Second, not all the participants committed rule-breaking with the same frequency. Therefore, we cannot generalise that rule-breakers who violate rules at a certain frequency ameliorated or intensified their cognitive conflict. Instead, we constrained ourselves to treat the frequency of rule-breaking in rule-breakers as a continuous variable to examine its effect on cognitive conflict. In our experiment, we did not find that rule-breaking frequency lead to ameliorate cognitive conflict. However, this could have been because of lack of power corresponding to specific frequencies of spontaneous deliberative rule-breaking. Higher frequencies of rule-breaking can reverse cognitive conflict (Wirth et al., 2018; Wirth et al., 2019), which our study cannot speak to. Further studies should increase the power of specific rule-breaking frequencies to understand how this shape cognitive conflict, e.g., by extending the number of trials that tempt participants to commit spontaneous deliberative rule-breaking.

To pursue our fourth research goal, we explored the relationships between personality, behaviour and cognitive processes in rule-followers and rule-breakers. Surely, pursuing of this goal implies alpha-error accumulation, as it necessitates multiple correlation analyses (Moye, 2000). Another limitation of this study is that we studied basic general norms instead of more complex norms, such as social or legal laws. Our findings, thus, cannot be generalised to the latter. Moreover, individuals can choose to break some norms while they decide to follow others. Future studies should address intraindividual differences of rule-breaking in relation to rule type (e.g., simple versus complex rule; general versus specific rules; social versus non-social rule). Our research reveals interindividual differences when it comes to breaking general norms which can be motivation to investigate the very same differences in the context of other types of consequence-dependent rules. Furthermore, we have focused mainly on evaluating the behaviour and personality traits associated with rule-breaking rather than ethical judgements. Nevertheless, previous studies on "perverse norms" (i.e., uncertain and unfulfilled norms imposed by members of the own group or an external agent) have shown that ethical judgements vary depending on the type of norm. Compared to situations in which the norm is crystal clear, individuals judging situations involving "perverse norms" tend to attribute a lack of trust and prestige to the agents imposing the rule and are less judgmental of those who violate the rules (Oceja and Fernández-Dols, 2001). Future studies should examine the importance of own ethical judgements in the context of spontaneous deliberative rule-breaking behaviour and trust and prestige judgements of the agent administrating the rule. We believe this to be a piece of valuable information to understand (a) the similarities of our rules (i.e., simple, straightforward and arbitrary rules that can lead to loss or gain) with perverse norms and (b) the role of ethical judgements in motivating spontaneous deliberative rule-breaking. An additional limitation is that our sample consisted of mostly young participants, therefore our

findings cannot be generalised across different age groups. Future studies should investigate rule-breaking across the lifespan.

4.4 Conclusion

Although previous research has already disclosed that the same stimuli raise differential individual behavioural responses or tendencies towards rules (Pfister et al., 2019; Gross et al., 2018), our study is pioneering a detailed analysis of these tendencies. Previous studies excluded participants who tend to follow rules from data analyses which we included. Rule-breakers expressed higher cognitive conflict than rule-followers, not only when breaking but also when following the rule. While rule-breakers prioritise increasing their payoffs over high cognitive conflict, rule-followers prioritise low cognitive conflict over increasing their payoffs. Thus, we uncovered a trade-off between deliberatively deciding whether to follow or violate norms to obtain more earnings versus experiencing higher cognitive conflict. These results suggest that– as expected–in the long run, conformism is more cognitively efficient than adaptively switching between rule-breaking and rule-following. This might explain why people stop questioning rules – often shortly after they start following them. Perhaps, this study can give a first hint on why members of political parties, religious or other authoritarian groups respect the rules of these institutions and stop questioning them in the long run, even when these rules negatively affect their surroundings (Blass and Schmitt, 2001; Désilets et al., 2020; Grajales, 2016; Shively and Larsen, 2012; Wirth et al., 2017). Recently the understanding of individual differences in rule-breaking became even more relevant as–due to the COVID-19 pandemic– the individual's adherence to infection mitigation measures affects others' lives daily (Oosterhoff and Palmer, 2020; Carvalho et al., 2020; Hartmann and Müller, 2022; Nofal et al., 2020). This study leaves the door open to genuinely investigate personal trends towards external regulations.

How rule-breaking as an individual tendency towards norms favours behaving "right" or "wrong" concerns morality and remains an open question. Rule-breaking can lead to adverse outcomes (e.g., legal problems, scientific misconduct, aggression; Bucy et al., 2008; Krenn and Buehler, 2019; O'Connell et al., 2021; Stroebe et al., 2012; Ternes et al., 2019; Tyler, 2006; Whipp et al., 2021), but it also has advantages (Hock and Fefferman, 2011). Examples of positive consequences of rule-breaking include being seen as a person with moral courage (Ambrose et al., 2015; Curtis, 2010), good heart (e.g., nurses helping patients even when going against clinic statements; Wadsworth et al., 2017), being creative (Salcedo-Albaran et al., 2009) or becoming an entrepreneur (e.g., increasing your earnings by selling new products that overcome the established rules in the market; Brenkert, 2009). Further studies about spontaneous deliberative rule-breaking rather than instructed rule-breaking could offer insights into motivating this behaviour. Considering how frequency, recency and latency of rule-breaking can affect cognitive conflict could target ways in which spontaneous deliberative rule-breaking does not imply an immense cognitive cost. Such evidence might in the future enable fostering constructive or societally productive forms of rule-breaking.

In summary, the present study shows that there are interindividual differences in rule-breaking. While some individuals tend to follow the norms, others tend to violate them to obtain benefits at the cost of more cognitive conflict. Rule-breakers suppress rule-following tendencies that are automatically activated upon encountering rule-related stimuli, especially when they plan to violate norms. Therefore, cognitive conflict is a robust and reliable downstream consequence of spontaneously and deliberatively violating rules in rule-breakers, mainly during action planning. These findings support the DIMI model and broad the application of this model to the interindividual differences in rule-breaking and particularly in spontaneous deliberative rule-breaking. Furthermore, certain personality traits relate and contribute to the understanding of behavioural and cognitive processes experienced by rule-

followers and rule-breakers. Future studies should further investigate how personality and manipulations of latency, recency and frequency of rule-breaking could ameliorate cognitive conflict in spontaneous deliberative rule-breaking and thus favour this behaviour. This research sheds light on the cognitive and personality characteristics of the interindividual differences in responses towards rules and especially of spontaneous deliberative rule-breaking.

Chapter 4: I make my own rules! The relationships of openness and idealism with entrepreneurial intention depend on rule-breaking tendencies[4]

Abstract

This study analyses the interplay of individual characteristics that motivate an individual to start a business, specifically how rule-breaking tendencies shape the relationship of personality and morality with entrepreneurial intention. We provide a comprehensive perspective on the antecedents of entrepreneurial intention by integrating research on the theory of planned behaviour with research on personality and morality. We argue that high openness and low idealism are linked to entrepreneurial intention, particularly in individuals with benefit-seeking rule-breaking tendencies. Our study (N = 112), in which we assess individuals' rule-breaking tendencies with a computerised task, supports our predictions. Our work features a novel methodological approach and contributes to entrepreneurship research by unravelling the interplay of individual antecedents of entrepreneurial intention.

1. Introduction

Before individuals engage in entrepreneurial actions, for example, founding start-ups or participating in entrepreneurial projects within large companies, they develop an intention to do so (Brandstätter, 2011; Lumpkin and Dess, 1996; Peng et al., 2012). Not all individuals, however, are equally likely to develop this intention to engage in entrepreneurship (Amit et al., 1993; Ismail et al., 2009). Entrepreneurial intention is the psychological state of a person with the desire, optimism and aspiration to initiate the creation of a new business or a new value extension within a current company (Guerrero et al., 2008; Peng et al., 2012; Shahab et al., 2019; Wu and Wu, 2008). To understand why some individuals are more likely to (or

[4] The study reported in this chapter is based on a working paper by Cubillos Pinilla, L., Hubner-Benz, S. & Emmerling, F., currently submitted to *Applied Psychology*.

have the intention to) engage in entrepreneurship than others, knowledge on individual differences predicting entrepreneurial intention is needed. Although numerous individual differences have been suggested as relating to individuals' entrepreneurial intentions (Arend, 2016; Arentz et al., 2012), a clear understanding of how different individual characteristics interact is missing (Douglas et al., 2021). To shed light on intraindividual mechanisms shaping entrepreneurial intentions, our study explores the interplay of personality, morality and rule-breaking tendencies.

Drawing on the theory of planned behaviour, entrepreneurship research found that attitudes and subjective norms that position entrepreneurship as an attractive career choice appear to predict entrepreneurial intention effectively (Ajzen, 2001; Malebana, 2014; Yang, 2013). However, which general individual characteristics specifically drive these attitudes and norms is less clear. Our study takes a psychological perspective and focuses on personality and morality as basic human characteristics that shape these attitudes and norms and thus, entrepreneurial intentions (Buchholz and Rosenthal, 2005; Clarke and Aram, 1997; Dlugosch et al., 2018; Kaptein, 2019; Payne and Joyner, 2006). In particular, our study focuses on openness (i.e., a personality trait; Bazkiaei et al., 2020; Chen et al., 2012) and idealism (i.e., a moral system; Aldrich and Cliff, 2003; Hueso et al., 2020; Kazmi et al., 2019; Kruse et al., 2021; Rahaman et al., 2019), both of which have been shown to relate to entrepreneurial intention. We propose that entrepreneurial intention is likely to develop in individuals high in openness because they are more likely to have attitudes that are positively related to entrepreneurial actions and the same intention is unlikely to develop in individuals high in idealism because they are inclined to prefer social norms that counter entrepreneurship.

Although research on entrepreneurial intention provides substantial knowledge on individual antecedents, the role of rule-breaking has, by and large, been overlooked. Here,

rule-breaking tendencies refer to individuals' tendencies to carefully and meticulously decide whether to follow or break rules in particular situations based on their own internal goals and the consequences of their behaviour (Arend, 2016; Gross et al., 2018; Pfister et al., 2019). People with rule-breaking tendencies violate norms as long as the expected consequence is advantageous and in concordance with their personal goals. These cognitive tendencies are likely to relate to entrepreneurial intention because entrepreneurship requires actions that are novel and therefore often challenge the norms of the economy and society (Ahlin et al., 2013; Khedhaouria et al., 2015). To understand the holistic impact of rule-breaking tendencies on entrepreneurial intention, consideration needs to be given to the combined effect of individual characteristics (Douglas et al., 2021; Magnusson and Törestad, 1993; Shi et al., 2020). We propose that rule-breaking tendencies shape the relationships of openness and idealism with entrepreneurial intention.

Previous research on the individual antecedents of entrepreneurial intentions used introspective measurements in the main (Shahab et al., 2019; Spector, 1994). However, introspective measures such as self-report surveys are highly susceptible to social desirability and retrospective biases (Alvesson and Sandberg, 2013; Brice and Spencer, 2007; Donaldson and Grant-Vallone, 2002; Rutter et al., 1998; Schyns and Schilling, 2013; Vigil-Colet et al., 2012). These are particularly problematic in measurements that involve disobeying external rules. Self-reports centre on perceptions rather than actual behaviour which diverges when it comes to breaking rules. Then, individuals tend to report less rule-breaking behaviour (Forsyth, 1980; Treviño et al. , 2006; Timothy et al., 2011; Obschonka et al., 2013). There are social desirability biases because humans are generally appreciated as more trusted, kind and attractive when they are perceived to be individuals who follow rules (Paunonen et al., 2006; Everett et al., 2016). Such biases are emphasised in individuals with an interest in entrepreneurship because they usually pursue social recognition even when facing financial

and emotional risk (Treviño et al., 2006; Timothy et al., 2011). In contrast to self-reports, registration of behaviours obtained from computerised tasks is less prone to external biases (Alvesson and Sandberg, 2013; Arend, 2016; Brice and Spencer, 2007; Hattwick, 1989; Laureiro-Martínez et al., 2014; Murnieks et al., 2011). Hence, analysing the combined effects of different individual antecedents, including rule-breaking tendencies, requires a multi-source analysis. We apply a multi-source approach that includes data obtained from an empirical computerised task in order to examine general rule-breaking tendencies (Arend, 2016; Gross et al., 2018).

Our research contributes to the entrepreneurship literature in three ways. Firstly, we integrate research on the theory of planned behaviour and research on personality and morality to provide a more comprehensive perspective on the antecedents of entrepreneurial intention. Our study illuminates how personality and morality, both of which relate to individuals' attitudes and subjective norms, affect the formation of entrepreneurial intention. Secondly, we introduce general rule-breaking tendencies into the discussion on individual antecedents of entrepreneurial intentions; so far, these have been mainly overlooked. We investigate the interplay of personality, morality and rule-breaking tendencies in order to provide an integrative and parsimonious perspective on the intraindividual antecedents of entrepreneurial intention. Specifically, we suggest that openness and idealism relate to entrepreneurial intentions and that these relationships are particularly influenced by rule-breaking tendencies. Thirdly, our study stretches beyond the scope of previous research that has ritualised the use of self-reports to study the antecedents of entrepreneurial intention. Using self-reports has most likely led to perplexing results, especially when examining rule-breaking tendencies. By implementing a multi-source approach in which both questionnaires and an empirical computerised task are administered, our study reduces the biases and thus provides new insights into novel methodologies in entrepreneurship.

2. Theoretical background

3. Personality, morality and entrepreneurial intention

Based on the theory of planned behaviour, individuals with positive attitudes towards entrepreneurship are more likely to develop entrepreneurial intention, because they consider it enjoyable, beneficial and relevant (Moriano et al., 2011). In our research, we intend to illuminate the influence of individual characteristics on entrepreneurial intentions. Individual characteristics shape the attitudes and subjective norms that promote entrepreneurial intentions. As these attitudes and norms are linked to personality and morality, these personal characteristics have already been and should still be considered individual antecedents of entrepreneurial intention (Ismail et al., 2009; Brandstätter, 2011; Karabulut, 2016; Şahin et al., 2019). Personality describes individuals in terms of patterns of behaviour−thoughts and emotions−which are reasonably constant (Mc Crae et al., 2003; Parks-Leduc et al., 2015). Personality traits, including openness, seem to give rise in individuals the desire to run a business (Ismail et al., 2009; Brandstätter, 2011; Karabulut, 2016; Şahin et al., 2019). Personality is typically evaluated by using self-reports, which constitute individuals' perceptions of themselves in several situations and these measures are considered to be indicators of the internal causes of an individual's motivations (e.g., entrepreneurial intention) and actions (Brandstätter, 2011). The most influential approach to personality worldwide is the "Big Five", which comprises five personality traits: openness to experience, conscientiousness, neuroticism, extraversion and agreeableness (Şahin et al., 2019). This approach can be employed to assess an individual’s fitness for entrepreneurship (Brandstätter, 2011; Obschonka et al., 2014; Şahin et al., 2019; Zhao et al., 2009). Several studies indicate that personality−and specifically openness to experience−is related to the attitudes relevant for the formation of entrepreneurial intention. For example, openness is related to the enjoyment of activities associated with entrepreneurship and to perceiving an entrepreneurial

career as beneficial and worthwhile (Awwad et al., 2020; Bazkiaei et al., 2020; Ciavarella et al., 2004; Kazmi et al., 2019; Murugesan and Jayavelu, 2017; Şahin et al., 2019).

As well as personality, morality also accounts for individual differences that are related to entrepreneurial intentions. Even when individuals have similar personalities, they can still reach opposite conclusions concerning moral worth when judging others or, the behaviour of others. Morality is grounded in individuals' moral systems (DeCew, 2015; Forsyth, 1980; Sharp, 1898; Unwin, 1985). Morality influences entrepreneurial intention because moral systems affect the subjective norms that are, according to the theory of planned behaviour, relevant for the formation of entrepreneurial intention (Arend, 2012; Fishbein, 1967; Lacap et al., 2018; Mair and Noboa, 2006; Zakaria et al., 2019). Depending on their moral systems, individuals may or may not consider entrepreneurship to be of value to others and/or themselves (Arend, 2012; Bacq and Lumpkin, 2021; Fishbein, 1967; Lacap et al., 2018; Mair and Noboa, 2006; Zakaria et al., 2019). For example, some people consider challenging the status quo−a challenge which is part of entrepreneurship−as something that should be valued and appreciated; others feel instead, that such behaviour is morally inappropriate. This is especially important since entrepreneurs often face complex moral choices (Brenkert, 2009).

3.1. Rule-breaking tendencies and entrepreneurial intention

We argue that understanding the effects of personality and morality on entrepreneurial intention requires taking individuals' rule-breaking tendencies into account. Previous research has shown that specific forms of rule-breaking favour entrepreneurship. Zhang and Arvey (2009) tested the relationship between rule-breaking in adolescence and entrepreneurial status in adulthood. They found that moderate rule-breaking in youth (i.e., delinquency, offences in family and school) relates to whether a person becomes an entrepreneur or a corporate manager. Interestingly, extreme rule-breaking (i.e., breaking an official contact, drug use and

crime) did not relate to entrepreneurship. These results were corroborated by Obschonka and colleagues (2013), when they performed a longitudinal study that took into account not only self-reports, but also official crime records. Moreover, discourse analysis of an archetypical and particularly successful entrepreneur, Steve Jobs, showed how dropping out of university was considered (as far as he was concerned) an episode of violation of the social standards. This has also been the case with other entrepreneurs (Dakoumi and Abdelwahed, 2014; Watt, 2016).

Consequently, specific forms of rule-breaking – i.e., moderate but not extreme rule-breaking – seems to relate to entrepreneurial intentions. Specifically, those rule-breaking tendencies that weigh up breaking the rule and its consequences are most likely to be relevant to entrepreneurship (De Vries, 1977). In this research, we use the term *rule-breaking tendencies* to refer to a basic individual pre-disposition of having an underlying tendency to break rules based on the expected outcome and internal goals or personal interest (Arend, 2016; Gross et al., 2018; Pfister et al., 2019). In other words, we refer to individuals as having general rule-breaking tendencies if they break rules where the subsequent outcome leads to a benefit corresponding to their internal goals. Previous research has shown that these rule-breaking tendencies can be observed spontaneously, i.e., without giving a concrete context and without explicitly instructing an individual that rule-breaking in a specific situation might be an option (Arend, 2016; Gross et al., 2018; Pfister et al., 2019). Different mechanisms can explain why such general rule-breaking tendencies relate to entrepreneurship.

Firstly, rule-breaking tendencies consist of violating rules voluntarily and proactively, without any explicit external instruction. These tendencies are a requirement of entrepreneurship because introducing novel products to the market or even creating new markets requires entrepreneurs to look proactively for alternative actions and these are likely to violate current rules or norms (Karabulut, 2016; Leutner et al., 2014; Lim et al., 2006;

Shumpeter, 2010; Stock et al., 2002; Tiwari et al., 2017; Zampetakis et al., 2011). Moreover, entrepreneurship requires nonconformism and "thinking outside the box" (Zampetakis et al., 2011; Wurthmann, 2014; Arend, 2016), traits which inherently challenge conventional norms. Secondly, individuals with rule-breaking tendencies have been shown to prioritise their own internal goals over external constraints. As entrepreneurs, they can pursue their goals and work towards getting the attention of others in order to collaborate with them on their goals (McGrath and MacMillan, 2000; Sibin et al., 2007). Thus, entrepreneurship is likely to appeal to individuals with rule-breaking tendencies.

Thirdly, individuals with rule-breaking tendencies have exceptional behavioural control. They feel that they can control outcomes and they only break rules when they expect to benefit (Arend, 2016; Karabulut, 2016). Entrepreneurs also need to believe that they control the environment, because only then do they feel that they are able to achieve favourable outcomes, persevering despite setbacks (Berg, 2014; De Pillis and Reardon, 2007; Rauch and Frese, 2007). Therefore, rule-breaking tendencies are likely to be linked to entrepreneurial intention (Ajzen, 1991; Dakoumi and Abdelwahed, 2014; Karabulut, 2016; Tiwari et al., 2017). Fourthly, individuals with rule-breaking tendencies decide to take risks by violating given rules. Similarly, entrepreneurial intention relates to risk-tolerance because entrepreneurship involves the risk of failure (De Pillis and Reardon, 2007; Gürol and Atsan, 2006; Tang et al., 2018; Verheul et al., 2012). If the venture fails, the entrepreneur often faces financial loss and possible social embarrassment (De Pillis and Reardon, 2007; Watkins and Knight, 1922). As individuals with rule-breaking tendencies show a higher risk tolerance than those who tend to follow rules, these individuals are more likely to develop entrepreneurial intentions.

3.2. Hypotheses development

Over the course of the following, we elaborate on our hypotheses by suggesting that entrepreneurial intention is likely to develop in individuals high in openness and unlikely to develop in individuals high in idealism. Additionally, we suggest that these effects depend on rule-breaking tendencies.

2.3.1 Openness, rule-breaking tendencies and entrepreneurial intention

Openness is a personality trait referring to the degree to which a person is open to new ideas and actions (Rammstedt and John, 2007). Openness relates to being innovative, curious, adventurous and receptive to new experiences and unconventional ideas (Ismail et al., 2009; Singh and DeNoble, 2003). Individuals high in openness are unpredictable, innovative, risk takers and they perceive themselves to be more inventive (Silvia et al., 2009; Sung and Choi, 2013). They usually have a high attention span and are likely to develop artistic interests (Chamorro-Premuzic et al., 2009). In contrast, those low in openness tend to be down-to-earth, with a narrow field of interests, unanalytical, conventional and focused on the concrete (Ismail et al., 2009). They tend to avoid unfamiliarity and follow traditional ways (Ismail et al., 2009; Roccas et al., 2002).

Individuals who are high in openness often exhibit abilities that are relevant to entrepreneurship, such as being constantly able to absorb new information and giving consideration and acceptance to different people and ideas (Roccas et al., 2002). Openness is more typical of entrepreneurs than professional employees (Brandstätter, 2011; Şahin et al., 2019; Zhao et al., 2009; Zhao and Seibert, 2006) and is typical in individuals who are satisfied with an entrepreneurial career (Ciavarella et al., 2004). Moreover, openness is important to entrepreneurs, specifically if they are trying to find new opportunities and ways of structuring and developing their enterprises (Brandstätter, 2011; Patriotta and Siegel, 2019). Indeed, amongst the "Big Five" personality traits, openness has the most consistent

relationship with entrepreneurial status (Brandstätter, 2011; Obschonka et al., 2014; Obschonka and Fisch, 2018; Obschonka and Stuetzer, 2017; Şahin et al., 2019; Zhao et al., 2009; Zhao and Seibert, 2006) and has been found to be the most powerful predictor of entrepreneurial intention, even in multi-cultural studies (Ismail et al., 2009; Brandstätter, 2011; Obschonka et al., 2014; Bernoster et al., 2020). Therefore, we expect openness to be positively related to entrepreneurial intention. Nevertheless, the relationship between openness and entrepreneurial intention is likely to depend on rule-breaking tendencies.

Individuals high in openness might recognise opportunities better, however it remains unclear as to whether they will act on these opportunities or not. Those who are high in openness but tend to follow rules (i.e., those with low rule-breaking tendencies) are unlikely to have entrepreneurial intention. They might acknowledge new opportunities as a result of their openness, but it is improbable that they will exploit or act upon these opportunities because this usually requires breaking rules, which those with low rule-breaking tendencies are unlikely to do (Obschonka, 2016). By contrast, individuals who have high openness and high rule-breaking tendencies are likely to recognise opportunities and are also likely to exploit them; they do not mind breaking the rules inherent in that exploitation (Brandstätter, 2011; Arentz et al., 2012; Slavec et al., 2017). We therefore expect, that the positive effect of openness on entrepreneurial intention is stronger in those with higher rule-breaking tendencies.

Hypothesis 1a: *Openness has a positive relationship with entrepreneurial intention.*

Hypothesis 1b: *Openness has a stronger positive relationship with entrepreneurial intention in individuals with high rule-breaking tendencies than in those with low rule-breaking tendencies.*

2.3.2 Idealism, rule-breaking tendencies and entrepreneurial intention

According to Forsyth (1980), idealism is defined as a moral system involving the use of universal moral principles when determining one's moral compass. Individuals with high idealism assume that universal moral principles are usually in line with the desirable consequences of an action. In contrast, those with low idealism tend to emphasise the consideration of the desirable or undesirable consequences of a particular action, which might or might not be aligned with universal moral principles. They would consider disregarding conventional principles as moral when it proves beneficial to themselves or others (Forsyth, 1980). Hence, those with low idealism favour being open to personally and socially positive outcomes and prioritise this over following universal moral principles (Forsyth, 1980).

Entrepreneurs often face moral choices. Examples of this include a willingness to (a) present themselves (or their business) better shape than the corresponding reality, (b) go against authority figures, (c) violate the norms of competitive contexts, or (d) violate laws to pursue the firm's goals (Brenkert, 2009). The violation of moral norms is intrinsic to entrepreneurship and often accepted as "what entrepreneurs do" (Brenkert, 2009; Grajales, 2016; Mckenna, 1996). We argue therefore, that low idealism is useful in tackling the moral choices related to entrepreneurship (Brenkert, 2009; Morgan, 2012; Cruz *et al.*, 2015). Individuals with low idealism are likely to be inclined towards using entrepreneurship as a way to fulfil their moral obligation, e.g., helping others (Kruse *et al.*, 2021; Lepoutre and Heene, 2006; Margiono and Heriyati, 2018; Wallace, 1999). Their judgements are based on what they believe is best for themselves or others (Forsyth, 1980). They are likely to be creative in considering multiple options (not just the options stipulated by moral principles) in order to fight for what they think is best (Hueso *et al.*, 2020; Shen *et al.*, 2019; Yurtsever, 1999; Zampetakis and Moustakis, 2006). A tendency to emphasise their own judgements, independent of accepted standards, is advantageous for entrepreneurship because entrepreneurship requires radical ways of thinking (Hueso *et al.*, 2020; Patriotta and Siegel,

2019; Shen *et al.*, 2019; Yurtsever, 1999; Zampetakis and Moustakis, 2006). In contrast, individuals with high idealism tend to agree with universal moral principles even if these principles compromise their personal interests and they are also less creative when considering options to overcome problems or when being innovative (Kruse *et al.*, 2021; Margiono and Heriyati, 2018; Wallace, 1999). Therefore, we expect idealism to be negatively related to entrepreneurial intention.

Furthermore, we argue that the effect of idealism on entrepreneurial intention is stronger in individuals with high rule-breaking tendencies. As entrepreneurs view moral universal principles as unsuitable and violate them, this behaviour is not often sanctioned but instead, accepted as an entrepreneurial characteristic (Brenkert, 2009). For entrepreneurs, doing something differently against moral standards may sometimes be preferable than aiming for moral perfection (Duggal and Verma, 2021). Furthermore, in the process of introducing novel approaches, products or services to the market, recognising new ways of solving problems and also being willing to act on them is almost always required despite corresponding rule-breaking (Bryant, 2009; Petrou et al., 2020). In other words, whilst idealism involves the recognition of new ways of solving problems as a cognitive state, rule-breaking tendencies involves the actual action of taking advantage of this state. The action component of violating norms is what characterises rule-breaking tendencies and distinguishes them from idealism. However, as argued above, being willing to act when recognising new ways of solving problems is unlikely for those who tend to follow rules (i.e., those with low rule-breaking tendencies). Thus, when individuals have low rule-breaking tendencies, their idealism might not make much of a difference. They might have their own judgements that contrast with universal moral principles, but they avoid going against these principles in any case because of their low rule-breaking tendencies (Lundmark and Westelius, 2012). In contrast, individuals with low idealism and high rule-breaking

tendencies perceive their judgements to be more important than universal moral principles (Dheer and Lenartowicz, 2019; Dheer and Lenartowicz, 2017; Shen *et al.*, 2019; Yurtsever, 1999) and also, they are likely to act based on their judgements, even when this requires rules to be broken (Bandura *et al.*, 1999; Bryant, 2009; Patriotta and Siegel, 2019; Vancouver and Day, 2005). In addition, they are not only−due to their low idealism−more creative in considering non-standard and questionable ideas in order to solve problems and adapt to change (Finkelman and Kelly, 2011), but they are also more likely to be willing to act on such ideas, even where they have to break the rules (Lundmark and Westelius, 2012; Shen *et al.*, 2019; Yurtsever, 1999; Zampetakis and Moustakis, 2006). Thus, we suggest that the negative effect of idealism on entrepreneurial intention is stronger in those with higher rule-breaking tendencies. Taken as a whole, this leads us to the following hypotheses:

Hypothesis 2a: *Idealism has a negative relationship with entrepreneurial intention.*

Hypothesis 2b*: Idealism has a stronger negative relationship with entrepreneurial intention in individuals with high rule-breaking tendencies than it does in those with low rule-breaking tendencies.*

2.3.3 Integrating personality, morality and rule-breaking tendencies as antecedents of entrepreneurial intention

While personality and morality have been shown to be important antecedents of entrepreneurial intention, the influence of rule-breaking tendencies on these relationships has been neglected. We suggest openness has a positive effect on entrepreneurial intention and idealism a negative effect and that these effects are dependent on rule-breaking tendencies. Those with high openness or low idealism are likely to recognise opportunities or prioritise their judgements and those who also have rule-breaking tendencies are more likely to have

the intention to act as regards entrepreneurial opportunities and their judgements. *Figure 1*. illustrates the hypotheses of this study.

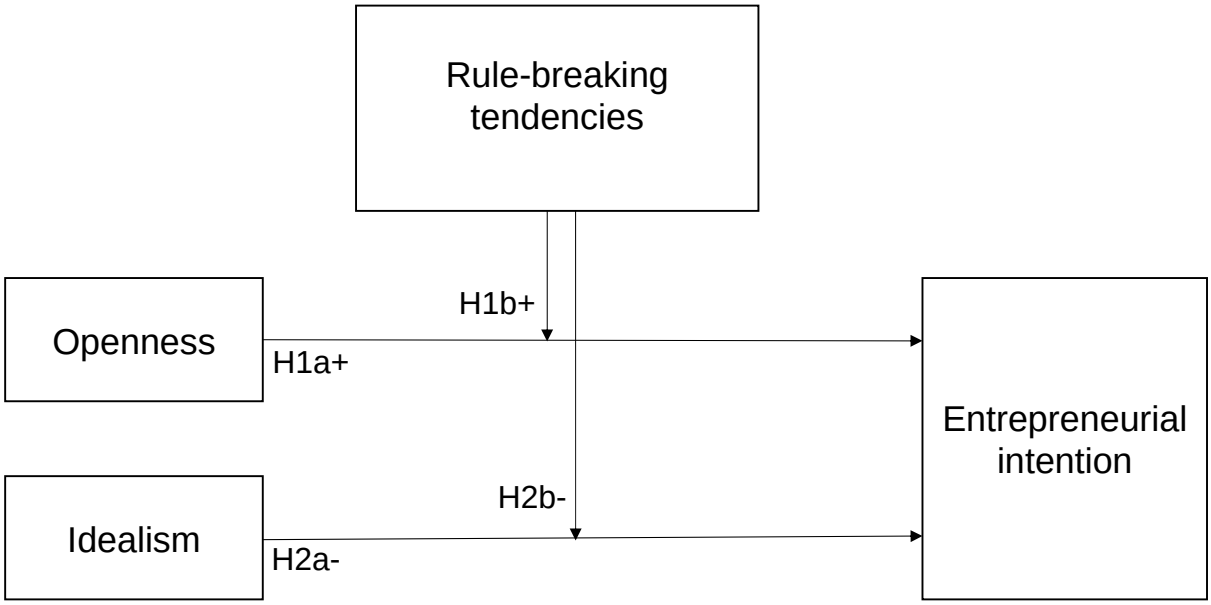


Figure 1. The moderation role of rule-breaking tendencies in the relationship that openness and idealism have with entrepreneurial intention.

4. Method

To test our hypotheses, we applied a multi-source approach in a laboratory setting. Our data collection includes data obtained from an empirical computerised task examining explicit behaviour (Arend, 2016; Laureiro-Martínez et al., 2014; Lee et al., 2010)and questionnaires.

4.1 Sample

120 individuals fluent in either German or English were invited to the authors' university's laboratory via e-mail to take part in the study. This sample size is large when compared to other studies, including computerised tasks in laboratory settings; such studies require considerable time and effort and therefore, tend to have smaller sample sizes than those which use self-report measures alone (Arend, 2016; Hedge *et al.*, 2018). One participant was excluded for showing a deviant reaction time pattern in the computerised task (for further

details see supplementary material) and the results of seven participants who either reported no veridic answers or showed patterned responses in the questionnaires were also ignored. The final sample therefore, was made up of 112 participants with complete datasets (Female = 51, Age_{Mean} = 25.4, Age_{SD} = 7.61, participants that were students = 97%). For more detailed information about the sample characteristics, see supplementary material (*Table S1*).

4.2 Procedure

The participants signed a written informed consent, after which they sat in individual cubicles to complete a computerised task that evaluated their rule-breaking tendencies. They subsequently filled out questionnaires. At the end of the experiment–it lasted approximately one hour–participants were paid based on their performance during the computerised task and according to the standards set by the laboratory (between eight to fourteen Euros per participant). All procedures were approved by the local Ethics Commission (project number: 64/19 s).

4.3 Measures

4.3.1 Entrepreneurial intention. To evaluate participants' entrepreneurial intention, we used six items of the EIQ scale (Chronbach alpha: .87 ;Liñán *et al.*, 2011; Liñán and Chen, 2009; Tsai *et al.*, 2016) as adapted by Liñán and colleagues (2011). Participants indicated their level of agreement with statements such as, "I am determined to create a business venture in the future", on a seven-point Likert scale (1 = strongly disagree, 7 = strongly agree).

4.3.2 Rule-breaking tendencies. Intraindividual differences in responses towards rules (i.e., high rule-breaking tendencies versus low rule-breaking tendencies) can be evaluated in controlled settings using a computerised task. To measure participants' tendencies, we adapted an established task (Gross et al., 2018), see *Figure 2.* At the beginning of the rule-

breaking task, participants were informed on the screen that, at the end of the experiment, they would receive 8 Euros for participation, but that this amount could increase proportionally according to the number of stocks they gained during the task (Range: 8-12 euros). The decisions that the participants took throughout the task therefore, led to real financial consequences. During the task, participants decided how to allocate balls to two areas: a blue box and an orange box (see *Figure 2.A*). Each box was associated with a different number of stocks for each trial (for trial-specific amounts of stocks see supplementary material). Participants first moved the cursor to a circle with a brick-texture (i.e., the home area) to pick a black ball and then dragged it into one of the boxes. For instance, in one given trial, dragging the ball to the blue area could result in a participant earning 1000 stocks, while dragging it to the orange area could result in the loss of 500 stocks. If participants took longer than 1000ms to complete a trial, a message ("Please try to leave the home area as quickly as possible!") appeared on the screen so that their attention was maintained throughout the task.

After five practice trials, participants started the task, which consisted of two parts – a "rule-free" and a "rule" part, see *Figure 2.B.* The "rule-free" part was made up of three blocks and the participants could freely choose the box they preferred. The subsequent "rule" part consisted of three blocks, but at the beginning of each block, a simple rule appeared on the screen (e.g., "The rule is to put each ball in the blue/orange area"). The colour indicated by the rule was counterbalanced across participants. No punishment was presented should rules be broken. After a total of 55 trials, participants received feedback on the total amount of stocks accumulated during the task. If they had followed the rules, seven trials led to a neutral consequence (i.e., same payoff), 24 trials to a negative (i.e., lower payoff) and 24 trials to a positive (i.e., higher payoff). Per block, all trials were presented in a fully

randomised order. In total, the task included 335 trials and took around 30 minutes to complete.

Rule-breaking tendencies were operationalised in the experiment according to the following criteria: Participants were classified as individuals with low rule-breaking tendencies if they tended to follow rules consistently independent of the consequences. In contrast, participants were classified as individuals with high rule-breaking tendencies when they tended to follow the rules when consequences were positive (i.e., higher payoff), but broke the rules if consequences were negative (i.e., lower payoff; Gross *et al.*, 2018). Breaking a rule for larger payoffs indicated that they had pursued their internal goals as showed in the "rule-free" part, demonstrating that this was more important to them than following that particular rule. Based on these criteria, the type of rule-breaking was coded as a binary variable (1 = low rule-breaking tendencies, 2 = high rule-breaking tendencies) [5]. For further details see supplementary material.

4.3.3 Openness. We measured participants' openness as part of the 10-item version of the Big Five Inventory (Reliability = .79; Rammstedt and John, 2007). In this well-established personality traits measure, participants rate their level of agreement to 2 items (e.g., "I see myself as someone who has an active imagination" and "I see myself as someone who has few artistic interests"; the score of the second item was reversed) on a five-point Likert scale (1 = Disagree strongly, 7 = Agree Strongly). Based on our hypotheses, the openness measure alone was included into the main analysis, while the other personality measures were included as covariates in the robustness checks.

[5] Participants were neither rewarded for following the rule, nor punished for breaking it. Participants were not instructed to follow or break the rule; thus, participants' behaviour was spontaneous. Participants who broke the rule were expected to achieve higher outcomes because they reached the box with the highest gain, in comparison to individuals who tended to follow the rules. Only three participants asked what they should do with the rule and in this case, experimenters answered "It is your decision". All participants reported that they had read the rule when it was presented to them on their screen. All participants classified as rule-breakers said explicitly that they had broken the rule to increase their pay-offs.

3.3.4 Idealism. To capture individual differences in moral orientation, participants completed the Ethics Position Questionnaire (Cronbach alpha = .80; Forsyth, 1980). Participants indicated their agreement to 20 statements by using a 9-point Likert Scale (1 = completely disagree, 9 = completely agree). Half of the items examined the idealism dimension pertaining to rejections of moral principles; exemplary items included, "Deciding whether or not to perform an act by balancing the positive consequences of the act against the negative consequences and deciding whether it is immoral". The other 10 items evaluated the realism dimension pertaining to subjective and situational concerns for consequences of actions; exemplary items included, "Moral standards are simply personal rules which indicate how a person would behave and are not to be applied when making judgments of others". Based on our hypotheses, we only included the idealism measure into the main analysis, while relativism was included as a covariate in the robustness checks.

3.3.5 Control variables. Previous studies show age and gender to be predictors for entrepreneurial intention (Shinnar *et al.*, 2014; Caliendo *et al.*, 2015) and so were therefore included as control variables in this study (gender dummy coded with 1 = female, 2 = male). In addition, we included the other four personality traits that belong to the big five (i.e., extraversion, agreeableness, conscientiousness, neuroticism) and an ethic position (i.e., realism) as control variables.

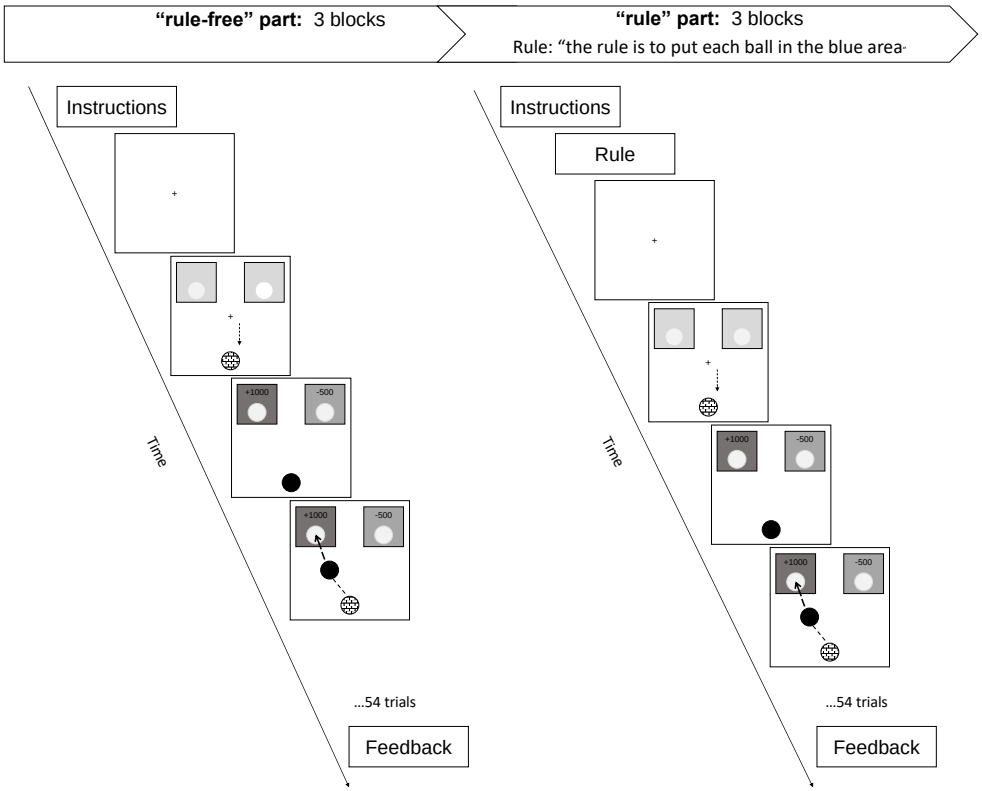


Figure 2. Structure of the rule-breaking task. In the "rule-free part", a fixation cross appeared in random intervals between 500-700ms spaced by 20ms. Afterwards, participants dragged the cursor towards the home-area (circle with bricks texture). Once they reached the home-area, the cursor changed to a black ball. Simultaneously, the screen displayed the coloured boxes and the stocks' values associated with each box. The participants were instructed to choose the number of stocks they wanted to keep for themselves. The sign "+" meant to earn and the sign "-" meant to lose money. If participants took more than 1000ms the message "please try to go faster to the home-area" pooped up on the screen. The trials finished when the participant reached either the blue (darker grey) or the orange box (lighter grey). Dashed arrows indicate the possible mouse movements of the participants in each trial step (See a GIF of all the task in the supplementary material). In the "rule-part" the same trial structure occurred, but at the beginning of the block a simple and arbitrary rule was displayed.

5. Results

The descriptive statistics and bivariate correlations of the main variables are presented in *Table I.* The successful implementation and validation of the rule-breaking task allowed 52 individuals with high rule-breaking tendencies (Females = 26, i.e., 50%, Age_{Mean} = 25.1, Age_{SD} = 6.97) and 60 individuals with low rule-breaking tendencies (Females = 25, i.e., 41.667%, Age_{Mean} = 25.7, Age_{SD} = 8.17) to be identified.

5.1 Effects of the type of rule-breaking on entrepreneurial intention

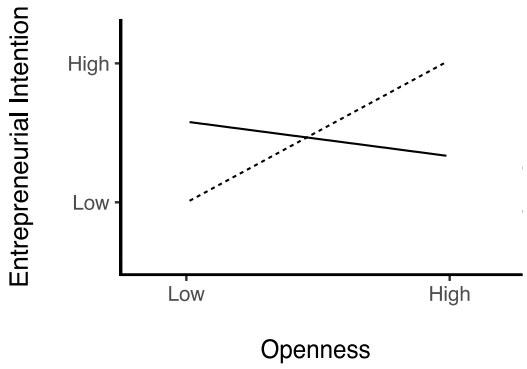
To investigate whether openness relates positively to entrepreneurial intention (H1a), we regressed entrepreneurial intention on openness. No significant results were found to suggest that hypothesis 1 is not supported by our data. Then, we tested to what extent being an individual with high rule-breaking tendencies versus low rule-breaking tendencies affects the relationship between openness and entrepreneurial intention (H1b). To do so, we regressed entrepreneurial intention on openness and rule-breaking tendencies (low vs. high) and then, as part of a second step, we regressed it on their interaction (see *Table II*). After performing bootstrapping analyses using 1000 permutations, we found significant interaction between openness and rule-breaking tendencies (b = .407, $t_{(111)}$ = .176, p = .024). Further analyses showed that entrepreneurial intention increases with openness, but only for individuals with high rule-breaking tendencies (b = .65, p = .01) and not for individuals with low rule-breaking tendencies (b = -.159, p = .51; see *Figure 3.A*).

We therefore find support for our hypothesis H1b, which predicts that openness shows its positive effect on entrepreneurial intention specifically in individuals with high rule-breaking tendencies. Openness seems to be positively related to entrepreneurial intention, particularly when combined with the tendency to break the rules.

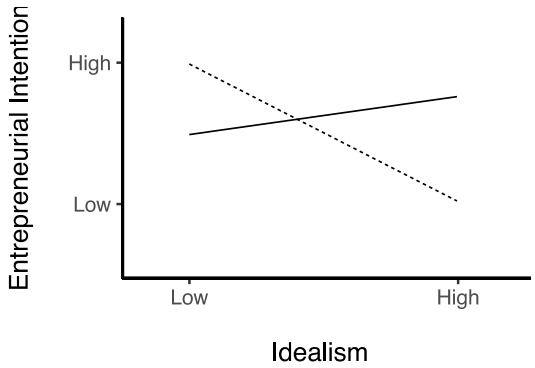
To investigate whether or not idealism relates negatively to entrepreneurial intention (H2a), we regressed entrepreneurial intention on idealism. No significant results were found to suggest that hypothesis 2 is not supported by our data. Next, to test whether idealism has a stronger negative effect on the entrepreneurial intention in those with high rule-breaking tendencies than in those with low rule-breaking tendencies (H2b), we executed another multiple regression analysis. Here, we regressed entrepreneurial intention on idealism and rule-breaking tendencies (low versus high) and, as a second step, on their interaction. Table II

illustrates these results; further details can be found in the supplementary material (*Table A.2*). After performing bootstrapping analyses using 1000 permutations, we found a significant interaction between idealism and rule-breaking tendencies (b = -.027, $t_{(111)}$ = -2.03, p = .045). Further analyses showed that entrepreneurial intention increases with low idealism, but only for individuals with high rule-breaking tendencies (b =-.044, p =.041) and not for those with low rule-breaking tendencies (b = .011, p = .509; see *Figure 3.B*). Thus, we find that hypothesis H2a, predicting that idealism shows a negative effect in individuals with high rule-breaking tendencies and not in those with low rule-breaking tendencies, is supported.

A.



B.



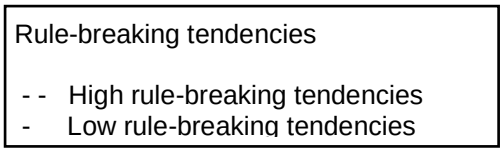


Figure 3. A. Interaction of rule-breaking tendencies and openness on entrepreneurial intention. **B.** Interaction of rule-breaking tendencies and idealism on entrepreneurial intention**.**

Table 1. Bivariate correlations and descriptive statistics.

Variables in the survey	Mean (min/max)	SD	1	2	3	4	5	6	7	8	9	10
1. Age	25.4 (18/68)	7.61	-									
2. Sex [a]	NA	NA	-.018	-								
3. Rule-breaking tendencies[b]	NA	NA	-.042	-.083	-							
4. Openness	3.429 (1/5)	.790	-.001	-.055	-.068	-						
5. Conscientiousness	3.226 (1/5)	.807	.078	-.245*	.013	.03	-					
6. Extraversion	3.434 (1/5)	.946	-0.077	.043	-.071	.252*	.172	-				
7. Agreeableness	3.584 (1/5)	0.850	0.11	-.003	-.015	-.094	.287*	.047	-			
8. Neuroticism	2.885 (1/5)	0.933	-.031	-0.2*	.049	-.044	-.206*	-.385*	-.155	-		
9. Relativism	55.319 (23/90)	11.331	-.276*	-.007	.104	-.13	-.045	-.033	.071	.004	-	
10. Idealism	64.531 (28/89)	10.766	.149	-.28*	.035	-.132	.11	-.086	.115	.023	.115	-
11. Entrepreneurial intention	3.802 (1/7)	1.496	-.014	-.303	-.093	.132	.142*	.264	-.164*	-.346	-.104	-.073

* Correlation significant at the .05 level (2 – tailed).

[a] 1 = female, 2 = male

[b] 1 = low rule-breaking tendencies, 2 = high rule-breaking tendencies.

Table 2. Effects of openness and relativism, on entrepreneurial intention moderated by rule-breaking tendencies.

DV													
		Std. coeff.	*t*	*p*	*Std. coeff.*	*t*	*p*	*Std. coeff.*	*t*	*p*	*Std. coeff.*	*t*	*p*
IV	Rule-breaking tendencies (1 = low rule-breaking tendencies, 2 = high rule-breaking tendencies)	-.127	-.89	.38	-1.524	-2.459	.52	-.136	-.95	.34	1.638	1.851	.067
	Openness	.239	1.33	.19	-1.592	-.646	.015						
Interaction	Rule-breaking tendencies X openness				.407	2.313	.023						
IV	Idealism							-.01	-.74	.46	.011	.663	.509
Interaction	Rule-breaking tendencies X idealism										-.027	-2.031	.045
Adjusted R^2				.006			.070			-.004			.05
Delta R^2							.064						.054
(Sig.)				(.258)			(.047)			(.475)			(.136)

Note. N = 112; for more detailed information see appendix (*Table S2*).

5.2 Robustness Checks

We ran several robustness checks for the analyses reported above by including control variables. For the analysis that relates to H1a and H1b, the modulation of openness, we controlled for sex, age and the remaining four Big Five dimensions. For the analysis that relates to H2a and H2b, the modulation of idealism, we controlled for sex, age and relativism. When including control variables, results did not differ substantially from the findings reported above. See supplementary material (*Table S3*) for details and statistics.

6. Discussion

The aim of this study was to investigate the role of rule-breaking tendencies in the relationships of personality and morality with entrepreneurial intention and to test these relationships based on a multi-source approach. We found that while openness and idealism did not have a direct effect on entrepreneurial intention, openness was positively related to them and idealism was negatively related, but only in individuals with high rule-breaking tendencies.

6.1 Theoretical implications

Our research contributes to the literature in the following ways. Firstly, drawing on the theory of planned behaviour, our study provides a more comprehensive approach to how individuals' personality and morality relate to their intention to start a new venture. Notably, McAdams (2009) has noticed that individuals high in openness tend to be less idealistic. This is interesting because we observed that both individual characteristics have similar effects on entrepreneurial intentions when combined with rule-breaking tendencies. Hence, our research builds upon previous theory and research to provide a more nuanced and therefore richer picture of the individual antecedents of entrepreneurial intention. Secondly, we introduce rule-breaking

tendencies into the discussion on entrepreneurial intentions and pioneer the idea of addressing the fact that the influence of personality and morality in entrepreneurship may be dependent on other individual factors (i.e., rule-breaking tendencies) as boundary conditions. While research on the nature of entrepreneurial intention has proliferated, the interaction of relevant and boundary antecedents has been neglected and thus, so far, provides an incomplete, reductionist or incoherent view on antecedents (Murnieks et al., 2020). Our study considers the complexity of the interplay between different intraindividual characteristics and therefore looks beyond what has been presented in previous literature (Brandstätter, 2011; Hu *et al.*, 2019; Karabulut, 2016; Mathieu and St-Jean, 2013; Nassif *et al.*, 2010; Obschonka and Stuetzer, 2017; Tiwari *et al.*, 2017).

Our findings point towards the relevance of considering rule-breaking tendencies associated with entrepreneurship. Whilst prior research observed that rule-breaking tendencies are linked to entrepreneurial status and entrepreneurial activities, we have uncovered the role these tendencies already play in forming entrepreneurial intention (Obschonka *et al.*, 2013; Zhang and Arvey, 2009). We argue that individuals who are high in openness or low in idealism and tend to break the rules not only exhibit cognitive processes and preferences that are relevant for the formation of entrepreneurial intention, but also intend to act entrepreneurially. With an open personality and high rule-breaking tendencies, it is likely that they are can recognise (due to openness) and are ready to exploit (due to rule-breaking tendencies) opportunities. Similarly, those with low idealistic morality and high rule-breaking tendencies are likely to recognise novel ways to overcome problems (due to low idealism) and intend to act on their ideas even if this requires going against the rules.

Thirdly, our multi-source measurement approach adds new methodological perspectives. We not only use introspective measurements, which are "ritualised" in entrepreneurship research, but measure concrete behaviour in a computerised task. For

example, we measured individuals' rule-breaking tendencies in a computerised task that assessed this information in real-time and under controlled conditions in a laboratory setting. We hope that our approach inspires entrepreneurship research to implement more multi-source designs that contribute to the theoretical integration of blurry constructs and make the jump from "what people say they do" to "what people do". Our implementation and validation of a computerised task provide novel insights into rule-breaking tendencies and its relationship to entrepreneurial intention beyond what traditional management models can predict.

6.2 Practical implications

Knowledge on individual antecedents of entrepreneurial intention is relevant practically because knowing what drives entrepreneurial intention enables entrepreneurship educators to recognise personal characteristics and incorporate individualised support in the design of entrepreneurship training (Fayolle and Gailly, 2015; Ndofirepi, 2020). Research on entrepreneurship education shows that education programmes often lack individualisation, which is crucial for entrepreneurship training (Florin *et al.*, 2007; von Graevenitz *et al.*, 2010). Not all individuals react equally to the same teaching strategies and the trajectories of how individuals develop entrepreneurial intentions are very diverse (Florin *et al.*, 2007; von Graevenitz *et al.*, 2010). Our research provides knowledge on intraindividual antecedents, which can help improve the individualisation of entrepreneurship training. Our findings indicate the relevance of discussing the necessity to break rules in entrepreneurship and this could be particularly fruitful for cultivating entrepreneurial intention in individuals with high openness or low idealism.

Another practical implication relates to the recruiting process in enterprises. Some enterprises need individuals with an entrepreneurial mindset, especially for creative jobs or to move the company into unexplored areas (Hughes *et al.*, 2018; Ouakouak and Ouedraogo,

2017; Wu and Wu, 2008). Therefore, companies and human resources teams must understand the personal causes of entrepreneurial intention to find a good match for these innovation-orientation-requiring positions (Morrison, 2006; Kim *et al.*, 2009). Depending on the aptitude set needed, they could consider measuring personality, morality and rule-breaking tendencies as part of their recruitment decision-making process.

6.3 Limitations and future directions of the study

The current study is, like any study, subject to limitations. Firstly, much of our sample was made up of university students. As the university is considered a "bubble", it is possible that the perceptions towards and predictors of entrepreneurial intention might differ in other groups of people (e.g., minimising or maximising the financial and personal risks that entrepreneurship entails). Indeed, previous studies have shown that age, prior entrepreneurial experience, job identification, work experience in small companies and social network are all relevant for entrepreneurial intention (Arend, 2016; Krueger, 1993; Quan, 2012; Turker and Selcuk, 2009). Although it is vital to understand how individuals develop their interest in becoming an entrepreneur in the university context, it would be interesting to see if the antecedents studied here still play a role in the entrepreneurial intention of those that have managerial experience.

Secondly, while our sample is large for a study incorporating a sophisticated computerised task with many trials (Lampit *et al.*, 2014; Arend, 2016), future studies are needed to validate whether our results hold in additional samples and whether they are generalisable. For example, previous studies have shown the existence of cultural differences in morality and its relationship to entrepreneurship, so much so that it is important to analyse residents in other countries (Sommer *et al.*, 2000; Forsyth *et al.*, 2008). Therefore, a multicultural study could contribute to our comprehension of the relevance of the individual antecedents of

entrepreneurial intention across cultural contexts. That aside, industry differences could also matter in terms of the relevance of openness, morality and rule-breaking. Additional research in different contexts employing and combining similar tasks and questionnaires is needed to clarify the scope of generalisation of our results (Vermeir et al., 2020).

Fourthly, even though many entrepreneurial activities are carried out in teams, our study does not evaluate how the interactions in a team motivate entrepreneurial intention (Park *et al.*, 2013; Klotz *et al.*, 2014). We could imagine that the relevance of the factors in our model could be positively influenced by the socialisation process (Cai et al., 2019; Gundry et al., 2016; Hughes et al., 2018). Future research should explore whether or not the influence of personality, morality and rule-breaking tendencies in entrepreneurial intention differ in a team setting where individuals' tendencies combine.

6.4 Conclusions

To better understand the intraindividual antecedents of entrepreneurial intention, we investigated the role of rule-breaking tendencies in the relationship that openness (as an entrepreneurship-related personality trait) and idealism (as an entrepreneurship-related moral system) have with entrepreneurial intention. We found that high openness and low idealism were linked to entrepreneurial intention in individuals with rule-breaking tendencies. Our research contributes to entrepreneurship by describing the interplay of the intraindividual antecedents of intentions to start a new venture. Additionally, this study's methodology is pioneering and opens up new vistas for novel techniques in the field of entrepreneurship.

Chapter 5: The effect of deliberative rule-breaking tendencies on entrepreneurial self-efficacy: a neurocognitive approach[6]

Abstract

Although previous research has not focused on the neurophysiological substrates of intraindividual antecedents of entrepreneurial self-efficacy, nowadays, neurocognitive methods allow for a deeper understanding of unobservable mental capacities associated with these antecedents. We hypothesised that a brain-mind model accounting for a neurocognitive mechanism (i.e., cognitive-conflict-capacity), behavioural tendencies (i.e., deliberative rule-breaking) and a personality trait (i.e., behavioural inhibition) predicts entrepreneurial self-efficacy. A multi-source approach was developed to test the model. Individuals were asked to complete a set of questionnaires and a computerised task. During the computerised task, we monitored their behaviour and measured their reaction times, mouse movements, eye movements and brain electrical activity. Our results showed that a high cognitive-conflict-capacity is required for the deliberative rule-breaking tendencies associated with entrepreneurial self-efficacy in individuals with low behavioural inhibition. This capacity is characterised by slow responses, complex and large mouse trajectories, numerous eye-fixations, slow saccades and low delta bandpower in frontocentral and parietal electrodes. Our research adds an integrative model with a neurophysiological basis to antecedents of entrepreneurship and has practical implications for recruiting, entrepreneurial education and navigating socioeconomic shifts of current occupations. The present study highlights the enormous potential of brain-mind models for studying the antecedents of entrepreneurship at the individual level.

Keywords: individual antecedents, entrepreneurial self-efficacy, neurocognitive methods

[6] The study reported in this chapter is based on a working paper by Cubillos Pinilla, L., Emmerling, F., Peus. C., currently submitted to *Personnel Psychology*.

1. Introduction

Entrepreneurship drives the world's economies (Pacheco et al., 2010; Studdard et al., 2013; Thompson et al., 2011). We currently encounter many challenges, such as inequality, climate change, pandemics, wars, migration and scarcity of natural resources (Becker et al., 2019; Bruton et al., 2021; Jakob, 2022; Rawtani et al., 2022; Silva et al., 2021). The complexity and entanglement of these challenges demands edgy and highly innovative solutions, i.e., entrepreneurial thinking. Societal success, therefore, relies on individuals who face crises and feel able to perform entrepreneurial activities either (a) independently by creating communities and enterprises that develop innovative ideas to combat current challenges or (b) within organisations by spreading their enterprises to other services or venues. In other words, we need individuals who can develop entrepreneurial self-efficacy, i.e., confidence in their ability to perform the different roles and tasks of innovative thinking and entrepreneurship (Balven et al., 2018; Chen et al., 1998; Orlitzky et al., 2011; Shahab et al., 2019; Siegel et al., 2004; Waldman et al., 2001). Career researchers, practitioners, educators and policymakers are interested in understanding the individual antecedents of entrepreneurial self-efficacy because of the growing influence of the entrepreneurial mindset on career development. To place suitable individuals into central positions in politics and economics and to further develop their abilities, we need to understand the qualities that make some individuals more prone to developing entrepreneurial self-efficacy than others (Memon et al., 2019), i.e., the intraindividual antecedents of entrepreneurial self-efficacy.

Newman et al. (2019) published a systematic review describing the intraindividual antecedents of entrepreneurial self-efficacy, which include work experience, education, training, role models, gender, entrepreneurial passion, personality and cognitive styles. Entrepreneurial self-efficacy is grounded in theories from self-efficacy research (e.g., theory

of social cognition and theory of agency), which is a broader field of study (Newman et al., 2019). Newman et al.'s (2019) research suggests that entrepreneurial self-efficacy is malleable. This perspective highlights the significance of studying the intraindividual antecedents of entrepreneurial self-efficacy as a starting point in order to design interventions that can impact its outcomes, such as entrepreneurial intentions, emotions, behaviours, performance and venture creations. The antecedents elucidated by previous work have proven to be important for the formation of entrepreneurial self-efficacy. They have, however, so far not focused on the underlying cognitive and neurophysiological mechanisms. To truly understand these antecedents, we should also rely on a brain-mind model.

Brain-mind models represent a constructive approach to integrating disciplines aimed at scientifically studying individuals' psychological processes at different levels of analysis (Westbrook & Braver, 2015). Brain-mind models include the following levels of analysis: neurocognitive mechanisms (e.g., cognitive capacities), behavioural tendencies (e.g., decision-making) and complex psychological processes (e.g., personality; Connors & Halligan, 2014; Montag & Panksepp, 2020; Shiffrin et al., 2020; Zmigrod & Tsakiris, 2021). These models are helpful to entrepreneurship research because they explore the neurophysiological substrates of mental capacities and their influence on corresponding behaviours. In particular, brain-mind models permit the study of and links between unobservable mental constructs and behavioural tendencies (e.g., cognitive capacities and decision-making processes) through new technologies; Kotchoubey et al., 2016; Lerner, 2020; Shinnar et al., 2014; Waldman & Balthazard, 2015). Therefore, scholars working with brain-mind models can ask questions not accessible with previous traditional approaches, such as to what extent cognitive capacities affect behavioural tendencies and how certain personalities influence entrepreneurial self-efficacy.

Previous research has analysed the potential contributions of brain research to strategic management and entrepreneurship (Cucino et al., 2021; Lin et al., 2022; Nicolaou & Shane, 2014; Waldman et al., 2017). Neurocognitive methods can measure cognitive variables (e.g., working memory span) that explain the variance of dependent variables in management and psychology research (Atlas & Wager, 2013; Burgess et al., 2011; Hannah et al., 2013; Kuklinski, 2001; Lindebaum et al., 2020; Waldman et al., 2011a; Waldman, et al., 2017). Brain-mind models, in particular, can explain previously unexplained variance of entrepreneurship-related variables (Korpysa, 2020). Although the neurocognitive perspective provides insights into the antecedents of self-efficacy (Lewis et al., 2020; Stone, 2018; Utami et al., 2020) and entrepreneurial self-efficacy research takes advantage of theories that support self-efficacy (Newman et al., 2019), this neurocognitive perspective has not yet been used in entrepreneurial self-efficacy research. Moreover, the investigation of decision-making using brain-mind models contributes to an understanding of the individual as opposed to the macro level of entrepreneurship (Drnovšek et al., 2010; Ortiz-Terán et al., 2013; Sharma et al., 2021; Tschannen-Moran & Hoy, 2007; Waldman et al., 2011a). Brain-mind models can help us to understand how rational and emotional aspects of an entrepreneur's decision-making are related to the functioning of the entrepreneur's brain (Nicolaou & Shane, 2013).

Furthermore, some studies that combine entrepreneurship and neuroscience use only one methodology. For example, Zaro et al. (2016) recorded qEEG during opportunity search and risk propensity tasks to predict entrepreneurial status, while neglecting other neurocognitive methods (e.g., psychophysics, mouse-tracking and eye-tracking). The integration of several neurocognitive methods gives assessment strategies of constructs which are often abstract greater convergent validity (Carlson & Herdman, 2010; Kotchoubey et al., 2016; Schweizer, 2012). Moreover, the use of neurocognitive methods informs the design and standardisation of computerised tasks that can measure antecedents of the entrepreneurial

mindset. Educators and scholars can use these tasks in interventions to foster behaviours that impact the entrepreneurial mindset (Arend, 2016; Ashkanasy et al., 2014). Despite the growing body of literature suggesting that a combination of neurocognitive science and entrepreneurship research can be fruitful (Gielnik et al., 2012; Korpysa, 2020; Lin et al., 2022; Waldman et al., 2019; Waldman et al., 2011b), there is still no empirical research addressing the precursors of entrepreneurial self-efficacy from a neurocognitive perspective. Therefore, the intraindividual antecedents of entrepreneurial self-efficacy through a brain-mind model should be studied.

A brain-mind model of entrepreneurial self-efficacy needs to address behavioural tendencies, a personality trait and a neurocognitive mechanism. The role of behavioural tendencies, particularly rule-breaking tendencies, in entrepreneurship has captured the interest of scholars over the course of the last decade. Rule-breaking tendencies are valuable for entrepreneurship as an antecedent of entrepreneurial status, orientation, intention and activity (Al-Ghazali & Afsar, 2021; Brenkert, 2009; Harris et al., 2009). Examples of rule-breaking tendencies in entrepreneurship include an eagerness for entrepreneurs to (a) offer novel goods to the market anticipating profit, (b) show themselves (or their ventures) in the most beneficial light, (c) oppose authority, (d) transgress norms in antagonistic surroundings, or (e) breach laws to fulfil the venture's aims (Brenkert, 2009). In addition, rule-breaking tendencies are strongly linked with self-efficacy (Keulemans, 2021; Miao, 2015). Rule-breaking tendencies have, however, not yet been studied in relation to entrepreneurial self-efficacy (Newman et al., 2019). We propose that a specific type, i.e., deliberative rule-breaking tendencies—in other words, the behavioural inclination to break the rules based on an expected outcome and personal interests—is related to entrepreneurial self-efficacy.

Personality-wise, behavioural inhibition has been negatively associated with entrepreneurial intention and entrepreneurial self-efficacy (Geenen et al., 2016). Behavioural inhibition is defined as the personality type that would evoke responses of prevention or repudiation when approached with anxiety-associated cues like punishment, non-reward and unfamiliarity (Fowles, 1988; Fowles, 1980; Gray, 1987; McNaughton & Gray, 2000) and it bias own perception to increase the focus on possible threats. Previous research has unravelled this concept's negative relationship with entrepreneurship because of the demanding challenges associated with the uncertainties surrounding entrepreneurial activities. This research has considered the impact of behavioural inhibition on entrepreneurial intention while neglecting the description of this particular personality trait's relationship with entrepreneurial self-efficacy (Farrukh et al., 2017; Gielnik et al., 2012; Jordaan, 2014; Newman et al., 2019; Schmutzler et al., 2018). This trait should therefore be investigated together with behavioural tendencies affecting entrepreneurial self-efficacy due to its broad relationship with entrepreneurship. Specifically, we propose that the brain-mind model that includes the effect of deliberative rule-breaking tendencies on entrepreneurial self-efficacy occurs mainly in individuals with low behavioural inhibition.

To appreciate the utility and potential instrumentality of deliberative rule-breaking behaviour on entrepreneurial self-efficacy in individuals low in behavioural inhibition, we must first understand their precedents–i.e., the neurocognitive correlates–of such conduct. Cognitive-conflict-capacity is described as the cognitive system's capacity to tolerate, respond and disentangle cognitively demanding situations due to uncertain, inconclusive or challenging information. Importantly, cognitive-conflict-capacity can be empirically quantified by the registration and analysis of parameters using several methods, such as psychophysics (Gescheider, 2013; Kingdom & Prins, 2016), mouse-tracking (Kieslich et al., 2019), eye-tracking (Blake, 2013; Carter & Luke, 2020) and electroencephalogram (EEG;

Darvas et al., 2004; Dickter & Kieffaber, 2013). Cognitive-conflict-capacity as a bio-cognitive marker should be the starting point for a brain-mind model (Obschonka, 2016).

The present study pioneers the empirical testing of a brain-mind model of the intraindividual antecedents of entrepreneurial self-efficacy. This study contributes to unravelling the intraindividual antecedents of entrepreneurial self-efficacy in three ways. Firstly, this research introduces the concept of deliberative rule-breaking tendencies as a behavioural antecedent measured by registering actual 'behaviour' in a computerised task. Secondly, we have developed a framework which combines deliberative rule-breaking and low behavioural inhibition. Thirdly and most importantly, the present study offers neurocognitive support for the notion that a combination of deliberative rule-breaking tendencies and low behavioural inhibition can be used to predict the extent of entrepreneurial self-efficacy in an individual. In particular, cognitive-conflict-capacity is the mental source that permits these behavioural tendencies and type of personality to have an impact on entrepreneurial self-efficacy. A brain-mind model for entrepreneurial self-efficacy is essential as potentially, we require the most impactful entrepreneurs and intrapreneurs to come up with non-obvious, insightful ideas to address society's current challenges.

2. Theoretical background

2.1 Deliberative rule-breaking and entrepreneurial self-efficacy

Recent studies have shown that certain forms of rule-breaking are more closely associated with entrepreneurship than others. Zhang & Arvey, (2009) demonstrated that entrepreneurial status was associated with moderate, adolescent rule-breaking (i.e., delinquency, offences in family and school) rather than extreme rule-breaking (i.e., breaking an official contract, drug use and crime). These results were replicated in another sample and backed up with official crime records (Obschonka et al., 2013). Even when controlling for other factors such as

parental social economic status and intelligence, moderate rule-breaking remains a strong predictor for entrepreneurship (Obschonka et al., 2013). Therefore, it is likely that rule-breaking tendencies are linked to entrepreneurship in circumstances where consequences for rule-breaking are not severe. For instance, discourse analyses of Steve Jobs, an archetypical entrepreneur, suggest that he attributed his success to violating social standards, such as dropping out of school in order to dedicate more time to his endeavours (Dakoumi & Abdelwahed, 2014; Watt, 2016). These rule-breaking tendencies probably affected his entrepreneurial self-efficacy as they reinforced his belief that he was in control of his environment and responsible for his actions. This belief is a crucial characteristic of entrepreneurs (Dakoumi & Abdelwahed, 2014; Watt, 2016).

The type of rule-breaking where benefits are weighed against consequences–as opposed to outcome-independent rule-breaking/general rule-breaking–is likely to be the most relevant for entrepreneurial self-efficacy (De Vries, 1977). We propose the term *deliberative rule-breaking tendencies* to describe an individual's basic behavioural tendencies to break rules based on the expected outcome and personal interests (Arend, 2016; Cubillos-Pinilla & Emmerling, 2022; Gross et al., 2018; Pfister et al., 2019). Such tendencies manifest when individuals choose to break a formal rule when the subsequent outcome benefits their interests. Importantly, these tendencies can be observed spontaneously, i.e., without an individual being explicitly informed that they can choose to break the rule in the first place (Arend, 2016; Cubillos-Pinilla & Emmerling, 2022; Gross et al., 2018; Pfister et al., 2019). Several mechanisms argue in favour of this specific kind of rule-breaking link with entrepreneurial self-efficacy.

Firstly, deliberative rule-breaking tendencies comprise voluntary and proactive actions. Thus, these tendencies involve taking the initiative in improving current

circumstances or creating new ones (Arend, 2016). That is, deliberatively rejecting the *status quo* rather than passively adapting to the present conditions (Crant, 2000). Along these lines, deliberative rule-breaking has been associated with trusting in one's own creative performance, imagination, "thinking outside the box" and innovation in the workplace—all of which are a part of entrepreneurial self-efficacy (Ahlin et al., 2013; Barakat et al., 2014; Kumar & Shukla, 2019). Deliberative rule-breaking tendencies are, therefore, essential to entrepreneurial self-efficacy which is rooted in the conviction that one can develop novel products, discover new opportunities, build strong relationships with other employees and investors or even create new markets (Ghasemzadeh et al., 2020; Jiatong et al., 2021; O'Shea et al., 2021; Leutner et al., 2014; Reichheld, 2001). Secondly, deliberative rule-breaking tendencies are associated with prioritising personal interests over external constraints and, thus, nonconformism (Verkuyten et al., 2010). The prioritisation of personal interests favours personal confidence and acceptance, which allows for feelings of entrepreneurial self-efficacy (Kim-Soon et al., 2022; Negara et al., 2019). This confidence allows individuals to believe that they can set challenging entrepreneurial activities, adhere to the tasks involved and apply more effort in pursuing these activities (Arend, 2016; Trevelyan, 2011). For instance, entrepreneurial self-efficacy is characterised by having directionality in pursuing goals and assertiveness in getting the attention of others when cooperating on those goals (McGrath & MacMillan, 2000; Sibin et al., 2007). Thus, deliberative rule-breaking tendencies are likely to relate to entrepreneurial self-efficacy based on their entanglement with proactivity, creativity and goal prioritisation.

Thirdly, individuals with deliberative rule-breaking tendencies have exceptional control of their actions and surroundings. Their behaviour empowers them to control outcomes and break the rules when expecting a benefit (Arend, 2016; Karabulut, 2016; Kor et al., 2007). Previous research has shown that individuals who carefully break the rules with

the expectation of receiving a positive outcome, benefit either financially (e.g., when going against the norms of the company and having a detrimental influence on the organisation and its employees while covering these acts with positive social impressions) or through social recognition (e.g., when going against the norms of the company and having a beneficial influence on the organisation and its employees) in the workplace (Chaker, 2020; Hviid et al., 2012). As respective actors gain confidence in violating norms in certain situations as they are obtaining rewarding outcomes, their self-efficacy increases; they have learnt that they are capable of controlling their surroundings (Zulkosky, 2009) (Genschow et al., 2022; Morrison & Phelps, 1999; Obschonka & Stuetzer, 2017). Furthermore, individuals high in entrepreneurial self-efficacy feel that they can achieve favourable outcomes if they persevere despite setbacks (Berg, 2014; Rauch & Frese, 2007). For instance, such individuals believe they can recruit and keep key employees or investors, even if they have had unfortunate experiences with former employees and investors (Bhide, 1992). For example, previous research has shown that the belief that personal actions can improve a given situation is, in all likelihood, related to outspokenness (Withey & Cooper, 1989). For entrepreneurial self-efficacy, outspokenness is critical for creating a trusting, open and dynamic working environment that encourages people to try new things (Bhide, 1992). Therefore, deliberative rule-breaking tendencies are relevant for entrepreneurial self-efficacy because these tendencies are associated with a feeling of control over one's surroundings.

Fourthly, taking decisions deliberatively is associated with risk tolerance and it is vital because entrepreneurs often face financial uncertainty and public embarrassment if their venture fails (Barbosa et al., 2007). In this sense, entrepreneurs are more exposed to risk than managers (Barbosa et al., 2007; Barbosa & Kickul, 2007; Ng & Jenkins, 2018). Indeed, entrepreneurial self-efficacy requires a person to tolerate ambiguity in risk situations and to persevere and to continue to perform entrepreneurial activities such as engaging and

maintaining favourable relationships with potential investors, taking decisions involving opportunity recognition, venture creation and growth (Barbosa et al., 2007; Barbosa & Kickul, 2007; Ng & Jenkins, 2018). This means that individuals who deliberatively deviate from the norms of reference in ways that are of benefit to themselves are more likely to have risk tolerance and thus more likely to have high entrepreneurial self-efficacy as wel.

Introspective measurements, particularly self-reports, have been the most common approach when investigating individual antecedents of entrepreneurial self-efficacy (Shahab et al., 2019; Spector, 1994). However, self-report measures that assess disobedience of external rules are especially problematic because personal judgements often differ from actual behaviour. Individuals tend to report less rule-breaking behaviour because of retrospective and social desirability biases (Alvesson & Sandberg, 2013; Brice & Spencer, 2007; Einola & Alvesson, 2020; Rutter et al., 1998; Schyns & Schilling, 2013; Vigil-Colet et al., 2012). This is especially true for individuals attracted to entrepreneurship as they crave social recognition even when there is economic and emotional risk (Timothy et al., 2011; Treviño et al., 2006). In addition, self-reports evaluate perceptions rather than behaviours (Forsyth, 1980; Obschonka et al., 2013; Timothy et al., 2011; Treviño et al., 2006). To avoid these external biases, researchers have devised computerised tasks to register these behavioural tendencies adequately (Arend, 2016; Cubillos-Pinilla & Emmerling, 2022; Gross et al., 2018). Computerised tasks allow the frequency of rule-breaking behaviours and the neurocognitive mechanisms associated with these behavioural tendencies to be studied.

Briefly, deliberative rule-breaking tendencies relate to entrepreneurial self-efficacy because of four main factors. Firstly, being proactive and creative in improving current circumstances or in the creation of new circumstances, demonstrated through deliberative rule-breaking tendencies, is essential for entrepreneurial self-efficacy. Secondly, prioritising self-interest in

pursuing personal goals enables higher entrepreneurial self-efficacy because it fosters feelings of confidence and acceptance. Thirdly, rewarding outcomes obtained by violating norms or rules increase self-efficacy because they increase an individual's belief that they have control over their environment. Fourthly, to feel confident about their perseverance when engaged in entrepreneurial activities, individuals benefit from deliberative rule-breaking tendencies because these tendencies are associated with risk tolerance. Deliberative rule-breaking can be measured in a computerised task and should be the type of rule-breaking that relates to entrepreneurial self-efficacy.

2.2 Deliberative rule-breaking, behavioural inhibition and entrepreneurial self-efficacy

Behavioural inhibition is a personality defined by the experience of discomfort and nervousness in situations with ambiguous cues (Almandoz, 2014; Berkman et al., 2009; Carver & White, 1994; MacAndrew & Steele, 1991), Individuals high in behavioural inhibition tend to interpret these cues as a signal of upcoming punishment. Their anticipation of this punishment makes them oversensitive to conditioned penance signals, non-reward and novelty (Avila, 1994; Berkman et al., 2009; Carver & White, 1994). They frequently experience negative emotions such as fear, anxiety, social anxiety, arousal, vigilance, sadness, frustration and negative affect (Fowles, 1988; Gray, 1987; Kimbrel et al., 2012). In contrast, those who are low in behavioural inhibition experience less anxiety as they are less concerned about awful occurrences and less sensitive to those events should they happen (Carver & White, 1994; Jürgens, 1994; Viana & Gratz, 2012); they are characterised by weak inhibition of impulses, less vulnerability to pain and nervousness in response to situations with aversive and ambiguous cues.

Low behavioural inhibition should strengthen the relationship between deliberative rule-breaking and entrepreneurial self-efficacy. Individuals who tend to break rules deliberatively and who are characterised by weak behavioural inhibition, experience less stress in uncertain situations and are, therefore, more likely to explore more diverse and innovative behaviours and subsequently, the full range of possible consequences of a making a decision in stressful situations (Jong & Hartog, 2007). They tend to be more critical about external restrictions and are less likely to complain behaviourally to them in situations of crisis (Can et al., 2020; Gette et al., 2021; Kamerdze et al., 2014; Wemm & Wulfert, 2017). This makes it easier for such individuals to select which action has led to their desired result, for example, deciding in a specific situation if following a rule would be appropriate (Bandura, 2006; Bandura et al., 1999; Frese, 2009). From the agency perspective of self-efficacy, this approach increases individuals' self-efficacy as far as their reactions to conditions of uncertainty are concerned and such conditions are prevalent in entrepreneurship endeavours.

In contrast, those with high behavioural inhibition experience extreme fear and anxiety in situations with ambiguous cues and they deny their ability to learn why distinct actions are associated with different outcomes (Can et al., 2020; Gette et al., 2021; Kamerdze et al., 2014; Wemm & Wulfert, 2017). In this way, even if they do tend to break the rules, it would be more difficult for them to grasp which behaviours would be appropriate to enhance performance in specific situations. They will therefore be less likely to develop entrepreneurial self-efficacy, as they will not put effort into completing entrepreneurial activities focusing on a potentially negative outcome.

Moreover, individuals with high deliberative rule-breaking tendencies and low behavioural inhibition cultivate entrepreneurial self-efficacy as they deliberatively break the

rules when they are not afraid of losing or being wrong (Raeder et al., 2019). Such configuration–i.e., not worrying about making mistakes – is reinforced by learning that such an approach eventually leads to winning (Laureiro-Martínez et al., 2014; Laureiro-Martínez & Brusoni, 2018). For them, the negative feelings associated with the consequences of their actions are not as impactful. Thus, space is created enabling them to give more weight to other factors during decision-making, such as personal gain, even if obtaining a profit implies the breaking of rules (Barbosa et al., 2007; Morales & Pérez-Mármol, 2019). Individuals with such behavioural tendencies increase their entrepreneurial self-efficacy by persevering in entrepreneurial activities, as they are not afraid of a temporary set-back. In contrast, those with high behavioural inhibition and the tendency to deliberatively break rules worry about making mistakes, often impeding their self-efficacy. Such individuals often stop believing in themselves and frequently, they don't persevere with their activities.

According to the self-efficacy theory of motivation and social cognition, individuals in stressful situations sense biophysiological signals (e.g., an increase in heart and respiration rate, sudation, "butterflies" in the stomach) and the positive interpretation of these signals can enhance their self-efficacy for accomplishing specific tasks (Bandura et al., 1999; Drnovšek et al., 2010). For individuals to develop positive interpretations of the biophysiological responses in stressful situations (e.g., I am afraid of launching new products in the market but feeling nervous means that pitching this product could represent an increment of sales for the company), they need low behavioural inhibition and deliberative rule-breaking tendencies so that they can avoid being emotionally overwhelmed with signals that can prevent them from adopting other perspectives, such as positive interpretations (Braem et al., 2013; Karademas & Kalantzi-Azizi, 2004). In contrast, individuals with deliberative rule-breaking tendencies who have high behavioural inhibition might be so overwhelmed by proprioceptive

biophysiological signals in stressful situations that they don't generate positive interpretations, thus impeding an increase in their entrepreneurial self-efficacy.

In summary, individuals with high deliberative rule-breaking tendencies and low behavioural inhibition should have high entrepreneurial self-efficacy for the following three reasons: Firstly, low behavioural inhibition facilitates the causal learning between actions and successful outcomes. Secondly, low behavioural inhibition allows them to persevere because they hope their actions will not result in disastrous consequences. Thirdly, low behavioural inhibition facilitates positive interpretations of stressful situations. Thus, we propose the following hypothesis:

Hypothesis 1: *The positive relationship between deliberative rule-breaking and entrepreneurial self-efficacy is strengthened by low behavioural inhibition.*

We have described the reasons why entrepreneurial self-efficacy should be higher in individuals with deliberative rule-breaking tendencies and low behavioural inhibition. These reasons only apply, however, if individuals are equipped with and driven by the necessary neurocognitive machinery. In the next section, we outline the neurocognitive mechanisms underlying rule-breaking and inhibition and how they relate to the antecedents of entrepreneurial self-efficacy.

2.3 Cognitive-conflict-capacity, deliberative rule-breaking tendencies, behavioural inhibition and entrepreneurial self-efficacy

Cognitive-conflict-capacity is fundamental in decision-making, especially when reacting to rules (Cubillos-Pinilla & Emmerling, 2022; Pfister et al., 2016a; Pfister et al., 2016; Pfister et al., 2019; Wirth et al., 2018). Cognitive-conflict-capacity refers to the cognitive system's capacity to endure, react to and resolve ambiguous, stressful or unclear stimuli. Following

rules is default behaviour because it plays a crucial evolutionary role in building cultures and societies. It requires less effort to obey rules than it does to go against them (Foerster et al., 2013; Vlachos et al., 2013). Therefore, cognitive-conflict-capacity during rule-breaking is vital in order to cope with the conflict between what a rule demands versus doing the opposite of what that rule states. This capacity allows for the simultaneous suppression of the need to follow a rule alongside the cognitive hurdle needed to plan to break it (Botvinick et al., 2001; Pfister, 2013; Schröger et al., 2007). Cognitive-conflict-capacity is also vital to smoothly navigate the negative affect related to violating norms. Individuals with high cognitive-conflict-capacity tend to put more effort into withstanding the dissonance of following the rules versus breaking them so it is easier to break the rules deliberatively; they can easily endure the negative affect and are more cognitively flexible (Hsieh & Lin, 2019; Pfister, 2013; Vermeylen et al., 2020; Wirth et al., 2016). On the contrary, individuals with low cognitive-conflict-capacity tend to put less effort into decision-making, so they opt for less laborious behavioural options, such as constantly following rules regardless of the consequences; they have difficulty handling the negative affect as this emotion feels strange and unwelcome (Hsieh & Lin, 2019; Pfister, 2013; Vermeylen et al., 2020; Wirth et al., 2016).

To learn and select which actions lead to successful outcomes, individuals who tend to deliberatively violate norms and have low behavioural inhibition require high cognitive-conflict-capacity. Having cognitive-conflict-capacity means that individuals have the neurocognitive machinery to opt rationally for alternative actions rather than restrict themselves to following the rules in uncertain situations (Mushtaq et al., 2011; Pfister et al., 2019). This careful exploration couples specific actions with respective positive outcomes (Arend, 2016). They can decide if, in a particular situation, stressful problems can be circumvented by violating a norm (Pfister et al., 2019). Furthermore, individuals with high

cognitive-conflict-capacity can handle the negative affect resulting from mentally evaluating options not addressed by rules (Pfister, 2013; Pfister et al., 2016a; Wirth et al., 2016, 2018). As they grow used to negative sensations, they are less sensitive to punishment in situations with ambiguous cues and therefore, become more perseverant (Caprara et al., 2013; Krupić, 2017; Mosing et al., 2012). For them, the negative-related feelings associated with the consequences of their actions are not highly noticeable (Cubillos-Pinilla & Emmerling, 2022; Pfister et al., 2019; Pfister et al., 2016a; Wirth, Foerster, Herbort, et al., 2018). Thus, more weight can be given to other factors during decision-making, such as personal gain, even if rule-breaking is inherent in obtaining that profit (Barbosa et al., 2007; Morales & Pérez-Mármol, 2019). Likewise, these same individuals are characterised by their cognitive flexibility, which helps them to distance themselves from emotions that relate to the anticipation of a punishment in situations with ambiguous cues, allowing for positive interpretations of these situations (Braem et al., 2013; Karademas & Kalantzi-Azizi, 2004). Following this line of thought, cognitive-conflict-capacity allows individuals to break the rules deliberatively, which, when combined with a low behavioural inhibition personality type, should affect entrepreneurial self-efficacy.

As cognitive-conflict-capacity is a rather abstract construct, assessing it by means of a multi-source approach has proven fruitful. This construct is mirrored in various dimensions of information processing of stimuli including psychophysics (e.g., assessed via reaction times), visual processing (e.g., assessed via eye-tracking parameters) and neural processing (e.g., assessed via EEG parameters; Dalmaso et al., 2019; Dinh et al., 2022; Overbye et al., 2021; Waskom et al., 2019; Ye & Damian, 2022). To avoid unreliable results and publication-bias for the identification of biomarkers of mental capacities, we observed various parameters of several neurocognitive methodologies that reflected cognitive-conflict-capacity (Ader et al., 2021; Cardon et al., 2009; Ghods et al., 2021).

2.3.1 Psychophysics. Cognitive-conflict can be assessed by measuring the time individuals need to make a decision during a computerised task. Psychophysics has used reaction time parameters for decades in order to investigate cognitive abilities and the stages of the decision-making process (Semmelmann & Weigelt, 2017). Indeed, reaction time parameters have been proven to be a reliable measure of cognitive-conflict-capacity in different laboratory settings (Cubillos-Pinilla & Emmerling, 2022; Pfister et al., 2019; Wirth et al., 2018a). The slower the average reaction times in trials associated with situations with ambiguous cues (e.g., trials related to negative consequences, such as losing money when following a rule), the more the cognitive effort and the higher the cognitive-conflict-capacity (Cubillos-Pinilla & Emmerling, 2022; Pfister et al., 2019; Wirth, et al., 2018). In trials associated with situations with ambiguous cues, the total time and planning time spent in completing an action seems to be a better predictor of this capacity than the movement time spent on a trial's execution (Cubillos-Pinilla & Emmerling, 2022; Wirth et al., 2018). This is because the planning time of an action is less sensitive to increased frequency of rule-breaking manipulations (Wirth et al., 2018).

2.3.2 Mouse-tracking parameters. Besides reaction time parameters, cognitive-conflict occurring during computerised tasks can be measured and quantified by analysing parameters of mouse trajectories, such as Maximum Absolute Distance (MAD) and Area Under the Curve (AUC). When individuals complete a trial where they must choose between two distant options on a computer screen using a mouse and starting from a central point between these options, the cursor trajectory provides information about the cognitive-conflict of this choice (Wirth et al., 2018). High cognitive-conflict-capacity is reflected by, on average, longer and more complex mouse movements in trials associated with situations with ambiguous cues (e.g., trials related to negative consequences, such as losing money when following a rule; Cubillos-Pinilla & Emmerling, 2022). Such mouse trajectory parameters are

valuable because they (a) are sensitive to specific response options toward rules (Freeman & Ambady, 2009; McKinstry et al., 2008; Song & Nakayama, 2009), (b) provide information about temptations regarding behavioural alternatives whilst probing for self-control (Dignath et al., 2014) and (c) reflect internal representations such as anticipated consequences resulting from actions (Pfister et al., 2014; Pfister et al., 2016b; Wirth et al., 2015).

2.3.3 Eye-tracking parameters. Eye-tracking can measure cognitive-conflict-capacity; this technique enlightens cognitive capacities underpinning several human behaviours, for example, deliberative rule-breaking. Gathering the best possible sensory visual information is essential for overcoming mental conflict, especially when it comes to cognitive-conflict-capacity in demanding situations. When the visual system is employed in this context and attention is directed towards task-relevant information, eye tracking parameters, such as the number of fixations on a given area of interest and the velocity of saccadic eye movements, indicate cognitive-conflict-capacity (Brunyé & Gardony, 2017). A larger than average number of fixations indicates higher cognitive-conflict-capacity (Just & Carpenter, 1976; Keskin et al., 2020; Krajbich et al., 2012; Rosch & Vogel-Walcutt, 2012), meaning that individuals use their faculty to explore different actions and consequences in trials involving situations with ambiguous cues (e.g., trials related to negative consequences such as losing money when following a rule). Interestingly, the average decrease in the number of fixations when individuals display high-stress levels suggests that they do not have enough cognitive-conflict-capacity (Walter & Bex, 2021). As well as the greater number of fixations, an average of the slow saccades provides a precise report of mental effort and self-assurance in decisions, which, in turn, evidences higher cognitive-conflict-capacity (Stasi et al., 2010).

2.3.4 EEG Parameters. EEG measures electrical brain activity via electrodes placed on the scalp (Berger, 1929; Biasiucci et al., 2019). Cognitive-conflict-capacity can be

measured by registering the delta bandpower from frontocentral and parietal electrodes depleting EEG; this measure is a neural marker of cognitive capacities (Harmony, 2013; Jaiswal et al., 2019; Nácher et al., 2013; Pfister et al., 2016a). Average small values of the delta bandpower in trials associated with situations with ambiguous cues (e.g., trials related to negative consequences such as losing money when following a rule) indicate high cognitive-conflict-capacity. In previous literature, low delta bandpower has been associated with a lack of inhibition regarding personal interests, high levels of unconventional thinking and high cognitive flexibility, all of which should permit individuals to act against external constraints deliberatively (Jaiswal et al., 2019; Kaiser et al., 2019; Kamarajan et al., 2004; Moore & Malinowski, 2009; Sanders et al., 2008; Sieger et al., 2016). Harmony (2013) proposed that these inhibition-based oscillations (i.e., low delta bandpower) provide a prolonged periodic suppression of activity (e.g., following rules). In this form, these inhibitory oscillations may modulate the activity of those networks that should be inactive in order to accomplish the activity desired (e.g., to violate norms). Significantly, delta bandpower has also been associated with learning and evaluating the contingency between actions and consequences (Rong et al., 2022). Furthermore, Boot et al., (2017) experimentally demonstrated that an individual's divergent thinking is more associated with low delta bandpower than convergent thinking. Kaiser et al., (2019) also showed that low delta bandpower in frontocentral sites favours action activation rather than inhibition of motor actions. Interestingly, this low delta bandpower pattern has been found mainly in parietal and frontocentral sites and is salient for individuals with a low behavioural inhibition personality type or those less vulnerable to anxiety (Biehl et al., 2013; Harper et al., 2019; Jaiswal et al., 2019; Knyazev et al., 2009; Miskovic et al., 2010). Taken together, previous studies support the fact that the measure of delta bandpower on frontocentral and parietal sites should reflect cognitive-conflict-capacity.

Taking all the arguments above into consideration, we also put forward the following hypothesis regarding the downstream effects of cognitive-conflict-capacity on deliberative rule-breaking tendencies:

Hypothesis 2: *Cognitive-conflict-capacity assessed by a multi-source approach including psychophysics, mouse-tracking, eye-tracking and EEG predicts deliberative rule-breaking tendencies.*

2.4 The brain-mind model of entrepreneurial self-efficacy

To understand the intraindividual antecedents of entrepreneurial self-efficacy better (see *Figure 1*), we propose using a brain-mind model. Deliberative rule-breaking tendencies are relevant for the study of entrepreneurial self-efficacy because these tendencies promote proactivity, innovation, prioritisation of personal goals, an increased sense of control and risk tolerance. Yet these tendencies are more relevant for entrepreneurial self-efficacy in individuals with low behavioural inhibition, because, for these individuals, it is easier to learn the contingency between actions and successful outcomes, to not shy away from acting in anticipation of adverse outcomes, to cultivate perseverance and to realise positive interpretations of stressful situations (Braem et al., 2013; Karademas & Kalantzi-Azizi, 2004). The positive effect that deliberative rule-breaking tendencies have on entrepreneurial self-efficacy in individuals with low behavioural inhibition is driven by its underlying neurocognitive mechanism, i.e., cognitive-conflict-capacity. This capacity is reflected by parameters from several neurocognitive methods.

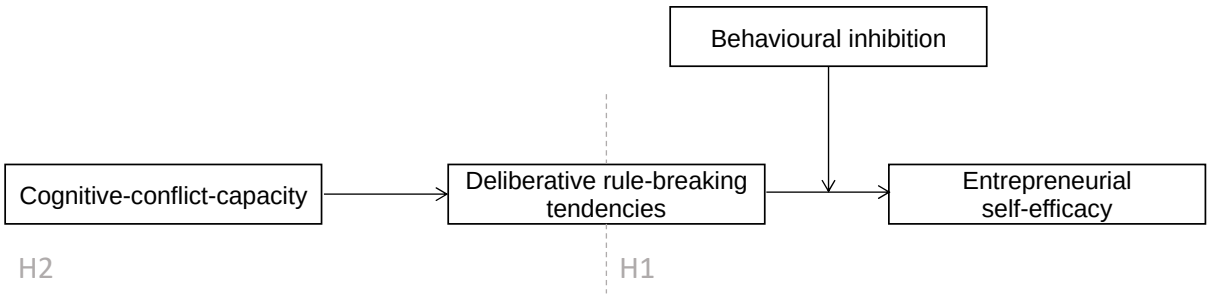


Figure 1. Brain-mind model of the intraindividual antecedents of entrepreneurial self-efficacy. H1 = Hypothesis 1, H2 = Hypothesis 2.

3. Method

3.1 Sample

50 participants (20 Females, Age_{Mean} = 26.8, Age_{SD} = 3.35, participants that were students = 74%) were included in our final sample. The study was conducted at the Neurophysiological Leadership Laboratory at the Technical University of Munich. This research adhered to the guidelines of and was approved by the Laboratory of Experimental Research in Economics and the Ethics Commission of the university (project number: 464/19s). All procedures were pre-registered (DOI: 10.17605/OSF.IO/EH97P).

3.2 Procedure

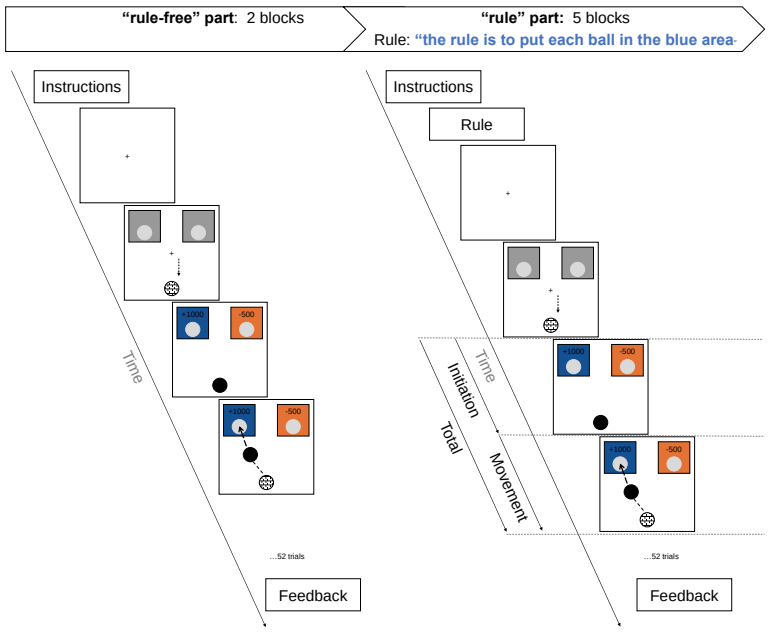
We opted for a multi-source approach in a laboratory setting. That is, we collected self-report data, as well as participants' actual behaviours, reaction times, mouse movements, eye movements and brain electrical activity during a computerised task. For each participant, the entire experiment lasted one and a half hours. Firstly, the participant signed the informed consent form and completed the questionnaires. Next, two professionals prepared the electrode cap on the participant's head. Afterwards, one of the professionals left the room, while the other communicated the computerised task's instructions to the participant in both a written and verbal manner. After the completion of the task, the professional debriefed and paid the participant based on task performance (14-20 Euros).

3.3 Behavioural assessment of rule-breaking tendencies

In the computerised task, participants were asked to allocate balls to either an orange or a blue box (see *Figure 2)*. In each trial, each coloured box displayed a certain number of stocks. When the participants allocated the ball to a certain box, the participant gained the number of stocks designated on the box selected. The decisions that the participants made throughout the task therefore had legitimate financial consequences, as the final sum of chosen stocks translated into monetary compensation. For further details regarding technical specificities, the specific splits of the number of stocks displayed on the coloured boxes and the trial structure, see the supplementary material, see section 1.

The computerised task consisted of two main sections: a 'rule-free' section and a 'rule' section (see *Figure 3*). The sections were preceded by five practice trials. The 'rule-free' part included two blocks in which participants were able to choose freely the box they preferred. The 'rule' part involved five blocks and introduced a simple colour-based rule that was displayed on the screen at the beginning of the block (e.g., "The rule is to put each ball into the blue area"). The colours "blue" and "orange" indicated by the rule were counterbalanced across participants and blocks. Rule-breaking did not have any additional consequences apart from receiving or losing the number of stocks associated with the chosen box. Each of the five blocks included 53 trials, amounting to 371 trials overall. When following the rule during the 'rule' blocks, 7 trials led to neutral (i.e., receiving the same number of stocks), 23 to positive (i.e., receiving the greatest number of stocks) and 23 to negative (i.e., receiving the lowest number of stocks) consequences. The trial sequence within each block was fully randomised. All further analyses focused on trials in which following the original rule was associated with negative consequences, because of the fact that individuals experienced cognitive-conflict in those trials.

A.



B.

Figure 2. A. Trial and block structure of the computerised task. In each trial, immediately after the fixation cross (500 - 700 ms), participants moved the mouse cursor to the brick-texture circle in the bottom-centre of the screen where the ball was. Once the back was picked up, the screen displayed the colour of the boxes and the stock values within each box. The time before the ball was moved outside from the brick-texture circle while the stock values were already displayed, was measured as the initiation time (action planning). Successively, the participants dragged the ball from the brick-texture circle towards either of the boxes and therewith earned or lost the number of stocks associated with the chosen box. This time was measured as the movement time (action execution). Regarding the block structure, the task included two "rule-free" and five "rule" blocks. After each block, participants received feedback on the total amount of stocks they accumulated during the whole task. In "rule-free" blocks, participants were instructed to freely choose the number of stocks they wanted to keep for themselves. In the "rule" blocks, participants read the simple rule at the beginning of the block. The "rule" blocks included trials associated to positive, neutral and negative consequences – if following the rule. These consequences were randomized. The analyses were focused on trials associated to negative consequences, as cognitive-conflict should be maximum in those trials. **B.** Setup of electroencephalogram, eye-tracking, and mouse-tracking during computerised task. (Further information see in supplementary material, section 1)

3.4 Measures

3.4.1 Entrepreneurial self-efficacy. To evaluate participants' entrepreneurial self-efficacy, as adapted by Liñán et al. (2011; Cronbach's alpha of .82, convergent validity of .47), we used six items from the entrepreneurial self-efficacy scale (De Noble et al., 1999; Liñán, 2008). Participants indicated their agreement to statements such as, "I can develop and maintain favourable relationships with potential investors" on a seven-point Likert scale (1 = strongly

disagree, 7 = strongly agree). Cronbach's alpha in the current study was .8. An additional factor analysis of all items constituted a unique component (for details see supplementary material, section 1.1.8).

3.4.2 Behavioural inhibition. To evaluate participants' behavioural inhibition, we administered seven items of the BIS/BAS scale (Cronbach's alpha of .74; Carver & White, 1994). Participants indicated their level of agreement to statements such as, "I have very few fears compared to my friends", on a four-point Likert scale (1 = very false for me, 4 = very true for me). Cronbach's alpha in the current study was .83. Additionally, a factor analysis of the seven items selected revealed a unique component (for further details see supplementary material, section 1.1.8).

3.4.3 Deliberative rule-breaking tendencies. Using the computerised task, we evaluated general deliberative rule-breaking tendencies by calculating participants' percentage of rule-breaking behaviour in trials in which this behaviour led to a gain (i.e., trials associated with negative consequences when following the original rule). The higher this value, the higher the individual's deliberative rule-breaking tendencies.

3.4.4 Cognitive-conflict-capacity. We computed an index to evaluate participants' cognitive-conflict-capacity using a multi-source approach. This approach included parameters extracted from psychophysics (i.e., reaction times), mouse-tracking (i.e., mouse movements), eye-tracking (i.e., eye movements) and neurophysiological (i.e., brain electrical activity) data sources. In particular, we focused on these parameters in trials where following the rule was associated with negative consequences. We generated an index that consisted of a compound score of the average of the following parameters after logarithmic transformation: total time, initiation time, maximum absolute distance and area under the curve of mouse trajectories, number of eye-fixations and velocity of saccades, delta

bandpower in frontocentral and parietal electrodes (see details outlined below). Note that our statistical results remain stable when performing our analyses based on the individual instead of the composite parameters (for details see supplementary material, section 2.3); we opted for a composite score to emphasise our multi-source approach, capturing the rather abstract concept of cognitive-conflict-capacity, not just from one but several distinct methods.

3.4.4.1 Psychophysics. *Figure 2* outlines the registration of three types of reaction times: a total reaction time consisting of the entire trial duration, an initiation time (i.e., the time in which individuals plan to either follow or break the rule) and a movement time (i.e., the time in which individuals perform movements to complete the action of following or breaking the rule). For the cognitive-conflict-capacity index, we selected total and initiation time (Cubillos-Pinilla & Emmerling, 2022; Dignath et al., 2013; Pfister et al., 2019).

3.4.4.2 Mouse-tracking parameters. Participants' mouse trajectories were mapped in MATLAB (MATLAB, 2019a, The MathWorks, Natick, 2019) in order to compute the maximum absolute distance and the area under the curve of these trajectories (see supplementary material for further technical details, section 1.1.5).

3.4.4.3 Eye-tracking. Binocular movements were recorded with a Tobii-Pro Spectrum eye-tracker (Desktop Mount model, video-based pupil- and corneal reflection eye tracking with dark and bright pupil illumination modes, resolution temporal and spatial = 600 Hz, 0.01° RMS, Tobii AB., Sweden). Our analyses focused on the number of eye-fixations and velocity of saccades restricted to the areas that included the coloured boxes for trials in which following the rule was associated with negative consequences. For further details, see supplementary material, section 1.1.6.

3.4.4.4 EEG. Brain electrical activity was recorded throughout the computerised task by means of a BrainVision LiveAmp amplifier with 32 active Ag/AgCl electrodes (actiCAP

snap; Brain Products, Germany) were put in place according to the extended 10-20 system. The data was referenced using an average (Kappenman & Luck, 2016; Keil et al., 2014; Land et al., 2019; Lopez-Calderon & Luck, 2014) and recorded at a sampling rate of 500Hz with low-pass filtered at 100Hz (low cut-off = DC). Impedances were below 10KW at the start of the experiment. Ocular movements were recorded with passive bipolar electrodes on the outer canthi of the right eye (VEOG). EEG data were preprocessed via EEGLAB (v2021.0, Delorme & Makeig, 2004) in custom-coded MATLAB software (MATLAB, 2019a, The MathWorks, Natick, USA). For further details on EEG data preprocessing, see the supplementary material, section 1.1.7. For analyses, we focused on trials in which rule following was associated with negative consequences. In each of these trials, Welch's power spectral density estimate (Stoica & Moses, 1997; Welch, 1967) was calculated in MATLAB in a window from the onset of the display of the number of stocks to the participants till the duration of the initiation time (i.e., during action planning). Evaluating delta bandpower in the respective time window ensured that we specifically evaluated cognitive-conflict-capacity. Then, we selected and averaged the delta bandpower associated with frequencies from .5 Hz to 4 Hz (Abhang et al., 2016; Attar, 2022; Thomas & Vinod, 2017) in the frontocentral (Fz, Cz, Fc1, Fc2) and parietal electrodes (Pz, P3, P4) per subject. Importantly, none of these electrodes were interpolated at any point in time.

3.5 Statistical analysis

Data was handled in R version v3.1.2. Statistical analysis was conducted in IBM SPSS Statistics (Version 27), using general linear models (2-tailed, sig. 0.05).

4. Results

4.1 Effects of deliberative rule-breaking and behavioural inhibition on entrepreneurial self-efficacy

Table 1 shows the descriptive statistics and bivariate correlations of the main variables. In order to investigate to what extent the relationship between deliberative rule-breaking and entrepreneurial self-efficacy is affected by behavioural inhibition (H1), we regressed entrepreneurial self-efficacy on rule-breaking tendencies and behavioural inhibition and as a second step, on their interaction additionally (see *Table 2*). After performing bootstrapping analyses using 5000 permutations, we found a significant interaction between rule-breaking tendencies and behavioural inhibition (b = .002, = 2.634, p = .01). Further analyses showed that entrepreneurial self-efficacy increases with rule-breaking tendencies only for individuals with high rule-breaking tendencies (b = .012, p = .021), not for individuals with low rule-breaking tendencies (b = -.007, p = .143; see *Figure 3*).

Thus, we find support for our hypothesis H1 predicting that deliberative rule-breaking tendencies show a positive effect on entrepreneurial self-efficacy specifically in individuals with high behavioural inhibition. Deliberative rule-breaking tendencies seem to be positively related to entrepreneurial self-efficacy, particularly when combined with behavioural inhibition. We ran several robustness checks for the analyses reported above by including control variables. We controlled for sex, age and behavioural activation systems (for results, see supplementary material, section 2.1).

Table 1. Bivariate correlations and descriptive statistics.

Variables in the survey	Mean (min/max)	SD	1	2	3	4	5	6	7	8	9	10
1. Age	25.4 (18/68)	7.61	-									
2. Sex [a]	NA	NA	-.018	-								
3. Rule-breaking tendencies[b]	NA	NA	-.042	-.083	-							
4. Openness	3.429 (1/5)	.790	-.001	-.055	-.068	-						
5. Conscientiousness	3.226 (1/5)	.807	.078	-.245*	.013	.03	-					
6. Extraversion	3.434 (1/5)	.946	-0.077	.043	-.071	.252*	.172	-				
7. Agreeableness	3.584 (1/5)	0.850	0.11	-.003	-.015	-.094	.287*	.047	-			
8. Neuroticism	2.885 (1/5)	0.933	-.031	-0.2*	.049	-.044	-.206*	-.385*	-.155	-		
9. Relativism	55.319 (23/90)	11.331	-.276*	-.007	.104	-.13	-.045	-.033	.071	.004	-	
10. Idealism	64.531 (28/89)	10.766	.149	-.28*	.035	-.132	.11	-.086	.115	.023	.115	-
11. Entrepreneurial intention	3.802 (1/7)	1.496	-.014	-.303	-.093	.132	.142*	.264	-.164*	-.346	-.104	-.073

* Correlation significant at the .05 level (2 – tailed).

[a] 1 = female, 2 = male

[b] 1 = low rule-breaking tendencies, 2 = high rule-breaking tendencies.

Table 2. Effects of rule-breaking tendencies on entrepreneurial self-efficacy moderated by rule-breaking tendencies.

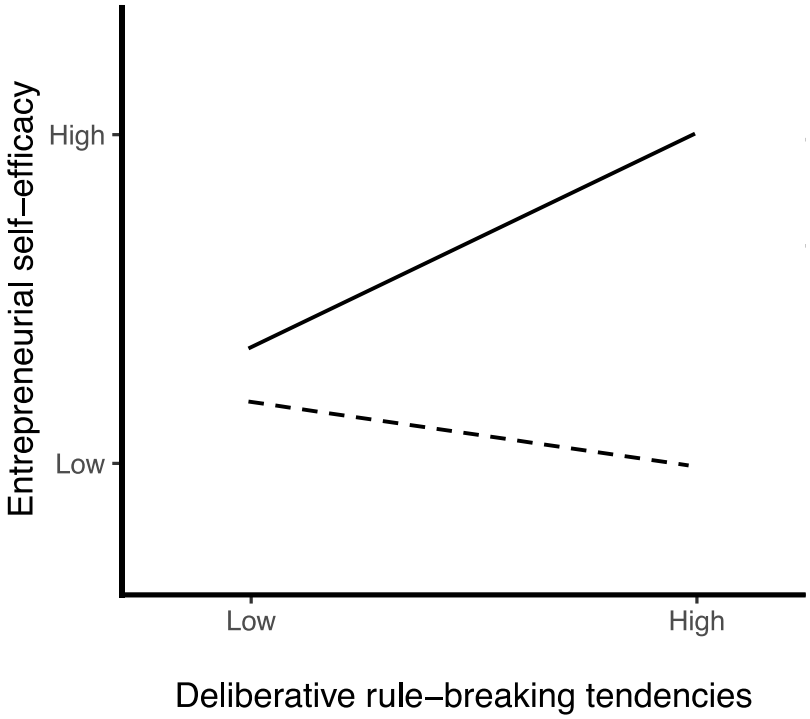
DV							
		Std. coeff.	*t*	*p*	*Std. coeff.*	*t*	*p*
IV	Deliberative rule-breaking tendencies	.068	.5	.620	.049	2.687	.01
	Behavioural inhibition	-.342	-2.498	.016	-.007	-.214	.831
Interaction	Deliberative rule-breaking tendencies X Behavioural inhibition				-.002	-2.634	.011
Adjusted R^2				.124			.238
Delta R^2							.114
(Sig.)				(.045)			(.005)

Note. Rule-breaking tendencies is defined by the percentage of frequency of deliberate rule-breaking
N = 50; for robustness checks analyses see supplementary material, section 2.4.

4.2 Effects of cognitive-conflict-capacity on deliberative rule-breaking tendencies

To investigate whether cognitive-conflict-capacity relates positively to deliberative rule-breaking tendencies (H2), we regressed the percentage of deliberative rule-breaking on the cognitive-conflict-capacity index on the percentage of the frequency of deliberative rule-breaking tendencies. The overall regression was statistically significant. It was found that cognitive-conflict-capacity positively predicts deliberative rule-breaking tendencies ($b = .635$, $p = .000$). Furthermore, as a robustness check, we regressed each of the parameters (i.e., total and initiation time, maximum absolute distance and area under the curve of mouse trajectories, number of eye-fixations and the velocity of saccades, delta bandpower in frontocentral and parietal electrodes) included in the composite score of cognitive-conflict-capacity on the percentage of the frequency of rule-breaking (see supplementary material, section 2.2). High cognitive-conflict-capacity -, shown by higher reaction times, larger and more complex mouse trajectories, a higher number of fixations and slow saccades and decreased delta bandpower - predicts deliberative rule-breaking tendencies (i.e., higher frequency of rule-breaking). All results showed a positive relationship between the single parameters and percentage of the frequency of rule-breaking. We executed several robustness-checks for all the analyses reported above by including sex and age as control variables (see supplementary material, section 2.4). Additionally, we found that the parameters that constitute cognitive-conflict-capacity correlate with each other (see supplementary material, section 2.3).

A.



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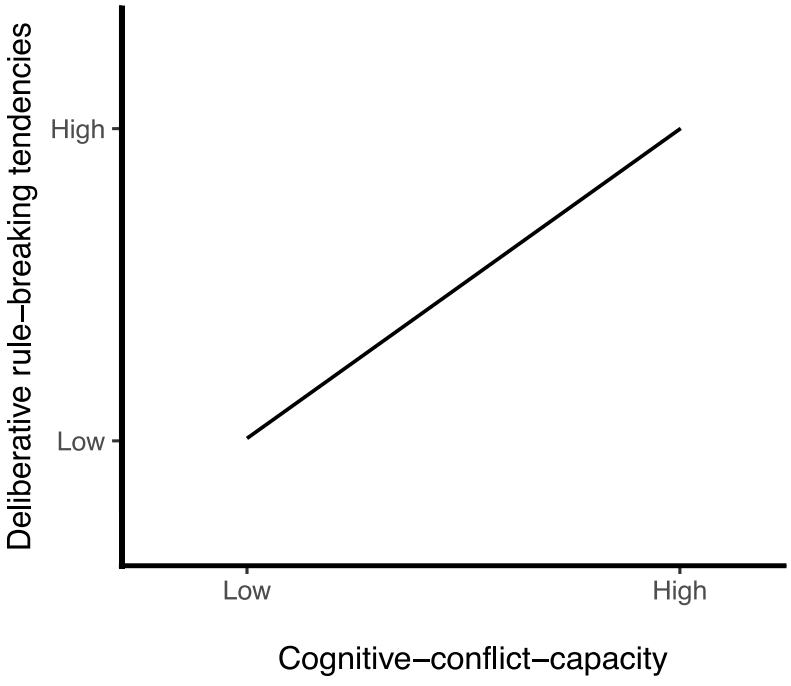

Figure 3. A. Interactive effects of deliberative rule-breaking tendencies and behavioural inhibition on entrepreneurial self-efficacy. Continuous line = high behavioural inhibition, pointed line = low behavioural inhibition. **B.** Cognitive-conflict-capacity positive effect on deliberative rule-breaking tendencies.

5. Discussion

The present study aims to develop and evaluate a brain-mind model of the intraindividual antecedents of entrepreneurial self-efficacy. For this purpose, our study implements a multi-source approach, including self-reports, concretely observed behaviour, psychophysics, mouse-tracking, eye-tracking and EEG. Using this array of methods, the current study evaluates the neurocognitive mechanisms and behavioural tendencies and personality type positively contributing to entrepreneurial self-efficacy. Our results support our hypotheses; the influence of deliberative rule-breaking tendencies on entrepreneurial self-efficacy is strengthened by low behavioural inhibition. Moreover, cognitive-conflict-capacity impacts the deliberative rule-breaking tendencies related to entrepreneurial self-efficacy in individuals with low behavioural inhibition. High cognitive-conflict-capacity, indicated by higher reaction times, larger and more complex mouse trajectories, a higher number of fixations and slow saccades and decreased delta bandpower, is associated with deliberative rule-breaking tendencies.

5.1 Contributions to theory and research

The current study provides an empirically tested brain-mind model of the intraindividual antecedents for the emergence of entrepreneurial self-efficacy. In addition to using methods entirely new to the field of entrepreneurship research, this study makes a threefold contribution. Firstly, this study establishes the notion that deliberative rule-breaking tendencies are a behavioural precursor of entrepreneurial self-efficacy and can be quantified by recording actual 'behaviour' in a computerised task. Typically, previous rule-breaking research has associated rule-breaking with negative connotations, such as antisocial behaviours and psychiatric diagnoses (Brezina & Topalli, 2012; Feldman et al., 2019). In this research, however, we show that a specific form of rule-breaking, i.e., deliberative rule-breaking, can be very beneficial for

individuals as it is a precursor of entrepreneurial self-efficacy. Likewise, in management literature, rule-breaking has been associated with positive connotations (Ferreira et al., 2017). Moderate rule-breaking has been related to entrepreneurship and prosocial rule-breaking has been considered a positive characteristic that enhances employees' job autonomy, prosocial co-workers' behaviour, creativity, quality customer service and relationship with leadership (Ferreira et al., 2017; Jong & Hartog, 2007; Zhang & Arvey, 2009). Perhaps, these tendencies encompass a broader category that includes moderate and prosocial rule-breaking and innovative behaviours in the workplace. For the first time, we have introduced spontaneous deliberative rule-breaking tendencies as an antecedent of entrepreneurial self-efficacy and we have evaluated real-time behaviour.

Secondly, while previous literature has associated rule-breaking and behavioural inhibition with entrepreneurship, this research has diverged. So far, the personality trait of behavioural inhibition has only been investigated in conjunction with actual behavioural tendencies relevant to the entrepreneurial self-efficacy construct (Farrukh et al., 2017; Gielnik et al., 2012; Jordaan, 2014; Newman et al., 2019; Schmutzler et al., 2018). According to the theory of agency and the social cognitive theory, self-efficacy beliefs evolve through learning experiences, i.e., behavioural tendencies (Gecas, 1989; Newman et al., 2019; Wilson et al., 2018). Yet behavioural tendencies are more likely to form such beliefs when individuals exhibit certain personality traits (Farrukh et al., 2017; Gielnik et al., 2012; Jordaan, 2014; Kamerdze et al., 2014; Schmutzler et al., 2018). Thus, the importance of conceptualising the integration and interaction of behavioural tendencies and personality on the prediction of self-efficacy has been depicted previously mainly in the fields of human health and well-being (Ajzen, 2005; Darvas et al., 2004). Herein, drawing on the theory of agency and social cognition, we bring this highly overarching and integrative model to entrepreneurship.

Thirdly and most especially relevant, the current study provides a neurocognitive foundation for encouraging deliberative rule-breaking tendencies and low behavioural inhibition personality type preceding entrepreneurial self-efficacy. Previous studies in entrepreneurship have struggled to find the biophysiological basis of behaviours and beliefs associated with entrepreneurship (Newman et al., 2019). We achieved a deeper understanding of decision-making processes in individuals that trust in their abilities to perform entrepreneurial activities, by identifying that cognitive-conflict-capacity is the required mental resource for these processes. This capacity broadly explains the variance of the behavioural tendencies associated with entrepreneurial self-efficacy. For the first time, a massive integrative approach of neurocognitive methods has served to explore the cognitive capacities underlying the entrepreneurial mindset.

5.2 Implications for practice

This research has practical implications for both recruiters and practitioners. Organisations require teams in which individuals have an entrepreneurial mindset in order to raise firm performance. Such a mindset is initiated through entrepreneurial self-efficacy (Günzel-Jensen et al., 2017; Jiatong et al., 2021; Mauer et al., 2017; McGrath & MacMillan, 2000; Miao, 2015). In organisations, individuals with an entrepreneurial mindset are mainly required to push creative ideas forward, persevere over the course of complex projects, act innovatively and add to venture growth are regards new business models or customers (Carvalho et al., 2020; Hughes et al., 2018; Javed et al., 2021; Ouakouak & Ouedraogo, 2017; Wu et al., 2008). Therefore, recruiters should understand the personal precedents of the entrepreneurial mindset in order to design professional profiles that suit these innovation-oriented positions (Javed et al., 2021; Kim et al., 2009; Morrison, 2006). For each specific role, recruiters could consider assessing–as a complementary measure to the organisation's requirements–cognitive-conflict-

capacity, rule-breaking tendencies and behavioural inhibition and they could include the resulting information in their decision-making processes. Finding good fits for enterprises could reduce the time and expense associated with personnel rotation (Alhamwan et al., 2015).

This research also helps practitioners to offer more specialised entrepreneurship training, training which is especially vital because of the increase in instability affecting most career paths (Newman et al., 2019). As much as the amount of research on entrepreneurship education has grown, many education programmes still lack personalisation, crucial for successful entrepreneurship training (Florin et al., 2007; von Graevenitz et al., 2010). Our findings can support the individualisation of training and, thereby, improve entrepreneurial education. For instance, as an exercise, practitioners could evaluate a course member's cognitive-conflict-capacity, deliberative rule-breaking tendencies and behavioural inhibition personality in order to predict their entrepreneurial self-efficacy. Upon completion of this exercise, participants could reflect on their profiles, cultivate self-enhancement and undergo behavioural training, which should then boost their confidence in their entrepreneurial endeavours (Kisubi & Korir, 2021). Moreover, practitioners can discuss the relevance of breaking the rules in order to foster entrepreneurial self-efficacy, particularly in individuals with low behavioural inhibition (Beck & Dozois, 2011; Berkman et al., 2009; Cate et al., 2016; Hester, 1995). Entrepreneurship training can take advantage by learning and assessing the antecedents described in this article to foster entrepreneurial self-efficacy throughout an individual's career as an opportunity for new venture creation (Mcgee et al., 2009), preserving and expanding enterprises (Shahab et al., 2019; Waldman et al., 2001) or building teams with followers and leaders that have entrepreneurial self-efficacy (Waldman et al., 2001).

Practitioners could also consider implementing neural interventions in their educational programmes. If we increasingly accumulate replicable evidence on the neurocognitive

mechanisms underlying an entrepreneurial mindset, this might eventually enable neurofeedback (Waldman & Balthazard, 2015). Our study might be a very early step in this process. Neurofeedback interventions, of course, should not stand alone but in conjunction with other techniques, such as behavioural training, self-reflection training and role-play. Combining training strategies, individuals can veridically and constructively be assisted with interpreting and developing their progress. For instance, practitioners could guide individuals on how to take advantage of their cognitive-conflict-capacity. Practitioners could advise individuals on how this capacity favours specific behavioural tendencies, i.e., deliberative rule-breaking, which, combined with low behavioural inhibition, impacts entrepreneurial self-efficacy. A challenge that should be addressed for the implementation of the computerised tasks that examine complex behavioural tendencies (e.g., rule-breaking) in neurofeedback is the lack of computers' capacity for (a) real-time high-quality artifact rejection processing (e.g., ICA label artifact rejection; Pernet et al., 2019) and (b) identification of non-binary stimuli.

Our work can benefit entrepreneurs and those in other fields because entrepreneurial thinking and behaviour are relevant for all current dynamic modern occupations. Recognising the antecedents of entrepreneurial self-efficacy described in our research can help individuals to proactively navigate economic, social and technological shifts in their positions. As the world changes rapidly, individuals must catch up with technological advancements and deal with socioeconomic crises and therewith, the antecedents of the entrepreneurial mindset gain meaning (Obschonka et al., 2013). For instance, the pandemic COVID-19 has had an enormous impact on the economy, including the disturbance of supply chains, temporary mass unemployment and increased inflation (Ozili & Arun, 2020). In particular, small and medium-sized enterprises are subject to great financial risk during such crises. While it is true that some entrepreneurs and employees in some countries have received immediate support from governmental institutions (Baker & Judge, 2020; Liu et al., 2020), they have also had to gain

confidence in their endeavours carrying out rapid changes to avoid bankruptcy (Bergenholtz et al., 2021; Zahurul et al., 2020). For instance, Bai et al., (2021) revealed that entrepreneurs and intrapreneurs of micro and small enterprises who have the confidence to be able to deal with challenges during entrepreneurial tasks have initiated digital transformations to become more efficient and reduce long-term costs (Bai et al., 2021; Belitski et al., 2022). These digital transformations include the use of new technologies for data-security, data-based management models in design, production, marketing, sales and communication (Almeida et al., 2020; Bai et al., 2021; Nachit & Belhcen, 2020). For instance, digital payments were implemented to avoid the agglomeration of individuals in queues and the manual exchange of cash, both things which could increase the risk of a COVID-19 infection (Bai et al., 2021). These transformations favour COVID-19 prevention regulations and have allowed location flexibility, shown to improve job satisfaction and productivity in enterprises (Tleuken et al., 2022). Furthermore, an entrepreneurial mindset has empowered intrapreneurs' and entrepreneurs' beliefs in their innovations to such an extent that they have modified previous technologies in order to produce fast antigen tests to detect COVID-19 infection (Makarona & Kavoura, 2021). Knowing the precedents of entrepreneurial self-efficacy, therefore, is important if we are to tackle the current reality (Hester, 1995).

5.3 Limitations

Even though this study provides important theoretical and practical implications, its limitations need to be discussed carefully. Firstly, a substantial part of our sample (three-quarters) were students. Although the students included did have work experience, results cannot be directly generalised to a population with extended work experience. Future studies need to address this concern by systematically comparing the extent of individuals' work experience (Henry, 2008). Our rationale for including university students and workers at the beginning of their careers

was the following: (a) this sample is characterised by the fact that the participants are facing career choices and might, therefore, be more prone to want to start gaining confidence in new endeavours; (b) rule-breaking in students and in individuals that are in the early years of career has been shown to relate to entrepreneurship in later life stages (Obschonka, 2016; Zhang & Arvey, 2009); (c) neurocognitive mechanisms, especially brain electrical activity measurements, are especially consistent and, thus, comparable within this age range (Li et al., 2022; Zoubi et al., 2018).

Secondly, this study has the limitation of a lack of power due to our sample size. Many studies using neurocognitive measures face this limitation because the preparation, acquisition and analysis of the respective type of data are extremely laborious and challenging (Button et al., 2013; see further details in supplementary material, section 1.1.7). Still, our sample exceeded the ones used in studies that have involved the study of behavioural tendencies and neurocognitive methods (Armitage et al., 2001; Bresnahan & Barry, 2002; Button et al., 2013; Dodwell et al., 2019; Fink et al., 2009; Kaiser & Schütz-Bosbach, 2018; Katmah et al., 2021; Kirov et al., 2009; Konicar et al., 2021; Pfister et al., 2016a). Furthermore, due to the lack of power in our study, we provide statistical support for two model-parts, instead of an overall model. We attribute these results to the diverse modalities of the data handled in the study and the different sources from where it came. While some variables were measured with introspective methods, others were examined with behavioural and neurocognitive methods. This diversity of data sources can lead to a mismatch of the type of noise induced in data (Baranowski, 2013; Bell et al., 2018; Hassani & Karami, 2015). Due to shared variance in noise, finding a correlation within modalities rather than between modalities is more likely (Hedge et al., 2018). That is, the relationships between constructs measured with questionnaires are more likely to be significant than the relationship between constructs measured with different methods (Hedge et al., 2018). If our sample were more extensive, the signal-to-noise

ratio would be higher which would allow for significant results when testing the overall model (Button et al., 2013). Further research should include the intraindividual antecedents of entrepreneurial self-efficacy evaluated in this study for our findings to be replicated and to perform later metanalyses that enhance its validity, adding evidence to the established brain-mind model and greater generalisability of results.

Thirdly, in our task, we are unable to control the frequency with which individuals break rules. This is intrinsic to the evaluation of deliberative rule-breaking because participants are not ordered to break or follow rules. In this sense, some participants break the rules repeatedly, while others rarely violate them. Other studies instruct participants to commit rule-breaking and, thereby, trigger this behaviour a delimited number of times while recording neurocognitive measurements (Pfister et al., 2016a). However, in this study, we were interested in individuals' naturalistic behavioural tendencies, tendencies that are much less artificial and much more ecologically valid (Cubillos-Pinilla & Emmerling, 2022). We were interested in the specific form of deliberative rule-breaking related to entrepreneurship, which includes those tendencies expressed spontaneously and not prompted by external constraints (Arend, 2016).

Fourthly, many psychological constructs such as behavioural inhibition, personality and entrepreneurial self-efficacy are variables that fluctuate (Caporuscio, 2021; McAdams, 2010; Pollack et al., 2019), which emphasises the importance of the test-retest reliability of questionnaires that evaluate these variables, even in a cross-sectional study (Polit, 2014). Therefore, we asked participants to fill out follow up questionnaires three months later. Unfortunately, our response rate did not exceed 40% and therefore, we could not include the follow-up data in our analysis (Kennedy, 2022). Future studies should replicate our findings and add test-retest reliability of the standardised questionnaires we employed. In our study, for

the selection of the questionnaires employed, we observed that previous studies had already reported satisfactory test-retest reliability (Behavioural inhibition personality = .67-.74, Entrepreneurial self-efficacy = .77; Agokei, 2013; Leone et al., 2001; Muris et al., 2005).

Fifthly, in this study we did evaluate the individuals' entrepreneurial self-efficacy and not actual entrepreneurial behaviour or performance. Although entrepreneurial self-efficacy is an established and stable antecedent of entrepreneurial behaviour and performance (Shaheen & AL-Haddad, 2018), it is a precedent and therefore might be considered a proxy of those constructs. The pioneering and relatively effortful experimental setup at hand did not allow to real-life entrepreneurs to be tested as a first step. We are, however, aware of the relevance in considering on-going entrepreneurship in future studies which evaluate the proposed brain-mind model. For instance, it would be very appealing to study the association between cognitive-conflict-capacity and entrepreneurial behaviour and performance of actual (successful) entrepreneurs and individuals within entrepreneurial teams in companies.

5.4 Conclusion

Our study provides novel insights into intraindividual antecedents of entrepreneurial self-efficacy by proposing a brain-mind model that uses a multi-source methodological approach. We demonstrate that an individual's cognitive-conflict-capacity is essential for deliberative rule-breaking tendencies, which, when combined with a low behavioural inhibition personality, precedes entrepreneurial self-efficacy. Amongst entrepreneurship research, the current research is pioneering in its use of multiple neurocognitive techniques and contributes to a deeper understanding of the antecedents for entrepreneurship at the individual level.

Chapter 6: General conclusions

Summary of findings

Deliberative rule-breaking tendencies are associated with the enhancement of the entrepreneurial mindset. This is especially true when these tendencies are combined with other personal characteristics. In this work, I explored the intraindividual antecedents of the entrepreneurial mindset by focusing on entrepreneurial intention and self-efficacy.

In chapter 1, I investigated the individual default tendencies towards norms. I designed, standardised and validated a rule-breaking task sensitive to distinguishing between deliberative rule-breakers and rule-followers. Rule-breakers are characterised because they deliberatively violated norms; they exclusively broke rules when these actions would lead to higher payoffs. Compared to rule-followers, rule-breakers obtained higher earnings and exhibited higher cognitive conflict during the computerised task (i.e., slower responses, longer and complex mouse trajectories). Rule-breakers also exhibited higher cognitive conflict when the consequences of following the rules were negative than they did when they were either neutral or positive. In the trials associated with negative consequences (i.e., following the rules leads to limited rewards or losses), rule-breakers experienced more cognitive conflict when they broke the rules compared to when they followed them. Notably, cognitive conflict during action planning of rule-breaking behaviour was more pronounced than during action execution. In the "rule" part and in trials associated with negative consequences, the cognitive conflict experienced during action planning by rule-breakers was enhanced by early, repetitive and frequent rule-breaking. However, this effect disappeared when analyses were focused on trials in which rule-breakers violated rules. Deliberative rule-breaking tendencies were related to low behavioural inhibition, grandiose narcissism, extraversion, sensation seeking, sensation seeking, risk propensity and goal-oriented motivation.

This study indicated that

(a) the computerised task stands as a standardised and valid procedure to evaluate deliberative rule-breaking tendencies and can, therefore, be applied in the management and entrepreneurship research fields,

(b) the trials of interest of this computerised task to evaluate cognitive-conflict are the ones associated to negative consequences, since individuals experience the most cognitive conflict during them,

(c) the time spend for planning an action in the trials associated to a negative consequence is the best indicator of cognitive conflict and

(d) deliberative rule-breaking tendencies can be related to other personal characteristics (e.g., low behavioural inhibition, grandiose narcissism, extraversion, opportunity recognition, sensation seeking, risk propensity and goal-oriented motivation).

In Chapter 2, I aimed to investigate the role of rule-breaking tendencies in the relationships of personality and morality with entrepreneurial intention and tested these relationships based on a multi-source approach. This approach included the use of questionnaires and a computerised task. I found that while openness and idealism did not have a direct effect on entrepreneurial intentions, openness was positively related to it and idealism was negatively related in individuals with high rule-breaking tendencies alone. This study empirically underlined the importance and relevance of including deliberative rule-breaking tendencies (measured via actual behaviour observation) as an antecedent of the entrepreneurial mindset and adds the interplay of intraindividual antecedents of entrepreneurial intention.

In Chapter 3, I aimed to develop and evaluate a brain-mind model of the intraindividual antecedents of entrepreneurial self-efficacy. For this purpose, the study implemented a multi-source approach including self-reports, a computerised task, psychophysics, mouse-tracking, eye-tracking and EEG. The results showed that cognitive-conflict-capacity impacts the deliberative rule-breaking tendencies related to entrepreneurial self-efficacy in individuals with low behavioural inhibition. High cognitive-conflict-capacity, reflected by higher reaction times, larger and more complex mouse trajectories, higher number of fixations and slow velocity of saccades and decreased delta bandpower in parietal and frontcentral sites, was associated with deliberative rule-breaking tendencies. This study added new insights into intraindividual antecedents of entrepreneurial self-efficacy by proposing a brain-mind model that uses a multi-source methodological approach. This research pioneers the use of multiple neurocognitive techniques in the investigation of the individual antecedents of entrepreneurship.

Theoretical contributions and implications

With respect to single studies, I have elaborated on specific implications in Chapters three to five. Here, I want to highlight the more general contributions of my dissertation.

Firstly, I provide cognitive science and management research communities with a standardised novel methodology with which to evaluate deliberative rule-breaking tendencies, cognitive conflict and cognitive-conflict-capacity (Cubillos-Pinilla & Emmerling, 2022). This task is sensitive enough to evaluate (a) interindividual differences of deliberative rule-breaking (i.e., distinguish rule-followers from rule-breakers) and (b) the extent to which a person commits deliberative rule-breaking (i.e., frequency of rule-breaking behaviour). The task I developed is also sensitive enough to evaluate cognitive conflict and cognitive-conflict-capacity in several conditions, such as (a) type of consequences if following the rule (e.g., positive, negative or

neutral consequences), (b) committing rule-breaking behaviour or rule-following behaviour and (c) presence versus absence of rules. Therefore, this computerised task allows for the possibility of a huge range of research questions for future studies in the management and entrepreneurship community.

This computerised task can be administered to individuals in combination with questionnaires. Such a multi-source approach adds new methodological perspectives. I not only use introspective measurements, which are traditionally used in entrepreneurship research, but also measure concrete behaviour during said computerised task (Alvesson & Sandberg, 2013; Brice & Spencer, 2007; Donaldson & Grant-Vallone, 2002; Rutter, S. M., Maughan, B., Pickles, A., Simonoff, 1998; Schyns & Schilling, 2013; Vigil-Colet et al., 2012). I hope that my approach inspires those involved in entrepreneurship research to implement more multi-source designs that contribute to the theoretical integration of blurry constructs and make the jump from "what people say they do" to "what people do". Both my implementation and validation of a computerised task provide novel insights into rule-breaking tendencies and their relationship to entrepreneurial mindset beyond those able to be predicted by traditional management models.

Secondly, I introduce deliberative rule-breaking tendencies as a behavioural precursor of entrepreneurial mindset and these can be quantified by recording actual 'behaviour' in a computerised task. Previous rule-breaking research has typically associated rule-breaking with negative connotations, such as antisocial behaviours and psychiatric diagnoses (Brezina & Topalli, 2012; Feldman et al., 2019). In this research, however, I show that a specific form of rule-breaking, i.e., deliberative rule-breaking, can be very beneficial for individuals as it is a precursor of the entrepreneurial mindset. Likewise, in management literature, rule-breaking has been associated with positive connotations (Ferreira et al., 2017). Moderate rule-breaking

has been related to being an entrepreneur versus a corporate manager and, prosocial rule-breaking has been considered a positive characteristic that enhances employees' job autonomy, prosocial co-workers' behaviour, creativity, quality customer service and relationships with leaders (Ferreira et al., 2017; Jong & Hartog, 2007). Deliberative rule-breaking tendencies is an umbrella concept that underlines the individual's inclination to choose whether to break a rule in an ambiguous situation according to the consequences and personal interests. It could perhaps be that these tendencies should comprise a broader category that is made up of moderate and prosocial rule-breaking behaviours at the workplace. Following this line of thought, investigating deliberative rule-breaking and its underlying cognitive mechanism is important for incentivising positive outcomes.

Thirdly and especially relevant, the dissertation presented provides a neurocognitive foundation for the antecedents of entrepreneurial mindset, most especially that of entrepreneurial self-efficacy. Previous studies in entrepreneurship have struggled to find the biophysiological basis of behaviours and beliefs associated with entrepreneurship (Newman et al., 2019). I opted for a brain-mind model, so I was able to measure mental constructs that needed to be accessed with neurocognitive methods and their impact on the behaviours and the type of personality associated with the entrepreneurial mindset. As a result of this approach, I achieved a deeper understanding of decision-making processes in individuals that are attracted to entrepreneurship by identifying the required mental resource for the decision-making processes that favour entrepreneurial self-efficacy. I showed that cognitive-conflict-capacity is the mental resource that precedes the deliberative rule-breaking tendencies associated with entrepreneurial self-efficacy in individuals with low behavioural inhibition. Indeed, I have shed light on the fact that this capacity broadly explains the variance of the behavioural tendencies associated with entrepreneurial self-efficacy. For the first time, an integrative approach of neurocognitive methods serves to explore the cognitive capacities underlying the

entrepreneurial mindset. Previous literature shows that the combination of multiple neurocognitive methods increments the reliability and decrements the publication-biased of biomarkers that reflect mental capacities (Ader et al., 2021; Cardon et al., 2009). For instance, I not only used isolated neural measurements (e.g., electroencephalogram), but I also combined them with other neurocognitive methods (e.g., psychophysics, mouse-tracking, eye-tracking) in order to mirror cognitive-conflict-capacity.

Neuroscience has been gaining importance because it has been used as a tool to evaluate and improve individual skills that researchers consider necessary in professional management roles (Boyatzis, 2011; Boyatzis et al., 2012; Cooper, 2000; Goleman & Boyatzis, 2008). Since there is an increased number of publications of organisational neuroscience (Balthazard et al., 2012; Boyatzis et al., 2014; Butler & Senior, 2007) and the probability stands of using novel technologies into managerial settings, the concerns of those calling for morals and ethics in this context are also growing (Cropanzano & Becker, 2013; Laureiro-Martínez et al., 2015; Lindebaum, 2013). For this reason, I would like to take a closer look at the ethical implications of my dissertation. First, the danger of given the impression of having a "neurological defect" even though they are–from a biological perspective–healthy (Lindebaum, 2013). As my dissertation has focused on predicting the entrepreneurial mindset, which is a positive characteristic, delivering individuals with information that means not to have the antecedents of this mindset can represent a psychological hazard. Second, the danger of using it as a deterministic factor for recruiting processes.

Therefore, it is important to develop protocols the correct use of these techniques in the industry. These protocols should that assure that individuals understand that (a) neuroscience data has its limitations, (b) neuroscience is a tool that provides extra information, (c) self-improvement is possible and is more complex than training your brain

waves, you need to train different aspects of your brain, (d) privacy regulations (e) authority, (f) the extent of application of findings regarding brain measurements (Farah, 2005; Lindebaum, 2013). Many neuroscientific organisations look to improve people's lives in schools, hospitals, research labs, etc. if there is the possibility to enhance leadership and entrepreneurship mindset quality with neuroscience without risking person's integrity, this will have a great positive impact in our society because the provided services will improve in quality (Cropanzano & Becker, 2013).

Practical contributions and implications

My research has practical implications for recruiters, practitioners, entrepreneurs and individuals involved in modern occupations. My findings on the intraindividual antecedents of entrepreneurial mindset are beneficial to recruiters because they improve hiring strategies. Organisations require teams in which individuals have the mindset of raising firm performance (Günzel-Jensen et al., 2017; Jiatong et al., 2021; Mauer et al., 2017; McGrath & MacMillan, 2000; Miao, 2015). In organisations, individuals with an entrepreneurial mindset are mainly required to push creative ideas forward, persevere through projects are complex, act innovatively and add to venture growth of new business models or customers (Carvalho et al., 2020; Hughes et al., 2018; Javed et al., 2021; Ouakouak & Ouedraogo, 2017; Wu et al., 2008). Therefore, recruiters should understand the personal precedents of this mindset in order to design professional profiles that suit these innovation-oriented positions (Javed et al., 2021; Kim et al., 2009; Morrison, 2006). Depending on the aptitude set needed, they could consider measuring personality, morality, deliberative rule-breaking tendencies, cognitive-conflict-capacity and include the resulting information into their decision-making processes. Finding a good fit for enterprises could reduce the time and expense associated with personnel rotation (Alhamwan et al., 2015).

Additionally, this research helps practitioners to recognise personal characteristics and incorporate individualised support in the design of entrepreneurship training throughout an individual's career or for whole teams within an enterprise (Fayolle and Gailly, 2015; Ndofirepi, 2020). Training in entrepreneurial thinking and behaviour is vital nowadays because of the increase in instability that affects most career paths. Entrepreneurial mindset is relevant for new venture creation (Mcgee et al., 2009), preserving and expanding enterprises (Shahab et al., 2019; Waldman et al., 2001) and building teams with followers and leaders that are innovative (Arend, 2016; Waldman et al., 2001). Research on entrepreneurship education shows that the education programmes often lack individualisation, which is crucial for entrepreneurship training (Florin et al., 2007; von Graevenitz et al., 2010). This is because not all individuals react equally to the same teaching strategies, plus the trajectories of how individuals develop the entrepreneurial mindset are very diverse (Florin et al., 2007; von Graevenitz et al., 2010). My findings are able to support individualisation of training and, thereby, improve entrepreneurial education. For instance, practitioners could–as an exercise–evaluate a course member's cognitive-conflict-capacity, deliberative rule-breaking tendencies, personality and morality to predict their entrepreneurial mindset. Once the exercise was completed, participants could reflect on their profiles, cultivate self-enhancement and undergo behavioural training, which should then boost their confidence in performing entrepreneurial endeavours (Kisubi & Korir, 2021). Moreover, practitioners can discuss the relevance of breaking the rules for fostering entrepreneurial mindset, particularly in individuals who exhibit certain personal characteristics such as low behavioural inhibition, low idealism and high openness (Beck & Dozois, 2011; Berkman et al., 2009; Cate et al., 2016; Hester, 1995).

Practitioners can also consider implementing neural interventions in their educational programmes. If the research community increasingly accumulates replicable evidence on the

neurocognitive mechanisms underlying an entrepreneurial mindset, this might eventually enable neurofeedback (Waldman & Balthazard, 2015). This dissertation can be a very early step towards achieving this. Neurofeedback interventions, of course, should not stand alone but in companionship with other techniques such as behavioural training, self-reflection training and role-playing. Combining training strategies, individuals can veridically and constructively be assisted with interpreting and developing their progress. For instance, practitioners could guide individuals on how they can take advantage of their cognitive-conflict-capacity. Practitioners can advise individuals that this capacity favours specific behavioural tendencies, i.e., deliberative rule-breaking, which, combined with low behavioural inhibition, impacts entrepreneurial self-efficacy. Another challenge that should be addressed when considering the implementation of the use of computerised tasks that examine complex behavioural tendencies (e.g., rule-breaking) in neurofeedback is the lack of computers' capacity for (a) real-time high-quality artifact rejection processing (e.g., ICA label artifact rejection; Pernet et al., 2019) and (b) identification of non-binary stimuli.

My work can benefit entrepreneurs and others because entrepreneurial thinking and behaviour are relevant for current dynamic modern occupations. Recognising the antecedents of entrepreneurial mindset described in my research can help individuals to proactively navigate economic, social and technological shifts in their positions. For instance, the pandemic COVID-19 has had an enormous impact on the economy disturbance of supply chains, temporary mass unemployment and increased inflation (Ozili & Arun, 2020). In particular, small and medium-sized enterprises face great financial risk during such crises. While it is true that in some countries, some entrepreneurs and employees have received immediate support from governmental institutions (Baker & Judge, 2020; Liu et al., 2020), they have also had to gain confidence in their own endeavours to carry out rapid changes and avoid bankruptcy (Bergenholtz et al., 2021; Zahurul et al., 2020). For instance, Bai and colleagues (2021)

revealed that entrepreneurs and intrapreneurs of micro and small enterprises that have had the confidence to be able to deal with challenges during entrepreneurial tasks have been able to start digital transformations. This entrepreneurial mindset has helped them to become more efficient and has reduced costs in the long-term (Bai et al., 2021; Belitski et al., 2022).

Digital transformations include the use of new technologies for data-security, data-based management models in design, production, marketing, sales and communication (Almeida et al., 2020; Bai et al., 2021; Nachit & Belhcen, 2020). A clear example is how they inserted digital payments in order to avoid the agglomeration of individuals in queues and the manual exchange of cash, both of which could increase the risk of COVID-19 infection (Bai et al., 2021). In addition, digital transformations have favoured COVID-19 prevention regulations and have allowed individuals to have location flexibility, shown to improve job satisfaction and productivity in enterprises (Tleuken et al., 2022). Furthermore, an entrepreneurial mindset empowers intrapreneurs and entrepreneurs to believe in their innovative capacity to modify previous technologies in order to combat contemporary challenges such as the design and production of fast antigen tests detecting COVID-19 infection (Makarona & Kavoura, 2021). It could be said that the entrepreneurs and intrapreneurs of these businesses will exhibit high cognitive-conflict-capacity which has permitted them to have deliberative rule-breaking tendencies resulting in being able to increase their entrepreneurial mindset in individuals with certain personalities (Hester, 1995).

Another example of the impact that my research could have on entrepreneurs and others is the following: In the 1970s, Katharine Graham, the owner of the Washington Post newspaper, faced a financial crisis that almost caused the newspaper's bankruptcy. The financial decay started because she hired a young editor and together they decided to publish

confidential information about the Johnson administration[7]. They violated rules, they went against politicians and the conservative board of the enterprise. However, Katharine Graham hired a young finance advisor; together they decided to buy-back the stocks on the public market. Their financial strategy was very innovative because no one was doing it at the time and nowadays, it serves as an example of financial arrangements (Davis, 2017; Graham, 2015; Mitchell & Dharmawan, 2007). In the aftermath, the Washington Post not only earned several prizes as a result of its publications, but it also recovered and exceeded previous financial performance. Katharine Graham and her employees most probably had the necessary cognitive-conflict-capacity associated with the behavioural tendencies and the type of personality that is relevant to be able to cultivate entrepreneurial mindset and thus combat economic crises.

Neuroscience has been gaining importance because it has been used as a tool to evaluate and improve individual skills that researchers consider necessary in professional management roles (Boyatzis, 2011; Boyatzis & Soler, 2012; Goleman & Boyatzis, 2008). Since there is an increased number of publications of organisational neuroscience (Balthazard et al., 2012; Boyatzis et al., 2014; Butler & Senior, 2007) and the probability stands of using novel technologies into managerial settings, the concerns of those calling for morals and ethics in this context are also growing (Cropanzano & Becker, 2013; Laureiro-Martínez et al., 2015;

[7] Katharine Graham and the young editor (Ben Bagdikian) together decided to publish confidential information about the United States' political and military involvement in Vietnam from 1945 to 1967 in the so-called Pentagon Papers. The article reported the systematic lying of the Johnson Administration to the public and Congress. At that moment, the publication of these papers was a breaking point for the company. Powerful politicians were against the enterprise and the traditional board of the company (plenty of conservative men) who had wanted to hide the reports in the first place went on strike, used sexist insults against Kathrine for being a woman and burned facilities. The company received hostile attacks from an investor who was aggressively buying up the shares of the company and habitual major investors started to sell their stakes as they lost hope in the company (Davis, 2017; Graham, 2015).

Lindebaum, 2013). For this reason, I would like to take a closer look at the *ethical implications* of my dissertation. First, the danger of given the impression of having a "neurological defect" even though they are–from a biological perspective–healthy (Lindebaum, 2013). As my dissertation has focused on predicting the entrepreneurial mindset, which is a positive characteristic, delivering individuals with information that means not to have the antecedents of this mindset can represent a psychological hazard. Second, the danger of using it as a deterministic factor for recruiting processes.

Therefore, it is important to develop protocols the correct use of these techniques in the industry. These protocols should that assure that individuals understand that (a) neuroscience data has its limitations, (b) neuroscience is a tool that provides extra information, (c) self-improvement is possible and is more complex than training your brain waves, you need to train different aspects of your brain, (d) privacy regulations (e) authority, (f) the extent of application of findings regarding brain measurements (Farah, 2005; Lindebaum, 2013). Many neuroscientific organisations look to improve people's lives in schools, hospitals, research labs, etc. if there is the possibility to enhance leadership and entrepreneurship mindset quality with neuroscience without risking person's integrity, this will have a great positive impact in our society because the provided services will improve in quality (Cropanzano & Becker, 2013).

Future research venues

In the chapter three to five, I have described in detail the limitations and future venues of my dissertation. To be concise, I will list here the aspects that should be involve in the future research. Future studies should

(a) systematically analyse to which individuals' work experience influence the models tested in this dissertation (Henry, 2008);

(b) replicate our findings and perform later metanalyses that enhance the power of the sample size, adding evidence to the established models and greater generalisability of results (García-Jurado et al., 2021; Paolini & McIntyre, 2019);

(c) examine the reaction towards norms, as well as the relationship between personality and morality to entrepreneurship in different industries, countries and cultures (Sommer et al., 2000; Forsyth et al., 2008);

(d) add test-retest reliability of the standardised questionnaires I employed, due to the possible fluctuation of personal characteristics (Polit, 2014);

(e) explore whether the influence of personality, morality and rule-breaking tendencies in entrepreneurial intention differ when working in teams where individuals' tendencies combine or socialisation processes could exacerbate certain qualities (Cai et al., 2019; Gundry et al., 2016; Hughes et al., 2018; Klotz et al., 2014; Park et al., 2013);

(f) study the intraindividual antecedents of entrepreneurial behaviour and performance of actual (successful) entrepreneurs and individuals within entrepreneurial teams in companies;

(g) address intraindividual differences of rule-breaking in relation to rule type (e.g., simple versus complex rules; explicit versus implicit rules; social versus non-social rules);

(h) evaluate spontaneous deliberative rule-breaking with paradigms optimized for the observation of the effect of frequency and recency on cognitive conflict. Future studies might increase the number of blocks in the "rule" part or increase the number of chances per block in which breaking the rule leads to gain (Pfister et al., 2019; Prével et al., 2021; Vandierendonck et al., 2012; Wirth et al., 2018).

Conclusion and take-home message

Cognitive-conflict-capacity allows individuals' to participate in deliberative rule-breaking tendencies which, when in interplay with certain personality and morality characteristics, precedes the formation of an entrepreneurial mindset. A multi-source and neurocognitive approach adds insights into the understanding of the intraindividual antecedents of entrepreneurship at the individual level.

Now is the time for you to be a deliberative rule-breaker!

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Chapter 1

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Chapter 5

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Chapter 6

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Supplementary material

Declaration/Erklärung

Ich versichere hiermit, dass ich die von mir eingereichte Abschlussarbeit selbstständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt habe.

20.10.2022

Ort, Datum, Unterschrift

Supplementary Material

The GIF of the computerised task of this dissertation can be found in this link: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0274837#sec036

Chapter 1

Table of content:

Methods

Exclusion Data

Because our study involved different types of responses (e.g., opt for the highest number of stocks during the rule-free part. commit rule-following. commit rule-breaking) within one *rule-breaking task* it was hard to exclude trials by reaction times. Moreover. we are profoundly interested in all of these kinds of responses. Therefore. we opted by limiting the reaction times from 250ms to 5000ms to avoid confounding the data by lack of attention towards the task.

Next, we performed outlier analyses of the reaction times only on the "rule" part of the task because our control analyses revealed that participants in general took more time in the "rule-free" part than in the "rule" part. Because the "rule-free" occurs earlier, the overall slower times clearly exhibited a learning process. Furthermore. the main analyses of this study focused in the "rule" part of the task. As our design includes a between subject factor (rule-followers vs. rule-breakers).
* We are open to share data and scripts with reviewers and readers.

List of combinations of Stock used per subject in each of the block.

Trial Number	Blue Box	Orange Box
1	-5000	0
2	-3000	-1000
3	-3000	-500
4	-3000	500
5	-3000	0
6	-1000	-3000
7	-500	-3000
8	-1000	-1000
9	-1000	-500
10	-1000	500
11	-1000	0
12	-500	-1000
13	0	-5000
14	0	-3000
15	0	0
16	-500	500
17	-500	500
18	-500	0
19	0	-1000
20	500	-3000
21	500	-1000
22	1000	-3000
23	1000	1000
24	0	500
25	0	-500
26	1000	-1000
27	3000	-3000
28	3000	-1000
29	-3000	1000
30	-3000	3000
31	-1000	1000
32	-3000	-3000
33	500	0
34	500	-500
35	500	-500
36	-1000	3000
37	-500	1000
38	-500	3000
39	0	1000
40	-500	-500
41	1000	0
42	1000	-500
43	1000	500
44	0	3000
45	0	5000
46	500	1000
47	500	500
48	3000	0
49	3000	-500
50	3000	500
51	3000	1000
52	500	3000
53	1000	3000
54	3000	3000
55	5000	0

24 Trials: Positive Consequences
24 Trials: Negative Consequences
7 Trials: Neutral Consequences

Questionnaires

Narcissism (13 items)

We evaluated and scored narcissism using the Narcissistic Personality Inventory (13 items; Gentile et al.. 2013).

Maximum possible value was 13. minimum possible value was 0.
Literature:
Cronbach's Alpha: .73
Validity: .32
Current Study:
Cronbach's Alpha: .62

Narcissism: grandiose (5 items)

Maximum possible value was 5. minimum possible value was 0.
Literature:
Cronbach's Alpha: 0.65
Validity: 0.26
Current Study:
Cronbach's Alpha:.45

Narcissism: leadership (4 items)

Maximum possible value was 4. minimum possible value was 0.
Literature:
Cronbach's Alpha: 0.66
Validity: 0.32
Current Study:
Cronbach's Alpha:.54

Narcissism: entitlement (4 items)

Maximum possible value was 4. minimum possible value was 0.
Literature
Cronbach's Alpha: 0.51
Validity: 0.21

Current Study:
Cronbach's Alpha:.35

Risk propensity

We evaluated and scored risk propensity using the risk propensity questionnaire (2 items; Antoncic et al., 2016). The maximum possible value was 5. minimum possible value was 1.

Literature:
Cronbach's Alpha: 0.747
Current Study:
Cronbach's Alpha:.68

Impulsiveness: Behavioral inhibition and activation systems

We evaluated and scored Behavioral inhibition and activation systems using the BIS/BAS inventory (24 items; Carver & White. 1994). The scales behavioral inhibition (7 items). behavioral activation drive (4 items). behavioral activation fun seeking (4 items). behavioral activation reward/responsiveness (4 items) had the maximum possible value of 4. minimum possible value of 1. IMPORTANTLY: lower values here indicate high behavioural inhibition/behavioural activation and greater values here indicate low behavioural inhibition/behavioural activation.

Literature:
Cronbach's Alpha: Reliability: 0.72
Validity: $p < 0.001$
Current Study:
Cronbach's Alpha: .7

Big Five personality

We evaluated and scored Big-Five personality traits using the Big Five inventory (10 items; Rammstedt & John. 2007). Each personality trait (Agreeableness. Conscientiousness. Neuroticism. Openness) was evaluated with two items. The maximum possible value was 5. minimum possible value was 1.

Literature:

Cronbach's Alpha: 0.75
Validity: 0.11
Current Study:
Cronbach's Alpha:.45

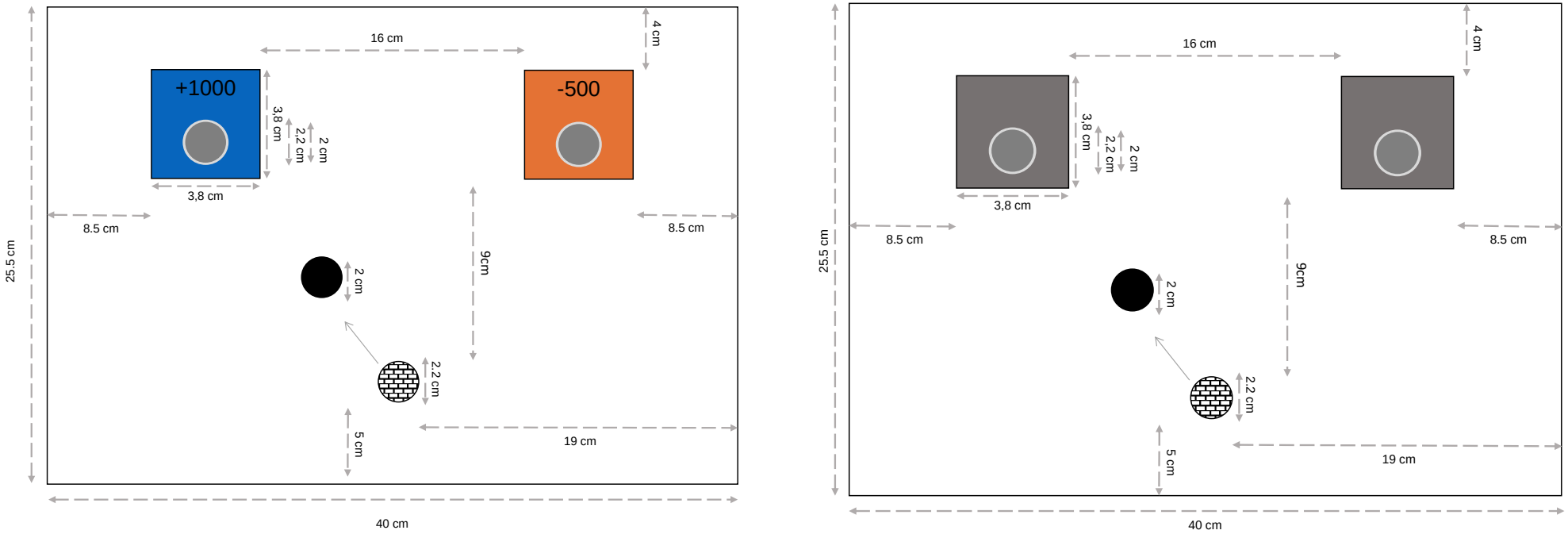


Figure S1. Stimuli location on the screen

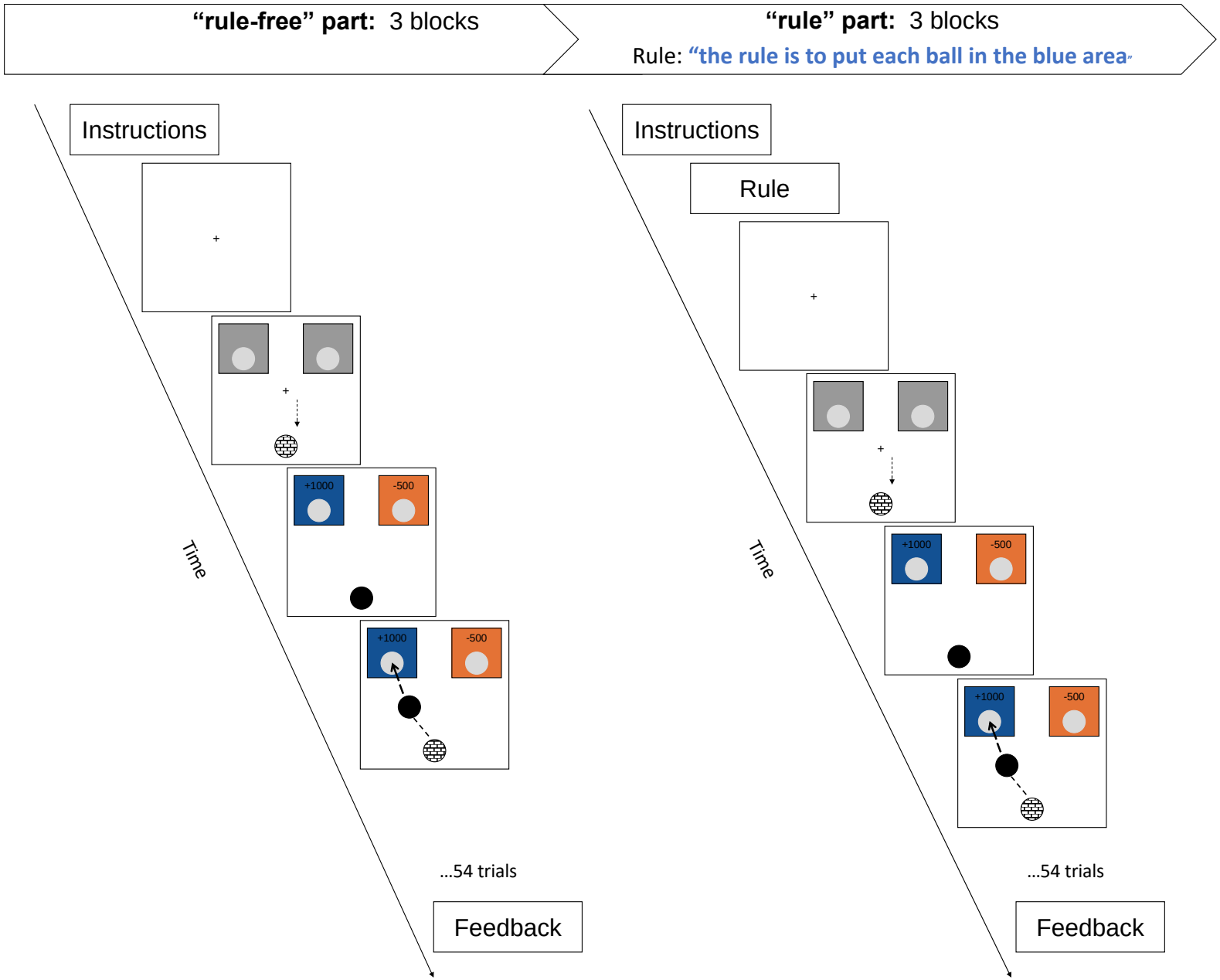


Figure S2. Additional diagram about the block structure

1.4 Mouse trajectory parameters

Calculation:

Maximum absolute distance (MAD):

1. For every measurement, a straight line is taken from the starting point to the target as a reference line.
2. Then the movement path of participant is taken and broken down into 100 step points.
3. MAD was then calculated as the maximum absolute distance from each of these points to the reference line (distance measured in terms of number of pixels).
4. To calculate MAD, they use this

   d(x) = sqrt((p1-x)^2 + (p2-y)^2)

   where, *(x,y)* is the point on reference line and *(p1,p2)* is the point on trajectory line.
5. By squaring and rearranging the above equation they get

   *d(x)^2 = (a^2+1)*x^2 + (2*a*b - 2*p1 - 2*p2*a)*x + p1^2 + p2^2 - 2*p2*b + b^2*
6. Now taking the derivative and equating it to zero, we get the value of x

   *x0 = (p1 + p2*a - a*b) / (a^2+1)*
7. Then y is calculated

   *y0 = a*x0 + b*

   where, a and b are the slope and intercept of the reference line.
8. Finally, 'ad' is computed as the simple Euclidean distance between the two points P(px,py) and G(x0,y0):

   ad = sqrt((px-x0).^2 + (py-y0).^2)
9. Then direction is calculated. Deviations towards the opposing target area were coded as positive values and deviations towards the nearest edge of the screen produced negative values.

   *direction = sign(py - (a*px+b))*

   (Jusyte et. al., 2017, pp. 939–946; Wirth et. al., 2020, pp. 2394–2416)

In Matlab:

function [ad, direction, linecoords] = comp_ad(px,py,a,b)

This function computes the absolute (Euclidean) distance of a point P (with the 2D-coordinates px and py) and a line, defined by slope a and intercept b. The arguments px and py may be scalars or vectors of the same length. In the latter case, ad will be a vector of distances. Additional output arguments are direction (1 = above the line, 0 = on the line, -1 = below the line) and line coordinates (=linecoords) (structure with the fields x and y for x0 and y0).

Area under the curve (AUC):

1. Measured in px^2.
2. Area between the actual movement and the perfect line.
3. Deviations towards the opposing target area were coded as positive values and deviations towards the nearest edge of the screen produced negative values.
4. AUCs are computed by dividing the area in triangular and square-shaped pieces and adding them up across the trajectory. The output is a vector representing the cumulative AUC across course of the trajectory. (Jusyte et. al., 2017, pp. 939–946; Wirth et. al., 2020, pp. 2394–2416)

In Matlab:

function [ad, direction, linecoords] = comp_ad(px,py,a,b)

This function computes the absolute (Euclidean) distance of a point P (with the 2D-coordinates px and py) and a line, defined by slope a and intercept b. The arguments px and py may be scalars or vectors of the same length. In the latter case, ad will be a vector of distances. Additional output arguments are direction (1 = above the line, 0 = on the line, -1 = below the line) and line coordinates (=linecoords) (structure with the fields x and y for x0 and y0).

References

1. Jusyte, A. et. al., (2017). Smooth criminal: convicted rule-breakers show reduced cognitive conflict during deliberate rule violations (81st ed.). Psychological Research.
2. Wirth, R. et. al., (2020). Design choices: Empirical recommendations for designing two-dimensional finger-tracking experiments (52nd ed.). Behavior Research Methods.

Results remain stable using different percentages

We have tested and are open to share scripts and data to test different percentages.

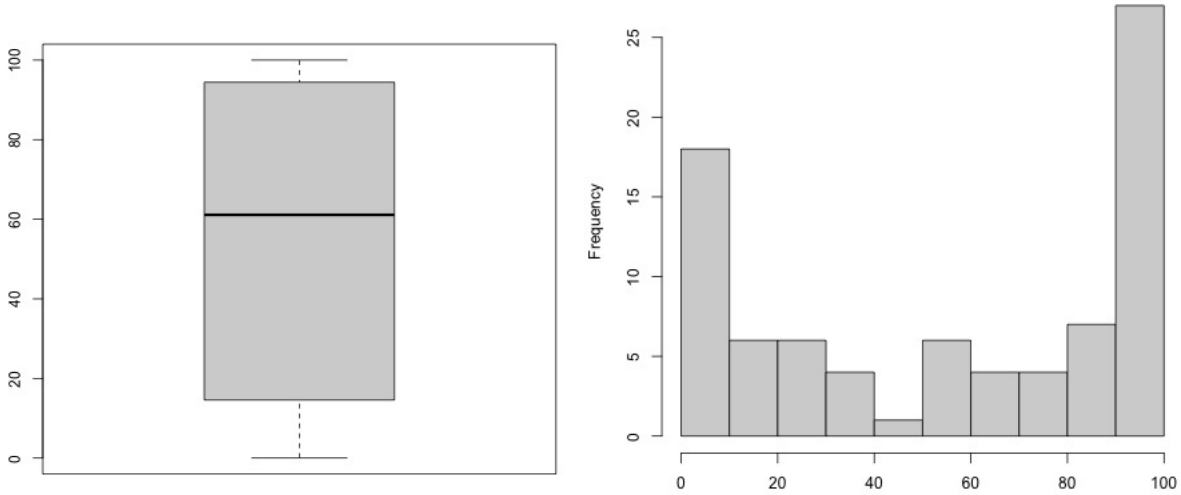


Figure S3. Distribution of the frequency of rule-breaking in trials where rules were violated to obtain benefits in individuals that broke the rule at least once.

In the data reported. the first lower quantile was classified as rule-followers. and the rest as rule-breakers. The results remained the same when trying different percentages ((5%. 10%. 15%. 20%. 55%). We tried 55% as this was the mean of the distribution. However. conceptually we believe the first 25% was a better measurement than the rest of percentages. as a trade-off between losing data and keeping valuable data. What is more. rule-breakers (the rest 75%') of the sample reported explicitly in a questionnaire that they broke a rule in order to get a benefit for themselves.

Decision-making in the "rule-free" and "rule" part

Multiple independent mixed 2 x 2 ANOVAs with the experimental part (i.e., "rule" part versus "rule-free" part) as a within group factor and the behavioral tendency (i.e., rule-followers versus rule-breakers) as a between group factor were computed to examine whether there were significant differences on participants behavior (i.e., payoffs. reaction times. mouse trajectory parameters) (see *Figure S3 and Table S1*). The dependent variables are the reaction times, and mouse trajectory parameters.

	Value	F	df	df	P	Effect size
Total time (ms)	0.541	154.400[b]	1	131	0	0.541
Initiation time (ms)	0.404	88.936[b]	1	131	0	0.404
Movement time (ms)	0.166	26.119[b]	1	131	0	0.166
MAD (px)	0.209	34.522[b]	1	131	0	0.209
AUC (px^2)	0.168	26.398[b]	1	131	0	0.168

Table S1. ANOVA for repeated measurement results

		Mean Difference	Std. Error	P	95% CI for B	
					Lower Bound	Upper Bound
Total time (ms)						
Behavioral tendencies						
Rule-breakers	Rule-followers	117.89*	29.11	0	60.32	175.47
Experimental Parts						
Rule	Rule-free	-197.21*	11.29	0	-219.55	-174.87
Behavioral tendency: Experimental Part						
Rule-breakers: Rule	Rule-followers: Rule-free	-79.31	31.22	.07	-162.31	3.68
	Rule-followers: Rule	258.21*	31.22	0	175.22	341.21
	Rule-breakers: Rule-free	-56.89	32.03	.46	-142.04	28.26
Rule-Breakers: Rule-free	Rule-followers: Rule-free	-22.43	31.22	1	-105.42	60.57
	Rule-followers: Rule	315.1*	31.22	0	232.10	398.09
Rule-followers: Rule	Rule-followers: Rule-free	-337.53*	30.39	0	-418.31	-256.75
Initiation time (ms)						
Behavioral tendencies						
Rule-breakers	Rule-followers	100.64*	20.05	0	60.99	140.3
Experimental Parts						
Rule	Rule-free	-141.9*	9.98	0	-161.64	-122.16

Behavioral tendency: Experimental Part						
Rule-breakers: Rule	Rule-followers: Rule-free	-41.25	22.39	.4	-100.78	18.28
	Rule-followers: Rule	194.75*	22.39	0	135.22	254.27
	Rule-breakers: Rule-free	-47.79	22.97	.23	-108.87	13.28
Rule-Breakers: Rule-free	Rule-followers: Rule-free	6.54	22.39	1	-52.99	66.07
	Rule-followers: Rule	242.54*	22.39	0	183.01	302.07
Rule-followers: Rule	Rule-followers: Rule-free	-236*	21.79	0	-293.94	-178.06
Movement time (ms)						
Behavioral tendencies						
Rule-breakers	Rule-followers	17.249	27.464	.53	-37.08	71.58
Experimental Parts						
Rule	Rule-free	-55.311*	9.043	0	-73.20	-37.42
Behavioral tendency: Experimental Part						
Rule-breakers: Rule	Rule-followers: Rule-free	-38.06	28.92	1	-114.93	38.81
	Rule-followers: Rule	63.47	28.92	.17	-13.40	140.34
	Rule-breakers: Rule-free	-9.09	29.67	1	-87.96	69.77
Rule-Breakers: Rule-free	Rule-followers: Rule-free	-28.97	28.92	1	-105.84	47.9
	Rule-followers: Rule	72.56	28.92	.08	-4.31	149.43
Rule-followers: Rule	Rule-followers: Rule-free	-101.53*	28.14	0	-176.35	-26.71

Maximum absolute distance (px)						
Behavioral tendencies						
Rule-breakers	Rule-followers	7.36	3.84	.06	-0.25	14.96
Experimental Parts						
Rule	Rule-free	-10.59*	1.93	0	-14.4	-6.77
Behavioral tendency: Experimental Part						
Rule-breakers: Rule	Rule-followers: Rule-free	-3.23	4.3	1	-14.66	8.2
	Rule-followers: Rule	18.69*	4.3	0	7.26	30.12
	Rule-breakers: Rule-free	0.74	4.41	1	-10.98	12.47
Rule-Breakers: Rule-free	Rule-followers: Rule-free	-3.97	4.3	1	-15.41	7.46
	Rule-followers: Rule	17.94*	4.3	0	6.51	29.38
Rule-followers: Rule	Rule-followers: Rule-free	-21.92*	4.19	0	-33.04	-10.79

Area under the curve (px^2)

		Mean Difference	Std. Error	P	95% CI for B	
					Lower Bound	Upper Bound
Behavioral tendencies						
Rule-breakers	Rule-followers	1299.22	1021.75	.21	-722.04	3320.49
Experimental Parts						
Rule	Rule-free	-1634.9*	509.43	0	-2642.68	-627.14
Behavioral tendency: Experimental Part						
Rule-breakers: Rule	Rule-followers: Rule-free	-335.69	1141.71	1	-3370.84	2699.47
	Rule-followers: Rule	3916.63*	1141.71	0	881.47	6951.78
	Rule-breakers: Rule-free	982.49	1171.36	1	-2131.51	4096.5
Rule-Breakers: Rule-free	Rule-followers: Rule-free	-1318.18	1141.71	1	-4353.34	1716.97
	Rule-followers: Rule	2934.13	1141.71	.06	-101.02	5969.29
Rule-followers: Rule	Rule-followers: Rule-free	-4252.31*	1111.25	0	-7206.51	-1298.11

Table S2. Posthoc results after testing significance in ANOVAs.

	Rule				**Rule-free**			
	Rule-breakers		**Rule-followers**		**Rule-breakers**		**Rule-followers**	
Dependent variables	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total time (ms)	1035.4	186.1	777.2	159.9	1092.2	150.3	1114.7	213.9
Initiation time (ms)	550.8	149.2	356.1	77.7	598.6	132.6	592.1	145.9
Movement time (ms)	484.5	189.9	421.1	130	493.6	163.3	522.6	178.9
MAD (px)	55.7	29.9	37	20.7	55	21	58.9	26.5
AUC (px^2)	12419.6	7770.3	8503.0	6420.7	11437.1	4997.9	12755.3	6796.5

Table S3. Descriptives of cognitive related variables

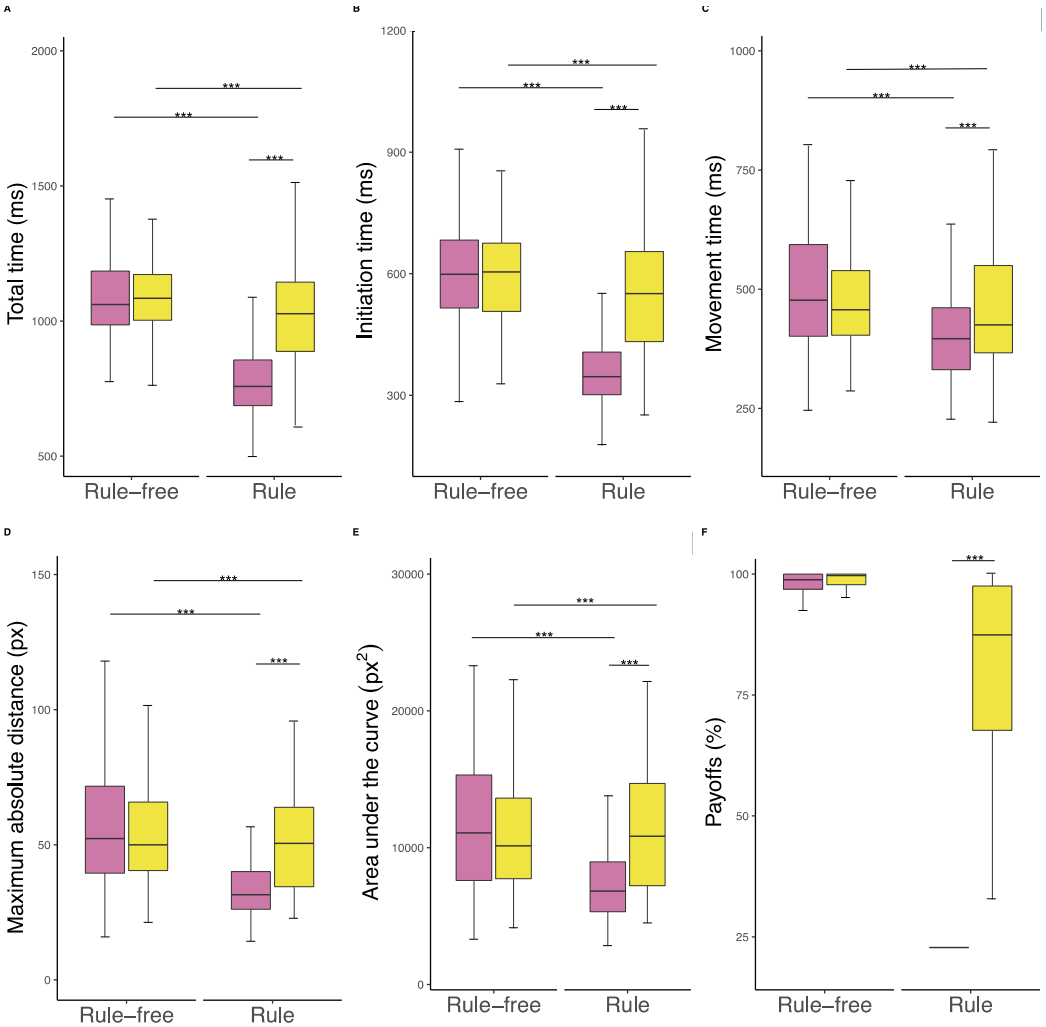


Figure S4. Reaction times and mouse trajectories across experimental parts and interindividual differences of responses towards rules. Yellow indicates rule-breakers. Pink indicates rule-followers. Significance: * = $p < .05$.

Post hoc analyses assuming independence of the groups (rule-followers and rule-breakers) when comparing trials associated a different type of consequences.

Behavioral tendency	Type of Consequences		Mean Difference	Std. Error	*P*	95% Confidence Interval	
						Lower Bound	Upper Bound
Total time (ms)							
Rule-followers	Positive	Negative	-21.98*	6.61	0	-38.21	-5.76
		Neutral	-14.36	6.26	.08	-29.72	1
	Neutral	Negative	-7.62	6.45	.73	-23.46	8.21
Rule-breakers	Positive	Negative	-128.1*	14.6	0	-164.02	-92.19
		Neutral	-73.95*	8.52	0	-94.91	-52.98
	Neutral	Negative	-54.16*	16.37	.01	-94.43	-13.89
Initiation time (ms)							
Rule-followers	Positive	Negative	-10.36*	3.67	.02	-19.36	-1.37
		Neutral	-2.49	3.04	1	-9.93	4.96
	Neutral	Negative	-7.88*	3.06	.04	-15.37	-0.38
Rule-breakers	Positive	Negative	-52.98*	8.72	0	-74.44	-31.53
		Neutral	-36.01*	5.96	0	-50.67	-21.36
	Neutral	Negative	-16.97	9.46	.23	-40.24	6.31
Movement time (ms)							
Rule-followers	Positive	Negative	-11.62	4.78	.05	-23.35	0.1
		Neutral	-11.88	5.15	.07	-24.51	0.76
	Neutral	Negative	0.26	5.63	1	-13.56	14.07
Rule-breakers	Positive	Negative	-75.12*	9.99	0	-99.71	-50.54
		Neutral	-37.93*	6.82	0	-54.72	-21.15
	Neutral	Negative	-37.19*	10.71	0	-63.55	-10.83

Maximum absolute distance (px)							
Rule-followers	Positive	Negative	-2.69*	0.9	.01	-4.9	-0.49
		Neutral	-0.98	0.93	.89	-3.26	1.3
	Neutral	Negative	-1.71	1.25	.53	-4.78	1.35
Rule-breakers	Positive	Negative	-26.23*	3.22	0	-34.14	-18.31
		Neutral	-8.96*	2.99	.01	-16.32	-1.61
	Neutral	Negative	-17.26*	4.34	0	-27.93	-6.6
Area under the curve (px^2)							
Rule-followers	Positive	Negative	-619.91*	189.17	.01	-1084.07	-155.74
		Neutral	-274.3	322.83	1	-1066.44	517.85
	Neutral	Negative	-345.61	342.97	.95	-1187.16	495.94
Rule-breakers	Positive	Negative	-5696.33*	709.85	0	-7443.03	-3949.62
		Neutral	-1502.01	686.4	.10	-3191.02	186.99
	Neutral	Negative	-4194.31*	1059.47	0	-6801.33	-1587.3

Table S4. Post hoc analyses assuming independence of the groups (rule-followers and rule-breakers) when comparing trials associated a different type of consequences.

The influence of frequency. recency. and latency of rule-breaking on reaction times and mouse trajectory parameters

	Coeff. B	Bias	Std.Error	P Value	*95% CI for B*	
					Conf. low	*Conf. high*
Percentage of rule-breaking						
Total time (ms)	2.90	-.02	.84	0	1.23	4.6
Initiation time (ms)	1.98	.03	.6	0	.9	3.18
Movement time (ms)	.92	.03	.82	.29	-.54	2.59
MAD (px)	.1	.01	.15	.53	-.17	.42
AUC (px^2)	23.07	-.03	38.69	.54	-51.70	107.52
Recency						
Total time (ms)	2.09	-.03	.81	.01	.5	3.65
Initiation time (ms)	1.53	.02	.57	.01	.35	2.62
Movement time (ms)	1.53	-.01	.56	.01	.33	2.53
MAD (px)	.01	.01	.14	.97	-.26	.29
AUC (px^2)	1.06	.82	34.24	.98	-64.34	68.92
Latency						
Total time (ms)	-4.88	-.06	1.42	0	-8.06	-2.31
Initiation time (ms)	-3.02	.02	1.09	.01	-5.3	-.87
Movement time (ms)	-1.86	-.07	1.18	.08	-4.5	.11
MAD (px)	-.57	.02	.23	.01	-.95	-.1
AUC (px^2)	-113.76	2.82	63.54	.07	-227.86	21.34

Table S5. Bootstrap analyses with 1000 permutations of the influence of frequency. recency and latency of rule-breaking on reaction times and mouse trajectory parameters in the "rule" part (N= 63).

	Std. coeff.	*Std. error*	*Beta coeff.*	*t*	*p*	***95% CI for B***		R^2	R^2 *adjusted*
						Conf. low	*Conf. high*		
Percentage of rule-breaking									
Total time (ms)	2.90	.91	.38	3.2	0	1.09	4.71	.14	.13
Initiation time (ms)	1.98	.72	.33	2.76	.01	.55	3.42	.11	.1
Movement time (ms)	.92	.96	.12	.96	.34	-1	2.83	.02	0
MAD (px)	.1	.18	.07	.55	.58	-.26	.46	.01	-.01
AUC (px^2)	23.07	45.22	.07	.51	.61	-67.34	113.48	0	-.01
Recency									
Total time (ms)	2.09	.83	.31	2.51	.02	.42	3.75	.09	.08
Initiation time (ms)	1.53	.65	.29	2.35	.02	.23	2.83	.08	.07
Movement time (ms)	1.53	.65	.29	2.35	.02	.23	2.83	.08	.07
MAD (px)	.01	.16	0	.03	.98	-.31	.32	0	-.02
AUC (px^2)	-.57	.36	-.20	-1.56	.12	-1.29	.16	.04	.02
Latency									
Total time (ms)	-4.88	1.93	-.31	-2.53	.01	-8.73	-1.02	.1	.08
Initiation time (ms)	-3.02	1.53	-.25	-1.98	.05	-6.07	.03	.06	.05
Movement time (ms)	-1.86	1.98	-.12	-.94	.35	-5.82	2.11	.01	0
MAD (px)	-.57	.36	-.20	-1.56	.12	-1.29	.16	.04	.02
AUC (px^2)	-113.76	92.58	-.16	-1.23	.22	-298.88	71.36	.02	.01

Table S6. The influence of frequency. recency. and latency of rule-breaking on reaction times and mouse trajectory parameters in trials in which there were negative consequences - if following the rule (N= 63).

	Coeff. B	Bias	Std.Error	P Value	*95% CI for B*	
					Conf. low	*Conf. high*
Percentage of rule-breaking						
Total time (ms)	2.90	-.02	.84	0	1.23	4.6
Initiation time (ms)	1.98	.03	.6	0	.9	3.18
Movement time (ms)	.92	.03	.82	.29	-.54	2.59
MAD (px)	.1	.01	.15	.53	-.17	.42
AUC (px^2)	23.07	-.03	38.69	.54	-51.70	107.52
Recency						
Total time (ms)	2.09	-.03	.81	.01	.5	3.65
Initiation time (ms)	1.53	.02	.57	.01	.35	2.62
Movement time (ms)	1.53	-.01	.56	.01	.33	2.53
MAD (px)	.01	.01	.14	.97	-.26	.29
AUC (px^2)	1.06	.82	34.24	.98	-64.34	68.92
Latency						
Total time (ms)	-4.88	-.06	1.42	0	-8.06	-2.31
Initiation time (ms)	-3.02	.02	1.09	.01	-5.3	-.87
Movement time (ms)	-1.86	-.07	1.18	.08	-4.5	.11
MAD (px)	-.57	.02	.23	.01	-.95	-.1
AUC (px^2)	-113.76	2.82	63.54	.07	-227.86	21.34

Table S7. Bootstrap analyses with 1000 permutations of the influence of frequency. recency and latency of rule-breaking on reaction times and mouse trajectory parameters in trials in which there were negative consequences - if following the rule (N= 63).

	Std. coeff.	*Std. error*	*Beta coeff.*	*t*	*p*	***95% CI for B***		R^2	R^2 *adjusted*
						Conf. low	*Conf. high*		
Percentage of rule-breaking									
Total reaction time (ms)	-.629	.95	-.083	-.662	.511	-2.527	1.27	.083	.007
Initiation time (ms)	.482	.743	.082	.649	.518	-1.002	1.967	.082	.007
Movement time (ms)	-1.111	1.051	-.132	-1.057	.294	-3.211	.989	.132	.017
Maximum absolute distance. MAD (px)	-.684	.276	-.298	-2.478	.016	-1.236	-.132	.298	-.132
Area under the curve. AUC (px^2)	-133.451	62.732	-.259	-2.127	.037	-258.811	-8.092	.259	.067
Percentage of recency of rule-breaking									
Total reaction time (ms)	-5.80	2.12	-.034	-.273	.785	-4.815	3.656	.034	.001
Initiation time (ms)	-1.362	1.649	-.103	-.826	.412	-4.658	1.934	.103	.011
Movement time (ms)	.782	2.356	.042	.332	.741	-3.926	5.491	.042	.002
Maximum absolute distance. MAD (px)	-.314	.642	-.061	-.489	.627	-1.597	.969	.061	.004
Area under the curve. AUC (px^2)	-35.599	144.382	-.031	-.267	.806	-324.123	252.926	.031	.001
Latency of rule-breaking									
Total reaction time (ms)	.793	1.406	.071	.564	.575	-4.815	.575	-2.016	.005
Initiation time (ms)	-.448	1.1	-.051	-.407	.685	-2.647	1.751	.051	.003
Movement time (ms)	1.242	1.559	.1	.796	.429	-1.874	4.358	.1	.01
Maximum Absolute Distance. MAD (px)	.42	.424	.124	.989	.326	-.428	1.267	.124	.015
Area under the curve. AUC (px^2)	77.598	95.493	.102	.813	.420	-113.228	268.425	.102	-.01

Table S8. The influence of frequency. recency. and latency of rule-breaking on reaction times and mouse trajectory parameters in trials in which there were negative consequences- if following the rule. and rule violations were committed (rule-breakers. N = 63).

	Coeff. B	Bias	Std.Error	P Value	***95% CI for B***	
					Conf. low	*Conf. high*
Percentage of rule-breaking						
Total time (ms)	-.81	.08	1.06	.45	-2.76	1.38
Initiation time (ms)	-.25	.04	.81	.77	-1.69	1.48
Movement time (ms)	-.55	.05	1.04	0.6	-2.44	1.6
MAD (px)	-.59	.01	.32	.08	-1.25	-.01
AUC (px^2)	-103.47	-.81	65.85	.12	-237.52	23.18
Recency						
Total time (ms)	-.90	.06	.94	.34	-2.64	1.01
Initiation time (ms)	-.22	-.06	.74	.77	-1.73	1.17
Movement time (ms)	-.68	.04	.97	.49	-2.43	1.28
MAD (px)	-0.6	0	.25	.02	-1.08	-0.1
AUC (px^2)	-110.01	3.25	51.87	.05	-205.30	-5.52
Latency						
Total time (ms)	-.07	-.13	1.61	.97	-3.45	3.1
Initiation time (ms)	1.12	-.09	1.46	.41	-1.79	3.9
Movement time (ms)	-1.19	.04	1.51	.41	-4.01	1.91
MAD (px)	-.34	.03	.38	.33	-.96	.57
AUC (px^2)	-86.71	3.74	76.18	.19	-224.63	74.96

Table S9. Bootstrap analyses with 1000 permutations of the influence of frequency. recency and latency of rule-breaking on reaction times and mouse trajectory parameters in trials in the rule part committed (rule-breakers. N = 63).

Results of t-tests comparing rule-breaking and rule-following trials in those trials associated to negative consequences

Dependent variables	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval		t	df	Sig.	Effect size
				Lower	Upper				
Total time (ms)	-154.53	280.87	37.20	-229.05	-80	-4.15	56	0	-.55
Initiation time (ms)	-97.22	166.27	22.02	-141.33	-53.1	-4.41	56	0	-.59
Movement time (ms)	-97.22	166.27	22.02	-141.33	-53.1	-4.41	56	0	-.28
MAD (px)	-40.78	59.85	7.93	-56.67	-24.9	-5.15	56	0	-.68
AUC (px^2)	-8654.86	9223.37	1805.24	-9223.37	-5038.53	-4.79	56	0	-.64

	Mean	Bias	Std. Error	Sig	95% Confidence Interval	
					Lower	Upper
Total Time (ms)	-154.53	-.62	36.57	0	-224.2	-85.62
Initiation Time (ms)	-97.22	-.46	22.15	0	-139.08	-52.83
Movement time (ms)	-57.31	-1.25	26.93	0	-113.05	-5.35
MAD (px)	-40.78	-.12	7.77	0	-56.67	-25.56
AUC (px^2)	-8654.86	-89.67	1783.38	0	-9223.37	-5372.40

Table S10. Results of t-tests comparing rule-breaking and rule-following trials in those trials associated to negative consequences (rule-breakers. N = 63).

	Response to rules			
	Broken		Followed	
	Mean	*SD*	*Mean*	*SD*
Total time (ms)	1183.29	223.66	1028.76	285.69
Initiation time (ms)	614.57	178.72	517.35	197.62
Movement time (ms)	568.72	238.53	511.41	208.65
MAD (px)	90.94	57.7	50.15	35.4
AUC (px^2)	11143.24	8500.16	19798.1	9223.37

Table S11. Descriptives of t-tests comparing rule-breaking and rule-following trials in those trials associated to negative consequences (rule-breakers. N = 63).

Results regarding the current and last trials responses in rule-breakers

		Mean Difference	Std. Error	P	95% CI for B	
					Lower Bound	Upper Bound
Current trial: Last trial						
Total Time (ms)						
Broken: Followed	Broken: Broken	67.51	34.75	0.32	-24.92	159.94
	Followed: Broken	-131.14*	34.75	0.00	-223.57	-38.71
	Followed: Followed	-110.17*	34.75	0.01	-202.60	-17.74
Followed: Broken	Followed: Followed	20.97	34.75	1.00	-71.46	113.39
	Broken: Broken	198.65*	34.75	<.001	106.22	291.08
Broken: Broken	Followed: Followed	-177.68*	34.75	<.001	-270.11	-85.25
Initiation time (ms)						
Broken: Followed	Broken: Broken	-42.19	28.43	0.84	-117.81	33.42
	Followed: Broken	-42.69	28.43	0.81	-118.30	32.93
	Followed:Followed	61.55	28.43	0.19	-14.06	137.17
Followed: Broken	Followed: Followed	0.50	28.43	1.00	-75.12	76.11
	Broken: Broken	104.24*	28.43	0.00	28.62	179.85
Broken: Broken	Followed: Followed	103.74*	28.43	0.00	28.13	179.36
Movement time (ms)						

Broken: Followed	Followed: Followed	5.96	36.81	1.00	-91.95	103.86
	Followed: Broken	-88.45	36.81	0.10	-186.36	9.45
	Broken: Broken	-67.98	36.81	0.40	-165.89	29.92
Followed: Broken	Followed: Followed	94.41	36.81	0.07	-3.49	192.31
	Broken: Broken	20.47	36.81	1.00	-77.43	118.37
Broken: Broken	Followed: Followed	73.94	36.81	0.27	-23.96	171.84

Maximum absolute distance (px)

Broken: Followed	Followed: Followed	3.16	7.80	1.00	-17.58	23.89
	Followed: Broken	-38.91*	7.80	<.001	-59.64	-18.17
	Broken: Broken	-28.68*	7.80	0.00	-49.42	-7.95
Followed: Broken	Followed: Followed	42.06*	7.80	<.001	21.33	62.80
	Broken: Broken	10.22	7.80	1.00	-10.51	30.96
Broken: Broken	Followed: Followed	31.84*	7.80	<.001	11.10	52.57

Area under the curve

Broken: Followed	Followed: Followed	728.69	1815.06	1.00	-4098.63	5556.00
	Followed: Broken	-8272.89*	1815.06	<.001	-13100.20	-3445.57
	Broken: Broken	-5632.72*	1815.06	0.01	-10460.03	-805.40
Followed: Broken	Followed: Followed	9001.57*	1815.06	<.001	4174.26	13828.89
	Broken: Broken	2640.17	1815.06	0.88	-2187.15	7467.48
Broken: Broken	Followed: Followed	6361.40*	1815.06	0.00	1534.09	11188.72

Table S12. *AN*OVA Statistics of the current and last trial responses in rule-breakers during the "rule" part. Significanc = $p < .05$.

	Followed: Followed		Broken: Followed		Followed: Broken		Broken: Broken	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total time (ms)	980.64	184.67	1048.15	152.19	1179.29	207.83	1158.33	227.42
Initiation time (ms)	519.46	146.95	581.01	139.23	623.70	178.65	623.20	170.17
Movement time (ms)	461.19	174.47	467.14	175.18	555.60	240.20	535.13	227.84
MAD (px)	44.84	24.35	48.00	27.09	86.90	57.23	76.68	55.28
AUC (px^2)	10004.66	6422.46	10733.34	7114.10	19006.23	9223.37	16366.06	9223.37

Table S13. Descriptives of the current and last trial responses in rule-breakers

		Mean Diff.	Std. Error	P	95% CI for B	
					Lower Bound	Upper Bound
Current trial: Last trial						
Total time (ms)						
Broken: Followed	Followed:Followed	135.15	54.03	0.08	-8.69	279.00
	Followed: Broken	-35.17	52.96	1.00	-176.16	105.82
	Broken: Broken	-14.11	52.96	1.00	-155.10	126.88
Followed: Broken	Followed: Followed	170.32*	47.88	0.00	42.84	297.80
	Broken: Broken	21.06	46.67	1.00	-103.20	145.31
Broken: Broken	Followed: Followed	149.26*	47.88	0.01	21.78	276.75
Initiation time (ms)						
Broken: Followed	Followed:Followed	105.08	42.03	0.08	-6.82	216.98
	Followed: Broken	-13.20	41.20	1.00	-122.89	96.48
	Broken: Broken	-9.93	41.20	1.00	-119.61	99.75
Followed: Broken	Followed: Followed	118.28*	37.25	0.01	19.11	217.46
	Broken: Broken	3.27	36.31	1.00	-93.39	99.94
Broken: Broken	Followed: Followed	115.01*	37.25	0.01	15.84	214.19
Movement time (ms)						
Broken: Followed	Followed: Followed	30.07	46.76	1.00	-94.42	154.57
	Followed: Broken	-21.96	45.83	1.00	-143.99	100.06
	Broken: Broken	-4.18	45.83	1.00	-126.20	117.85
Followed: Broken	Followed: Followed	52.04	41.44	1.00	-58.30	162.37
	Broken: Broken	17.79	40.39	1.00	-89.75	125.33
Broken: Broken	Followed: Followed	34.25	41.44	1.00	-76.08	144.59

Maximum absolute distance						
Broken: Followed	Followed: Followed	18.16	11.15	0.63	-11.54	47.85
	Followed: Broken	-22.68	10.93	0.24	-51.79	6.43
	Broken: Broken	-12.98	10.93	1.00	-42.08	16.13
Followed: Broken	Followed: Followed	40.84*	9.88	<.001	14.52	67.16
	Broken: Broken	9.70	9.63	1.00	-15.95	35.36
Broken: Broken	Followed: Followed	31.13*	9.88	0.01	4.82	57.45
Area under the curve (px^2)						
Broken: Followed	Followed: Followed	3941.10	2512.81	0.71	-2749.11	10631.30
	Followed: Broken	-4653.05	2462.97	0.36	-11210.57	1904.46
	Broken: Broken	-2100.45	2462.97	1.00	-8657.96	4457.07
Followed: Broken	Followed: Followed	8594.15*	2227.02	<.001	2664.84	14523.46
	Broken: Broken	2552.61	2170.63	1.00	-3226.57	8331.78
Broken: Broken	Followed: Followed	6041.54*	2227.02	0.04	112.24	11970.85

Table S14. ANOVA Statistics of the current and last trial responses in rule-breakers in trials associated with negative consequences. The asterisks * mark significant results with a significance level of 0.05.

	Followed: Followed		Broken: Followed		Followed: Broken		Broken: Broken	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total time (ms)	1011.75	279.97	1146.90	348.07	1182.07	212.42	1161.01	224.09
Initiation time (ms)	508.18	194.61	613.26	282.80	626.46	181.50	623.19	170.90
Movement time (ms)	503.57	204.26	533.64	238.10	555.61	239.40	537.82	225.55
MAD (px)	33.88	4.49	65.59	62.31	88.27	60.38	78.56	56.60
AUC (px^2)	10677.21	8539.21	14618.31	9223.37	19271.36	9223.37	16718.75	9223.37

Table S15. Descriptives of the current and last trial responses in rule-breakers in trials associated with negative consequences

	Paired Differences							
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper	t	df	Two-Sided p
Total time (ms)	1167.31	217.25	19.35	1129.00	1205.61	60.31	125.00	<.001
Movement time (ms)	543.86	233.41	20.79	502.71	585.01	26.16	125.00	<.001
Initiation time (ms)	621.95	173.76	15.48	591.31	652.59	40.18	125.00	<.001
MAD (px)	80.29	56.32	5.02	70.36	90.22	16.00	125.00	<.001
AUC (px^2)	9223.37	9223.37	1134.19	9223.37	9223.37	15.59	125.00	<.001

Table S16. Paired T-Tests with paired Differences and Significance leve in trials associated with negative consequences when participants broke the rule Comparison between breaking the rule in the current trial after following it versus breaking the rule in the current trial after have recently broken it in the las trial.

		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
Total time (ms)	Cohen's d	217.25	5.37	4.68	6.06
	Hedges' correction	218.57	5.34	4.66	6.02
Initiation time (ms)	Cohen's d	233.41	2.33	1.99	2.67
	Hedges' correction	234.83	2.32	1.98	2.65
Movement time (ms)	Cohen's d	173.76	3.58	3.10	4.05
	Hedges' correction	174.81	3.56	3.08	4.03
Maximum absolute distance (px)	Cohen's d	56.32	1.43	1.18	1.67
	Hedges' correction	56.66	1.42	1.17	1.66
Area under the curve (px^2)	Cohen's d	9223.37	1.39	1.14	1.63
	Hedges' correction	9223.37	1.38	1.14	1.62

Table S17. *Paired Samples Effect Sizes corresponding to talbe S16.* [(a)]*The denominator used in estimating the effect sizes. Cohen's d uses the sample standard deviation of the mean difference. Hedges' correction uses the sample standard deviation of the mean difference. plus a correction factor.*

	Followed: Broken		Broken: Broken	
	Mean	SD	Mean	SD
Total time (ms)	1179.29	207.83	1158.33	227.42
Initiation time (ms)	623.70	178.65	623.20	170.17
Movement time (ms)	555.60	240.20	535.13	227.84
MAD (px)	86.90	57.23	76.68	55.28
AUC (px^2)	19006.23	9223.37	16366.06	9223.37

Table S18. Descriptives of the current and last trial responses in rule-breakers in trials associated with negative consequences when participants broke the rule Comparison between breaking the rule in the current trial after following it versus breaking the rule in the current trial after have recently broken it in the las trial.

Correlation tables

Table 3. Correlation table of rule-followers versus rule-breakers and personality, and across individuals in these two groups during the "rule" part

Variables	1	2	3	4	5	6	7	8	9
Rule-followers versus rule-breakers [b]		-.06	.06	-.09	-.05	-.03	.05	.09	.02
Rule-followers									
Total pay-off		-.1	-.05	-.04	-0.13	0.08	0.04	-0.03	-0.08
Total time (ms)		-0.13	.12	-0.12	-0.01	-0.04	.31*	0.2	0.09
Initiation time (ms)		0.08	.06	0.14	0.16	-0.04	0.22	0.2	0.1
Movement time (ms)		0.11	.1	-.24*	-0.11	-0.03	.25*	0.13	0.05
AUC (px^2)		0.08	.11	-.04	-0.14	-0.02	-0.17	-0.17	-0.15
MAD (px)		-0.05	.12	-.07	-0.16	0.01	-0.13	-0.14	-0.15
Rule-breakers									
Total pay-off		-0.36	-.21*	-0.2	-.21*	0.19	.28*	.29*	0.24
Total time (ms)		-.36*	-0.21	-0.15	-0.2	-0.17	.27*	.26*	0.18
Initiation time (ms)		0	0.07	0.16	0.13	0.02	-0.19	-0.16	-0.08
Movement time (ms)		-.38*	-0.19	-0.13	-0.16	-0.14	.25*	.24*	0.2
AUC (px^2)		-0.16	0.2	0.06	-0.24	-0.16	-0.1	0.14	0.01
MAD (px)		-0.05	-0.04	-0.02	-0.01	-.26*	0.04	0.07	-0.01

Note: 1 Grandiose narcissism, 2 Agreeableness, 3 Conscientiousness, 4 Extraversion, 5 Risk propensity, 6 BAS drive, 7 BAS fun seeking, 8 BAS reward, 9 BIS. * = p value is less than .05, AUC = area under the curve, MAD = Maximum absolute distance, [b] 1 = rule-followers. 2 = rule-breakers. Further correlation analyses can be found in the supplementary material (Tables S19-S23).

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
Total pay-off	-0.05	-0.15	-.19*	0.11	-0.13	0.059	0.187	-0.005	0.122	0.08	0.15	0.14	-0.06
Total time (ms)	.24*	-0.08	-0.11	0.1	-0.13	0.055	0.145	0.022	0.111	-0.08	.21*	0.15	-0.03
Initiation time (ms)	-0.1	-0.04	-0.1	0.11	0.01	0.04	0.06	-0.026	0.039	-0.01	0.13	0.11	-0.09
Movement time (ms)	-0.014	-0.07	-0.05	0.04	-.18*	0.027	0.08	0.031	0.068	-0.1	0.16	0.09	0.05
AUC (px^2)	0.06	0.01	0.03	0.06	-.22*	0.027	0.004	-0.063	-0.013	-0.02	0.04	-0.01	-0.06
MAD (px)	0.08	0.02	0.03	0.04	-.22*	0.088	0.135	0.087	0.153	-0.04	0.04	-0.02	-0.05

Table S19. Correlation of personality across all variables in rule-followers and rule-breakers during the "rule" part
1 Conscientiousness, 2 Extraversion, 3 Agreeableness, 4 Neuroticism, 5 Risk propensity, 6 Narcissism, 7 Narcissism: leadership, 8 Narcissism: grandiose, 9 Narcissism: entitlement, 10 BAS drive, 11 BAS fun seeking, 12 BAS reward responsiveness, 13 BIS. Correlation significant at the .05 level (2 – tailed) represented with asterisk (*).
BIS: Behavioural inhibition system. BAS: Behavioural activation system. No correlation was found to be significant between rule-followers versus rule-breakers, which was reported in the manuscript.

Descriptives

Variables	Mean (min/max)	SD
1. Age	25.2 (18/68)	7.1
2. Sex [a]	NA	0.5
4. Total pay-off	250883.4 (115000/342000)	57955.9
5. Total time (ms)	934.7 (500/1602)	248.3
6. Initiation time (ms)	463.2 (173.2/1131)	170.5

7. Movement time (ms)	471.6 (219.6/1246)	183.7
8. Area under the curve (px^2)	7164.7 (-6076/58434.8)	10656.4
9. Maximum absolute distance (px)	29.2 (-26.6/205.6)	42.3
11. Conscientiousness	3.2 (1/5)	0.8
12. Extraversion	3.4 (1.5/5)	0.9
13. Agreeableness	3.5 (1/5)	0.8
14. Neuroticism	2.9 (1/5)	0.9
15. Risk propensity	3.2 (1/5)	0.9
16. Narcissism	12.8(8/20)	2.6
17. Narcissism: leadership	9 (4/15)	2.3
18. Narcissism: grandiose	4.6 (3/7)	1.3
19. Narcissism: entitlement	2.7 (1/6)	1.3
20. BAS drive	5.4 (4/8)	1.2
21. BAS fun seeking	8.3 (4/14)	2.1
22. BAS reward responsiveness	7.6 (4/11)	1.6
23. BIS	14.9 (7/23)	3.5

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Total pay-off	-0.13	-0.1	-0.21	-0.04	-0.11	-0.02	-0.08	0.08	0.04	-0.03	-0.058	-0.077	0.029	-0.054
Total time (ms)	-0.01	0	0	-0.12	0.11	0.11	0.09	-0.04	.31*	0.2	-0.058	-0.116	0.183	0.001
Initiation time (ms)	0.16	-0.13	0.15	0.14	-0.03	-0.09	0.1	-0.04	0.22	0.2	-0.159	-0.178	-0.116	-0.228
Movement time (ms)	-0.11	0.08	-0.08	-.24*	0.16	0.19	0.05	-0.03	.25*	0.13	-0.043	-0.141	-0.052	-0.115
MAD (px)	-0.14	0.11	0	-0.04	0.16	0.14	-0.15	-0.02	-0.17	-0.17	-0.17	-0.135	-0.112	-0.212
AUC (px^2)	-0.16	0.08	-0.02	-0.07	0.15	0.15	-0.15	0.01	-0.13	-0.14	0.121	0.134	0.214	0.232

Table S20. Correlation of personality across all variables in rule-followers during the "rule" part
Correlation significant at the .05 level (2 – tailed) represented with asterisk (*).
BIS: Behavioural inhibition system. BAS: Behavioural activation system
1 Risk propensity, 2 Agreeableness, 3 Conscientiousness, 4 Extraversion, 5 Openness, 6 Neuroticism, 7 BIS, 8 BAS drive, 9 BAS fun seeking, 10 BAS reward responsiveness, 11 Narcissism: leadership, 12 Narcissism: grandiose, 13 Narcissism: entitlement, 14 Narcissism

Variables	**Mean (min/max)**	**SD**

1. Age	25(18/68)	6
2. Sex [a]	1.5(1/2)	.5
3. Total pay-off	250883.4 (115000/342000)	19131.1
4. Total time (ms)	934.7 (500/1602)	159.8
5. Initiation time (ms)	463.2 (173.2/1131)	77.7
6. Movement time (ms)	471.6 (219.6/1246)	129.9
7. Maximum absolute distance (px)	29.2 (-26.6/205.6)	20.6
8. Area under the curve (px^2)	7164.7 (-6076/58434.8)	6420.6
9. Risk propensity	3.2 (1/5)	0.9
10. Agreeableness	3.5 (1/5)	0.7
11. Conscientiousness	3.2 (1/5)	0.7
12. Extraversion	3.4 (1.5/5)	0.9
13. Openness	3.4 (1/5)	0.7
14. Neuroticism	2.9 (1/5)	0.9
15. BIS	14.9 (7/23)	3.3
16. BAS drive	9 (4/15)	2.1
17. BAS fun seeking	8.3 (4/14)	1.9
18. BAS reward responsiveness	7.6 (4/11)	1.7
16. Narcissism	13.1(8/20)	7.4
17. Narcissism: leadership	5.4(4/8)	1.7
18. Narcissism: grandiose	2.96(1/6)	2.1
19. Narcissism: entitlement	4.7(3/7)	1.5

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Total pay-off	-.21*	-0.36	-.21*	-0.2	-0.11	0.96	0.19	.28*	.29*	0.24	0.109	-0.177	0.035	-0.026
Frequency of rule-breaking	-0.2	-.36*	-0.21	-0.15	-0.08	0.09	-0.17	.27*	.26*	0.18	0.04	0.003	-0.014	0.019
Recency	0.13	0	0.07	0.16	-0.03	0.05	0.02	-0.19	-0.16	-0.08	0.171	0.015	0.051	0.112
Latency	-0.16	-.38*	-0.19	-0.13	-0.05	0.07	-0.14	.25*	.24*	0.2	0.002	-0.015	0.102	0.038

Total time (ms)	-0.24	-0.16	0.2	0.06	0	0	-0.16	-0.1	0.14	0.01	0.166	0.027	-0.03	0.08
Initiation time (ms)	-0.01	-0.05	-0.04	-0.02	0.03	0.15	-.26*	0.04	0.07	-0.01	0.036	0.041	0.011	0.044
Movement time (ms)	-0.23	-0.11	0.23	0.08	-0.02	0.11	0.04	-0.13	0.08	0.03	0.109	-0.177	0.035	-0.026
MAD (px)	-.28*	0.01	0.18	0.21	-0.14	-0.1	0	-0.04	0.15	0.04	0.048	0.003	-0.014	0.019
AUC (px^2)	-.26*	0.01	.21*	.12*	-.16*	-.08*	0	-0.03	.16*	0.06	0.171	0.015	0.051	0.112

Table S21. Correlation of personality across all variables in rule-breakers during the rule-part
Correlation significant at the .05 level (2 – tailed) represented with asterisk (*).
BIS: Behavioural inhibition system. BAS: Behavioural activation system
1 Risk propensity, 2 Agreeableness, 3 Conscientiousness, 4 Extraversion, 5 Openness, 6 Neuroticism, 7 BIS, 8 BAS drive, 9 BAS fun seeking, 10 BAS reward responsiveness, 11 Narcissism: leadership, 12 Narcissism: grandiose, 13 Narcissism: entitlement+

Descriptives

Variables	Mean (min/max)	SD
1. Age	24.8 (18/68)	6.3
2. Sex [a]	1.5 (1/2)	0.5
3. Total pay-off	303182.53 (179500/342000)	41463.6
4. Frequency of rule-breaking	22.1 (1.2/38.1)	12.4
5. Recency	69.6 (12.5/100)	30
6. Latency	45.5 (33/101)	16.1
7. Total time (ms)	1088.2 (604.5/1602.2)	225.1
8. Initiation time (ms)	566.1 (241/1131)	177
9. Movement time (ms)	522.0 (223.2/1245.9)	215.3
10. Maximum absolute distance (px)	48.8 (-10.8/205.5)	45.8
11. Area under the curve (px^2)	11416.9 (2384.2/58434.8)	11398.8

12. Risk propensity	3.1 (1.5/5)	0.8
13. Agreeableness	3.4 (1/5)	0.9
14. Conscientiousness	3.2 (2/5)	0.7
15. Extraversion	3.3 (1.5/5)	0.9
16. Openness	3.4 (1/5)	0.7
17. Neuroticism	2.9 (1/5)	0.9
18. BIS	15 (7/23)	3.6
19 BAS drive	8.8 (5/15)	2.3
20. BAS fun seeking	8.3 (4/14)	2.1
21. BAS reward responsiveness	7.7 (4/11)	1.5
16. Narcissism	13.12(8/20)	2.7 2.7
17. Narcissism: leadership	4.7(3/7)	1.3
18. Narcissism: grandiose	2.9(1/6)	1.4
19. Narcissism: entitlement	5.4(4/8)	1.2

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Total pay-off	-0.21	-.36*	-0.21	-0.2	-0.11	0.09	-0.19	.28*	.29*	0.24	-0.009	-0.178	0.035	-0.224
Frequency of rule-breaking	-0.2	-.36*	-0.21	-0.15	0.08	0.09	-0.17	.27*	.26*	0.18	0.137	-0.013	-0.014	0.071
Recency	0.13	0	0.07	0.16	-0.03	0.05	0.02	-0.19	-0.16	-0.08	0.131	-0.042	-0.002	0.04
Latency	-0.16	-.38*	-0.19	-0.13	-0.05	0.07	-0.14	.25*	0.24	0.2	0	-0.047	-0.029	-0.113
Total time (ms)	-0.21	-0.09	0.23	0.09	0	0.01	-0.14	-0.16	0.11	-0.07	0.139	-0.061	0.012	0.038
Initiation time (ms)	0	-.01*	-0.01	0	0.01	0.14	-0.26	0	0.03	-0.05	0.131	-0.041	0.041	0.104
Movement time (ms)	0.22	0.08	.24*	0.09	-0.01	-0.1	0.05	-0.17	0.08	-0.03	-0.044	-0.061	0.084	-0.005
AUC (px^2)	-.25*	0	0.15	0.12	-0.11	-0.09	0	-0.08	0.11	-0.05	0.168	0.007	-0.025	0.109
MAD (px)	-.23*	0	0.19	0.12	-0.14	-0.07	0.01	-0.08	0.12	-0.01	-0.01	0.072	-0.013	0.082

Table S22. Correlation of personality across all variables in rule-breakers in trials associated with negative consequences
Correlation significant at the .05 level (2 – tailed) represented with asterisk (*).
BIS: Behavioural inhibition system. BAS: Behavioural activation system
1 Risk propensity, 2 Agreeableness, 3 Conscientiousness, 4 Extraversion, 5 Openness, 6 Neuroticism, 7 BIS, 8 BAS drive, 9 BAS fun seeking, 10 BAS reward responsiveness, 11 Narcissism: leadership, 12 Narcissism: grandiose, 13 Narcissism: entitlement

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Total pay-off	-0.21	-.37*	-0.23	-0.2	-0.12	0.11	-0.19	0.28	0.29	.25*
Frequency of rule-breaking	-0.2	-.36*	-0.21	-0.15	-0.08	0.09	-0.17	.27*	.26*	0.18
Recency	0.13	0	0.07	0.16	-0.03	0.05	0.02	-0.19	-0.16	-0.08
Latency	-0.16	-.38*	-0.19	-0.13	-0.05	0.07	-0.14	.25*	0.24	0.2
Total time (ms)	-0.08	0.08	.4*	.25*	0.18	-0.1	-0.13	-.34*	-0.01	-0.23
Initiation time (ms)	0.14	0.07	0.08	0.1	0.11	0.05	-0.22	-0.14	-0.12	-0.2
Movement time (ms)	-0.18	0.02	.31*	0.15	.08*	-0.13	0.04	-0.2	0.08	-0.06
AUC (px^2)	-0.16	0.18	0.17	0.2	0.04	-0.13	-0.01	-0.11	0.07	-0.08
MAD (px)	-0.2	0.12	0.15	0.2	0	-0.09	-0.03	-0.09	0.08	-0.04

Table S23. Correlations of personality across all variables in rule-breakers when they break the rule
Correlation significant at the .05 level (2 – tailed) represented with asterisk (*).
BIS: Behavioural inhibition system. BAS: Behavioural activation system
1 Risk propensity, 2 Agreeableness, 3 Conscientiousness, 4 Extraversion, 5 Openness, 6 Neuroticism, 7 BIS, 8 BAS drive, 9 BAS fun seeking, 10 BAS reward responsiveness, 11 Narcissism: leadership, 12 Narcissism: grandiose, 13 Narcissism: entitlement

Highlights

- Individuals who tend to break the rules to obtain higher payoffs experience significantly more cognitive conflict, measured via response times and mouse movement trajectories, than those who follow the rules.
- Cognitive conflict is more pronounced when violating the rules than when following them.
- Cognitive conflict is more intense in the action planning of rule-breaking than in its execution.
- The Decision-Implementation-Mandatory switch-Inhibition model applies to the cognitive schema of interindividual differences in rule-breaking.
- Personality traits seem to play a role in appreciating behaviours and cognitive characteristics of rule-followers and rule-breakers.

Chapter 4

Table of content

1. **Exclusion criteria according to rule-breaking task.**

We excluded practice trials and trials in which the reaction times were below 150ms or above 5000ms. Afterwards, we performed outlier analyses with respect to reaction times according to the outlier labelling rule by Hoaglin, Iglewicz, & Tukey, (1986), which led to the exclusion of one participant.

- Criteria for high rule-breaking tendencies:
  - Less than ≈ 10% of trials break the rule when the consequence of following the rule is positive.
  - Break the rule in more than ≈ 10% of trials when following the rule has a negative consequence. The 10% was chosen to give a margin of error to those participants that break the rule by mistake.
  - Receive benefits in more than ≈ 60% percent of the trials.
  - In order to confirm that conditional high rule-breaking tendencies act according to the internal goals we evaluated the performance of the individuals during the "rule-free" part. In this part, on average participants opt for obtaining a greater amount of stocks for themselves in around 98% of the times.

- Criteria for low rule-breaking tendencies:
  - Less than ≈ 10% of trials break the rule when the consequence of following the rule is positive.
  - More than ≈ 10% of trials break the rule when the consequence of following the rule is negative.
  - In the "rule-free" part, on average participants opt for obtaining a greater number of stocks for themselves in around 98% of the times.

2. **Trial specific amounts of stocks in the rule-breaking task.** Dragging the ball to either the blue or the orange box led to the following consequences in terms of stock amounts: −5000, -3000, −1000, −500, 0, 500, 1000, 3000, 5000. Each participant was confronted with all trial combinations within each block. Each of the stock combinations was presented once, except for the combination -500 versus 500. The distribution of stock was arranged in a way that low rule-breaking tendencies obtain a maximum of 39000 stocks in the "rule" part while high rule-breaking tendencies were able to achieve 171000 stocks. This was monitored with the purpose of increasing motivation of high rule-breaking tendencies to violate the norms.

3. Table with demographic data of the sample

Table S1. Overview demographic variables.

Total Sample	112
Age (SD) [min, max]	25.4(7.61) [18,68]
Female (%)	51 (45.536)
Participants with entrepreneur parents	23
Participants with mother language German	54
Participants with German nationality	56
Participants that have visited an entrepreneurship course	51
Education level: High school degree or equivalent	50

Education level: Bachelor`s degree	49
Education level: Master's degree	13

4. Detailed information about the result's table 2

Non standardised scores and standardised error of the statistical tests performed are included

Table S2. Effects of openness and idealism on entrepreneurial intention, moderated by rule-breaking tendencies.

DV		Entrepreneurial intention							
		Std. coeff.	*Std. error*	*t*	*p*	*Std. coeff.*	*Std. error.*	*t*	*p*
IV	Rule-breaking tendencies (1 = low rule-breaking tendencies, 2 = high rule-breaking tendencies)	-.127	.142	-.89	.38	-1.524	.619	-2.459	.52
	Openness	.239	.180	1.33	.19	-1.592	.246	-.646	.015
Interaction	Rule-breaking tendencies × openness					.407	.176	2.313	.023

IV	Idealism		
Interaction	Rule-breaking tendencies × idealism		
Adjusted R^2		.006	.070
Delta R^2			.064
(Sig.)		.258	(.047)

DV		Entrepreneurial intention							
		Std. coeff.	*Std. error*	*t*	*p*	*Std. coeff.*	*Std. error*	*t*	*p*
IV	Rule-breaking tendencies (1 = low rule-breaking tendencies, 2 = high rule-breaking tendencies)	-.136	.142	-.95	.34	1.638	.885	1.851	.067
	Openness								
Interaction	Rule-breaking tendencies × openness								
IV	Idealism	-.01	-.013	-.74	.46	.011	.017	.663	.509
Interaction	Rule-breaking tendencies × idealism					-.027	.013	-2.031	.045
Adjusted R^2					-.004				.05
Delta R^2									.054
(Sig.)					(.475)				(.136)

5. Table with robustness check analyses

Table S3. Robustness checks of the effects of openness and idealism on entrepreneurial intention, moderated by rule-breaking tendencies.

DV		Entrepreneurial intention							
		Std. coeff.	*Std. error*	*t*	*p*	*Std. coeff.*	*Std. error*	*t*	*p*
Controls	Extraversion	.185	.155	1.19	.237	.189	.153	1.237	.219
	Agreeableness	.187	.162	1.15	.251	.189	.160	1.179	.241
	Conscientiousness	.232	.181	1.28	.205	.24	.179	1.336	.185
	Neuroticism	-.312	.156	-1,99	.049	-.284	.155	-1.830	.070
	Age	-.005	.017	-.33	.746	-.005	.017	-.295	.769
	Sex	.873	.277	3.15	.002	.839	.274	3.062	.002
	Idealism								
IV	Rule-breaking tendencies (1 = low rule-breaking tendencies, 2 = high rule-breaking tendencies)	-.067	.13	-.51	.608	-1.174	.572	-.439	.043
	Openness	.215	.17	1.27	.209	-.102	.231	-2.053	.662
Interaction	Rule-breaking tendencies X openness					.322	.162	1.987	.049
IV	Idealism								
Interaction	Rule-breaking tendencies X idealism								
Adjusted R^2					.182				.269
Delta R^2									.087
(Sig.)					.001				.001

DV		Entrepreneurial intention							
		Std. coeff.	*Std. error.*	*t*	*p*	*Std. coeff.*	*Std. error.*	*t*	*p*
Controls	Extraversion Agreeableness Conscientiousness Neuroticism								
	Age	-.009	.019	-.48	.63	-.01	.019	-.521	.603
	Sex	-.92	.288	3.20	.00	.873	.287	3.043	.003
	Relativism	.015	.013	-1.16	.250	-.012	.013	-.915	.363
IV	Rule-breaking tendencies (1 = low rule-breaking tendencies, 2 = high rule-breaking tendencies) Openness	.088	.139	-.64	.525	1.348	.869	1.55	.124
Interaction	Rule-breaking tendencies X openness								
IV	Idealism	.004	.013	.35	.72	-.021	.016	1.253	.213
Interaction	Rule-breaking tendencies X idealism					-.022	.013	-.915	.097
Adjusted R^2					.066				.132
Delta R^2									.065
(Sig.)					.031				.019

Note. N = 112. When adding covariates, the regressions showed similar results for the interaction analyses.

1.Methods

1.1 Computerised task

1.1.1 Exclusion criteria for participants

1.1.2 Measures of all the objects displayed on the screen

1.1.3 Trial Structure

1.1.4 Specific splits of number of stocks displayed on the coloured boxes

1.1.5 Mouse-tracking processing

1.1.6 Eye-tracking setup and programs, and processing

1.1.6.1 Eye-tracking set up and programs.

1.1.6.2 Eye-tracking processing.

1.1.7 EEG preprocessing and processing

1.1.7.1 EEG Preprocessing.

1.1.7.2 EEG detailed processing to obtain delta bandpower in frontocentral and parietal electrode sites.

1.1.8 Questionnaires factor analyses

1.1.8.1 Entrepreneurial self-efficacy.

1.1.8.2 Behavioural inhibition.

2.Results

2.1 Robust checks analyses for the first hypothesis

2.2 Cognitive-conflict-capacity index

2.3 Correlation and regression supporting analyses related to the second hypothesis

2.3.1 Bivariate correlations and descriptive statistics of the parameters that measured cognitive-conflict-capacity in trials associated to negative consequences

1. Methods

1.1 Computerised task

The computerised task was designed in E- Prime 3.0 (Psychological Software Tools, Pittsburgh, PA) and conducted on a monitor (24-inch Predator display, resolution of 1920 × 1080 px, refresh rate of 144Hz). The computer had an Intel Core i5-9600 CPU @ (3.7 GHz) processor and an NVIDEA GeForce RTX 2060 SUPER graphic card. Participants sat in front of the device with a distance of at least 65 cm, to ensure that their visual field covered the entire screen. The mouse coordinates were at the sample rate of 13-14 Hz. The mouse was configured with a report rate of 1000 Hz and 800 dpi, and mouse precision was deactivated.

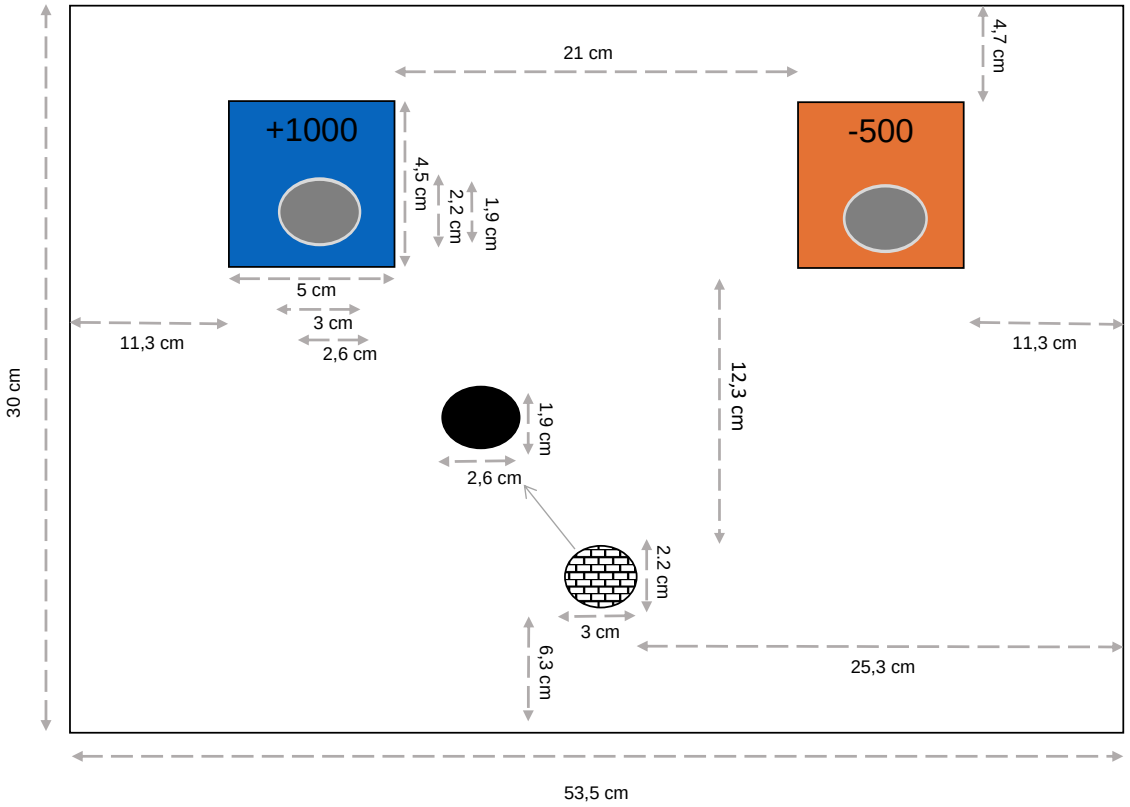
The computerised task was designed in E- Prime 3.0 (Psychological Software Tools, Pittsburgh, PA) and conducted on a monitor (24-inch Predator display, resolution of 1920 × 1080 px, refresh rate of 144Hz). The computer had an Intel Core i5-9600 CPU @ (3.7 GHz) processor and an NVIDEA GeForce RTX 2060 SUPER graphic card. Participants sat in front of the device with a distance of at least 65 cm, to ensure that their visual field covered the entire screen. The mouse coordinates were at the sample rate of 13-14 Hz. The mouse was configured with a report rate of 1000 Hz and 800 dpi, and mouse precision was deactivated.

1.1.1 Exclusion criteria for participants

- Four participants were excluded because the EEG presented a strange sinusoidal artifact throughout all the recording.
- One participant was excluded because the computerised task crashed in the middle of the experiment due to the extension of the task. For these reasons, the researchers opted for dividing the task into two parts.
- Trials that took less than 150 ms or more than 5000 ms were excluded to control for attention to the stimuli presented on the screen.

- After averaging response times, mouse-trajectory parameters, and eye-tracking parameters across participants for outlier exclusion, no participants were additionally excluded.

1.1.2 Measures of all the objects displayed on the screen



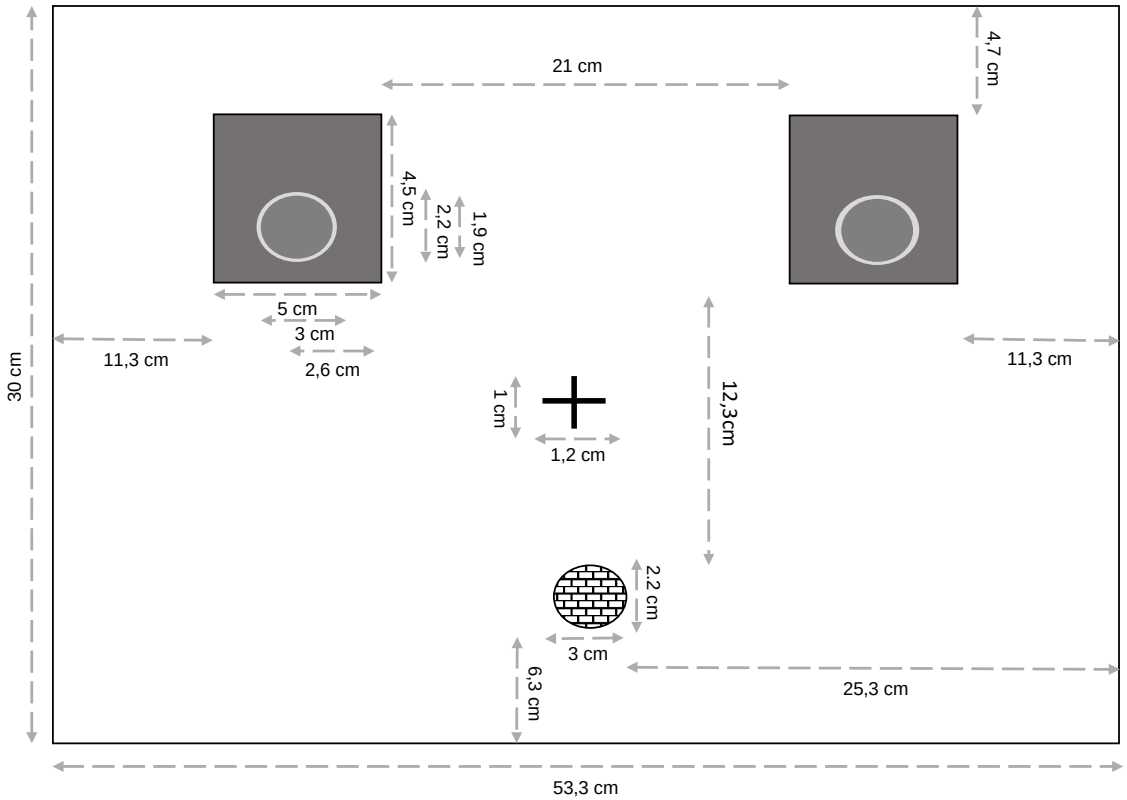


Figure S1. Measurements of the object on the screen of the computerised task

1.1.3 Trial Structure

Each trial began with a fixation cross of 500-700 ms duration (jittered randomly in steps of 20 ms). Once the fixation cross faded, the screen displayed a cross-shaped cursor in the centre of the screen, a brick-texture circle in the lower part, and two grey boxes on the superior parts of the screen (for further information about the stimuli see the supplementary material). Immediately after the participants placed the cross-shaped cursor on the brick-texture circle located in the lower part of the screen, a black ball was displayed as the cursor, two boxes changed colour (blue or orange respectively), and a specific number of stocks was displayed inside each coloured box. The time spent inside the brick-texture circle, while the number of stocks appeared, was registered as the initiation time. In other words, this is the time in which participants prepare themselves for either breaking or following rules. The

participants then dragged the ball at the bottom of the screen into one the grey circles into one of the coloured boxes with the stocks. Thus, participants completed a trial. Their placement of the ball into the coloured box demonstrated their decision for which box to choose. The time between the ball being dragged from its original position to one of the boxes was registered as the movement time. That is the time they took to execute the action of rule-following or rule-breaking. If participants took more than 1000 ms to complete this action, a message, "Please try to leave the home-area as quickly as possible!" was displayed. This ensured that the participants remained focused on the task. The assignment of the colours to each of the boxes was randomised across all trials. The use of blue versus orange ensured that all participants recognised them as two different colours, even if they were colour-blind (see *Figure 3*).

1.1.4 Specific splits of number of stocks displayed on the coloured boxes

We followed the same structure used by Gross et al. (2018). The only difference is that we use "Stocks" as incentive for rule-breaking behaviour. In the following picture you will see the combinations of stocks used in each of the blocks of the task. In a "rule" block in which the rule is: "the rule is to put each ball in the blue area", the numbers in blue will appear in that box and the number in orange will appear in the orange box. The cells with background white indicate positive consequences–if following the rule. The cells with background grey indicate neutral consequences–if following the rule. The cells with background dark grey indicate negative consequences–if following the rule.

	-5000	-3000	-1000	-500	0	500	1000	3000	5000
-5000					1				
-3000		1	1	1	1	1	1	1	
-1000		1	1	1	1	1	1	1	
-500		1	1	1	1	1	1	1	
0	1	1	1	1	1	1	1	1	1
500		1	1	1	1	1	1	1	
1000		1	1	1	1	1	1	1	
3000		1	1	1	1	1	1	1	
5000					1				

1.1.5 Mouse-tracking processing

For the processing of mouse-tracking parameters see GitHub repository: Cubillos-Pinilla, L. Script for mouse movement, mouse tracking parameters [Computer software].

1.1.6 Eye-tracking setup and programs, and processing

1.1.6.1 *Eye-tracking set up and programs*.

The eye-tracker was placed bellow the monitor and calibration were performed at the beginning of the experiment. Calibration and communication between the software used for the computerised task, E-Prime software was performed using the E-prime extensions for Tobii Pro 3.2 software (Psychological Software Tools, Pittsburgh, PA). The software used to implement the triggers to analyse the data was Tobii Pro Lab (Tobii Pro AB (2014). Tobii Pro Lab (Version 1.171.34906 x64) [Computer software]. Danderyd, Sweden: Tobii Pro AB.),

1.1.6.2 **Eye-tracking processing.**

The triggers were marked for the beginning of the trial (from the time the participant must take the cursor down to the brick-texture circle to pick up the ball) till the end of the trial (the moment in which the participants put the ball in one of the boxes). Due to limitations of the programs for adding these triggers, each eye-tracking trial data-point has the noise associated to the eye-tracking data occurring before the participant "picked up" the ball from the brick-texture circle. Therefore, to get a ride of this noise, we opted for dividing the screen in three parts and exclude the middle part for further analyses. In this form we only include the number of fixations and the velocity of saccades (to be precise the peak of velocity of the exit saccade) of the left and right sides of the screen. Moreover, the program also presented the limitation that the last trial of each block took till the beginning of the first trial for completion. Therefore, the last trial of all blocks was excluded for further analyses. Interesting, further analyses showed that participants when breaking the rule spend more time and increased fixations in the side they are looking to go for breaking the rule than in the side for following the rule.

1.1.7 EEG preprocessing and processing

The setup and EEG procedure takes two trained researchers to set up the cap, and one researcher to continuously observe the signal throughout the experiment to avoid any noise in the signal produced by external factors (e.g., accommodate participants due to high-frequency noises due to crossing cables as a consequence of participants' body movement). The number of electrodes is defined according to the EEG forward model, which recommends using average reference in the analyses of frequency bands to control for the source projection error (Acar & Makeig, 2013; de Munck et al., 2012). Participants were encouraged to reduce eye blinking, mainly during the period between target onset and response, in order to minimize artifacts in the EEG data.

Limitations: While allocating the cap with thirty-two Ag/AgCl electrodes to achieve a low impedance implies extensive preparation times, it also ensures good raw data quality. The number of electrodes is defined according to the EEG forward model, which recommends using average reference in the analyses of frequency bands to control for the source projection error (Acar & Makeig, 2013; de Munck et al., 2012). Moreover, activities such as adapting the computerised tasks to all the neurocognitive methods and analysing the data are time-consuming. The complexity of the employed computerised task necessitates fully custom-developed code that is not available in current commercial programs. For instance, the demarcation of the remaining trials of interest during EEG processing needed to be implemented and tested for each participant.

1.1.7.1 EEG Preprocessing.

First, we filtered the data according to previous literature in the context of instructed rule-breaking (Pfister et al., 2016). The data was filtered with a .1 Hz high pass filter, a 70 Hz low-pass filter, and a (47.5 Hz- 52.5 Hz) band-stop filter. Next, automatic channel rejection (Z-score maximum threshold: 5) was performed, however only one channel was deleted in four participants. Afterwards, the data was segmented into target-locked epochs around the onset of the display of the number of stocks to the participants (200ms prestimulus to 1000ms poststimulus) and baseline corrected using the first 200ms prestimulus. In order to get rid of artifacts associated with muscular activity and eye movements, an independent component analysis was performed using the runnica algorithm(Delorme et al., 2007; Pernet et al., 2022), and the resulted components were flagged as artifacts using ICALabel and

removed at .9-1 as the range of probability (Pion-Tonachini et al., 2019). Afterwards, an automated simple voltage limits (-100 125 uV) were settled to finish with the clean of the signal (Saastamoinen et al., 1998). In all the subjects, less than 20% of the trials were excluded. Finally, channels were automatically interpolated assuming the sphere model in those participants were channel rejection occurred (Pedroni et al., 2019; Saba-Sadiya et al., 2020). All the rights reserved for this preprocessing protocol to Leidy Cubillos-Pinilla. Please cite this paper if you perform the same protocol.

Pedroni, A., Bahreini, A., & Langer, N. (2019). https://doi.org/10.1016/j.neuroimage.2019.06.046

Pion-Tonachini, L., Kreutz-Delgado, K., & Makeig, S. (2019). Ihttps://doi.org/10.1016/j.neuroimage.2019.05.026

Saastamoinen, A., Pietilä, T., Värri, A., Lehtokangas, M., & Saarinen, J. (1998). https://doi.org/10.1016/S0925-2312(98)00005-8

Saba-Sadiya, S., Alhanai, T., Liu, T., & Ghassemi, M. M. (2020). https://doi.org/10.1109/BIBM49941.2020.9312979

1.1.7.2 EEG detailed processing to obtain delta bandpower in frontocentral and parietal electrode sites.

After the data was clean, we decided to perform the following steps to obtain the delta bandpower during the initiation time, that is the time spend in planning the action (i.e., rule-breaking or rule-following) in trials associated with a negative consequence. As every EEG data set based in trials, this data set had trials which were not possible to be recorded per conditions, and some of the trials were rejected in the pre-processing (less than 20% of trials were rejected per participants and per condition). However, we need to know which trial corresponded to the specific initiation times, to adjust the windows of delta bandpower analyses. This process was done using the EEG-LAB toolbox, given that we were going to analyse this data along with other parameters and due to the immense number of trials and subjects, there was a necessity to build a script in the software that could save us time identifying automatically which trials were rejected and subsequently mark the trials of each subject with their respective condition and match them with their respective reaction times that are essential to this study. Further details can be found in the following GitHub repository: Varona Camacho, J. A. Script for marking EEG rejecting trials, organizer and processor [Computer software], https://github.com/MSNEvarona/Master_Thesis.git. In total the analyses were performed with 5247 trials, 3782 corresponding to follow the rules and 1465 corresponded to breaking the rules. Afterwards, the delta

bandpower analyses were performed as described in the paper, see also: Varona Camacho, J. A. Script for marking EEG rejecting trials, organizer and processor [Computer software], https://github.com/MSNEvarona/Master_Thesis.git.

1.1.8 Questionnaires factor analyses

1.1.8.1 Entrepreneurial self-efficacy.

Principal Component Analysis showed that all items belong to one component

Questionnaire items	Variance explained
I can work productively under continuous stress, pressure and conflict.	.549
I can originate new ideas and products.	.773
If I were an entrepreneur, I can develop and maintain favourable relationships with potential investors.	.797
If I were an entrepreneur, I can see new market opportunities for new products and services.	.821
If I were an entrepreneur, I can recruit and train key employees.	.571
I can develop a working environment that encourages people to try out something new.	.763

1.1.8.2 Behavioural inhibition.

Principal Component Analysis showed that all items belong to one component

Questionnaire items	Variance explained
Even if something bad is about to happen to me, I rarely experience fear or nervousness.	.661
Criticism or scolding hurts me quite a bit.	.657
I feel pretty worried or upset when I think or know somebody is angry at me.	.802
If I think something unpleasant is going to happen I usually get pretty "worked up."	.756
I feel worried when I think I have done poorly at something important.	.671
I have very few fears compared to my friends.	.615
I worry about making mistakes.	.777

2. Results

2.1 Robust checks analyses for the first hypothesis

DV							
		Std. coeff.	*t*	*p*	*Std. coeff.*	*t*	*p*
IV	Deliberative rule-breaking tendencies	.003	.802	.427	0	.09	.928
	Behavioural inhibition	.065	2.403	.021	.09	3.896	0
Interaction	Deliberative rule-breaking tendencies x Behavioural inhibition	.002	2.634	.012	0	.867	.391
Covariates	Sex	.057	.238	.813	.166	.799	.429
	Age	.022	.6	.552	.031	.338	.738
	BAS: drive						
	BAS: fun seeking						
	BAS: responsive reward						
Adjusted R^2				.245			.529
Delta R^2				.121			.405
(Sig.)				.025			0

Note. Deliberative rule-breaking tendencies is defined by the percentage of frequency of deliberate rule-breaking
N = 50; for robustness checks analyses see supplementary material (*Table S2*).

2.2 Cognitive-conflict-capacity index

Cognitive-conflict-capacity index was calculated including the following parameters: total time, initiation time, maximum absolute distance, area under the curve, number of fixations, velocity of saccades, delta band power in frontocentral sites, delta band power in parietal sites.

And by performing the following steps:

1. Selecting the data of the trials associated with negative consequences for each of the parameters
2. Averaging the data of trials per subject
3. Calculating the logarithmic transformation of all the parameters. Note: For the delta bandpower in the frontocentral and parietal sites, we obtained negative and positive values and for this reason we had to make an step before the logarimic transformation of them. We opted for the neglog transformation approach described by Whitaker (2005).

Reference:
Whittaker, J., Whitehead, C., & Somers, M. (2005). The neglog transformation and quantile regression for the analysis of a large credit scoring database. *Journal of the Royal Statistical Society: Series C (Applied Statistics)*, *54*(5), 863-878.

2.3 Correlation and regression supporting analyses related to the second hypothesis

2.3.1 Bivariate correlations and descriptive statistics of the parameters that measured cognitive-conflict-capacity in trials associated to negative consequences

Variables in the survey	Mean (min/max)	SD	1	2	3	4	5	6	7	8
1. Total time	861.28 (534.05/1730.4	251.04	-							
2. Initiation time	450.58 (202.93/1051.1	176.17	.922**	-						
3. Maximum absolute distance (px)	454.88 (417.72/677.89	44.40	.311*	.271	-					
4. Area under the curve (px^2)	8056.05 (4068.41/22	3531.58	.347*	.178	.638**	-				

5. Number of fixations	4.54 (0.73/7.13)	1.48	.430**	.378**	.316*	.333*	-			*
6. Velocity of saccades	272.72 (16.43/788.53)	144.92	.204	.224	.074	.177	.424**	-		
7. Frontocentral delta bandpower (uV^2/Hz)	-9.53 (-13.70/-4.92)	1.86	-.484**	-.524**	.058	-.108	-.001	-.259	-	
8. Parietal delta bandpower (uV^2/Hz)	-9.52 (-13.90/-5.75)	1.82	-.454**	-.528**	.055	-.139	.30	-.243	.867**	-

Correlation significant at the .05 level (2 – tailed). **Correlation significant at the .01 level (2 – tailed).
[a] 1 = female. 2 = male. SD = Standard deviation
Note: further details that include only trials were participants broke/followed the rules, should be requested to the authors.

2.3.2 Independent regression analyses of the parameters that measured cognitive-conflict-capacity in trials associated to negative consequences as independent variables, and deliberative rule-breaking tendencies as dependent variables

To prevent any confounds regarding the reliability of the cognitive-conflict capacity index, all analyses were executed not only using the cognitive-conflict index, but also using the parameters independently.

- An independent linear regression was performed using the total time as independent variable and the percentage of frequency of deliberative rule-breaking tendencies as dependent variable. The total time was a significant predictor of the percentage of frequency of deliberative rule-breaking tendencies, F[1,49]=26,667, b=0,598,t=5,164, p<.001, R^2=0,357).

- An independent linear regression was performed using the initiation time as independent variable and the percentage of frequency of deliberative rule-breaking tendencies as dependent variable. The initiation time was a significant predictor of the percentage of frequency of deliberative rule-breaking tendencies, F[1,49]=33,896, b=0,643, t= 5,822, p<.001, R^2=0,414).

- An independent linear regression was performed using area under the curve as independent variable and the percentage of frequency of deliberative rule-breaking tendencies as dependent variable. The area under the curve was a significant predictor of the percentage of frequency of deliberative rule-breaking tendencies, F[1,49]=14,792, b=0,485, t=3,846, p<.001, R^2=0,236).

- An independent linear regression was performed using maximum absolute distance as independent variable and the percentage of frequency of deliberative rule-breaking tendencies as dependent variable. The maximum absolute distance was a significant predictor of the percentage of frequency of deliberative rule-breaking tendencies, $F[1,49]=5,961$, $b=0,332$, $t=2,441$, $p<.05$, $R^2=0,110$).

- An independent linear regression was performed using the number of fixations as independent variable and the percentage of frequency of deliberative rule-breaking tendencies as dependent variable. The number of fixations was a significant predictor for the percentage of frequency of deliberative rule-breaking tendencies, $F[1,48]=8,259$, $b=0,016$, $t(48)= 2,874$, $p=0,006$, $R^2=0,147$).

- An independent linear regression was performed using the peak velocity of exit saccades left and right as independent variable and the percentage of frequency of deliberative rule-breaking as dependent variable. The peak velocity of exit saccades left and right was a significant predictor for the percentage of frequency of deliberative rule-breaking, $F[1,48]=5,583$, $b=0,079$, $t(48)= 2,363$, $p=0,022$, $R^2=0,104$).

- An independent linear regression was performed using the delta bandpower measured in frontocentral electrodes as independent variable and the percentage of frequency of deliberative rule-breaking as dependent variable. The delta bandpower measured in frontocentral electrodes was a significant predictor of the percentage of frequency of deliberative rule-breaking, ($F[1,48]=7,325$,$b=-,364$,$t(48)=-2,707$, $p<.01$, $R^2=,132$).

- An independent linear regression was performed using the delta bandpower measured in parietal electrodes as independent variable and the percentage of frequency of deliberative rule-breaking as dependent variable. The delta bandpower measured in parietal electrodes was a significant predictor of the percentage of frequency of deliberative rule-breaking. ($F[1,48]=7,311$,$b=-,364$,$t(48)=-2,704$, $p<.01$,$R^2=,132$).

2.4 Robust checks analyses for the second hypothesis

The same regression analyses were repeated by adding the covariates age and sex:

- A one-way ANOVA was performed to compare the effect of the total time, age and sex as independent variables on the percentage of frequency of deliberative rule-breaking tendencies as the dependent variable. The total time had a significant effect on the percentage of frequency of deliberative rule-breaking tendencies, $F[18,31]=5,814$, $p<.001$.

- A one-way ANOVA was performed to compare the effect of the initiation time, age and sex as independent variables on the percentage of frequency of deliberative rule-breaking tendencies as the dependent variable. The initiation time had a significant effect on the percentage of frequency of deliberative rule-breaking tendencies, $F[18,31]=5,614$, $p<.001$.

- A one-way ANOVA was performed to compare the effect of area under the curve, age and sex as independent variables on the percentage of frequency of deliberative rule-breaking tendencies as the dependent variable. Area under the curve had a significant effect on the percentage of frequency of deliberative rule-breaking tendencies, F[18,31]=8,809, p<.001.

- A one-way ANOVA was performed to compare the effect of maximum absolute distance, age and sex as independent variables on the percentage of frequency of deliberative rule-breaking tendencies as the dependent variable. Maximum absolute distance had a significant effect on the percentage of frequency of deliberative rule-breaking tendencies, F[18,31]=17,586, p<.001.

- A one-way ANOVA was performed to compare the effect of the number of fixations, age and sex as independent variables on the percentage of frequency of deliberative rule-breaking tendencies as the dependent variable. The number of fixations had no significant effect on the percentage of frequency of deliberative rule-breaking tendencies, F[18,31]=1,535, p=.144.

- A one-way ANOVA was performed to compare the effect of peak velocity of exit saccades left and right, age and sex as independent variables on the percentage of frequency of deliberative rule-breaking tendencies as the dependent variable. Peak velocity of exit saccades left and right had no significant effect on the percentage of frequency of deliberative rule-breaking tendencies, F[18,31]=1,851, p=.64.

- A one-way ANOVA was performed to compare the effect of delta bandpower measured in frontocentral electrodes, age and sex as independent variables on the percentage of frequency of deliberative rule-breaking tendencies as the dependent variable. Delta bandpower measured in frontocentral electrodes had no significant effect on the percentage of frequency of deliberative rule-breaking tendencies, F[18,31]=1,196 , p=0.321.

- A one-way ANOVA was performed to compare the effect of delta bandpower measured in parietal electrodes, age and sex as independent variables on the percentage of frequency of deliberative rule-breaking tendencies as the dependent variable. Delta bandpower measured in parietal electrodes had a significant effect on the percentage of frequency of deliberative rule-breaking tendencies, F[18,31]=3,378, p=.001.