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Can cognitive biases be good for entrepreneurs?

Cognitive
biases of
entrepreneurs

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Abstract

Purpose – While some studies have found that cognitive biases are detrimental to entrepreneurial performance, others have conjectured that cognitive biases may stimulate entrepreneurial action. This study uses a typology of availability and representative heuristics to examine how two patterns of biases affect entrepreneurial performance. Drawing on ideas from cognitive science, this study predicts that various levels of biases in each pattern stimulate entrepreneurial behavior and performance.

Design/methodology/approach – A profile-deviation approach was employed to analyze data from 253 entrepreneurs and zero-truncated Poisson regression and the zero-truncated negative binomial regression to test hypotheses.

Findings – This study finds some positive associations between a particular level of cognitive biases in each of the two patterns and entrepreneurial behavior and performance. Results show that the patterns of biases often stimulate and never hurt entrepreneurial behavior and performance. The opposite holds for a lack of cognitive biases, which hurts and never stimulates entrepreneurial behavior and performance.

Originality/value – This study examines patterns of cognitive biases of entrepreneurs instead of single biases. The study broadens the perspective on the heuristics and cognitive biases of entrepreneurs by examining patterns of biases emanating from the availability and the representativeness heuristic that make a difference for entrepreneurial behavior and performance. The study also brings the “great rationality debate” closer to the entrepreneurship field by showing that a normative rule based on statistics and probability theory does not benefit entrepreneurial behavior and performance.

Keywords Cognitive science, Profile-deviation approach, Cognitive biases, Entrepreneurial behavior, Entrepreneurial performance

Paper type Research paper

Introduction

Recent research has investigated how the entrepreneurial setting, with its high level of risk, uncertainty, time pressure and emotional intensity and the characteristics of entrepreneurs themselves affect entrepreneurial decision-making (Mitchell *et al.*, 2002; Sheperd *et al.*, 2015). Examining entrepreneurs' cognitive biases may also provide interesting insights into entrepreneurial behavior (Keh *et al.*, 2002; Zhang and Cueto, 2017). In the entrepreneurship literature, the general perception of biases has been negative (Zhang and Cueto, 2017), with cognitively biased thought processes involving erroneous inferences or assumptions and biased decision-making leading to major mistakes (Forbes, 2005; Baron, 1998). This study examines explicitly whether cognitive biases are good or bad for entrepreneurial behavior and performance.

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Studies of cognitive biases across several fields have asserted varied opinions. For example, from a judgment and choice perspective, some researchers have perceived cognitive biases to be systematic errors both in the use of logic and with respect to the principles of probability theory (Kahneman, 2003; Kahneman and Tversky, 1973; Stanovich, 2009; Tversky and Kahneman, 1974), but other cognitive researchers have criticized this strict adherence to normative rules of logic and probability (Cohen, 1981; Gigerenzer, 1996; Tetlock and Mellers, 2002). In the strategic management literature, cognitively biased judgments have been referred to as being “faulty” (Barnes, 1984, p. 129). In their work, Keh *et al.* (2002) presented ways to overcome biases that imply that cognitive biases are undesirable.

A more controversial perspective offered by Burmeister and Schade (2007) argued that, on one hand, the bounded rationality of real decision-makers makes the use of simple decision heuristics advantageous. But they acknowledged that, on the other hand, cognitive biases may lead to less comprehensive decision-making, hindering new ventures’ performance. Another suggestion was that cognitive biases might be advantageous for the decision to start a venture or introduce risky products but ultimately lead to decreased venture performance (Simon *et al.*, 2000; see also Simon and Houghton, 2003). Thus, even entrepreneurship researchers with the most positive viewpoint have asserted that although cognitive biases may stimulate entrepreneurial behavior, they are still detrimental for entrepreneurial performance. However, to date this assertion has not been unilaterally and empirically confirmed.

Following the ideas of Baron (2007) and Zhang and Cueto (2017), the authors anticipate that any entrepreneur faces not just a single bias but uses a pattern of biases simultaneously. This study uses the typology of biases of Kahneman and Tversky (e.g. Kahneman, 2003). Overconfidence, illusion of control and sample size fallacy have been studied extensively in relation to entrepreneurship (Forbes, 2005; Hayward *et al.*, 2010; Keh *et al.*, 2002; Simon *et al.*, 2000; Simon and Houghton, 2003). However, hindsight bias (Cassar and Craig, 2009), illusory correlation, base-rate fallacy and regression fallacy have received only limited attention in the entrepreneurship field. Studying two patterns of biases emanating from two different heuristic has methodological implications.

This study uses a profile-deviation approach to analyze data from 253 entrepreneurs and zero-truncated Poisson regression and the zero-truncated negative binomial regression to test hypotheses. Instead of a reductionist approach in which single biases can be examined, a systems approach is needed to investigate the two patterns of biases (i.e. the bias profile of an entrepreneur) in a more holistic way (Drazin and Van de Ven, 1985; Hill and Birkinshaw, 2008; Hult *et al.*, 2006; Venkatraman, 1989; Venkatraman and Prescott, 1990; Vorhies and Morgan, 2003).

This study uses insights from cognitive science to develop hypotheses. In particular, it predicts that for each pattern, a particular level of cognitive biases (the bias profile of the entrepreneur) might stimulate entrepreneurial behavior and performance. Thus, the bias profile of a successful entrepreneur will exhibit some particular level of biases, which may not be the lowest level possible. Moreover, this study predicts that limiting the level of biases within each pattern as much as possible will be detrimental for entrepreneurial behavior and performance.

The empirical results offer support for the hypotheses and thereby contribute to entrepreneurial cognition literature in several ways. First, it broadens the perspective on the heuristics and cognitive biases of entrepreneurs by examining patterns of biases emanating from the availability and representativeness heuristics that influence entrepreneurial behavior and performance. Four of the biases in these patterns are relevant for entrepreneurs but, until now, have received only limited research attention. Second, it offers future research directions for studying heuristics and biases for entrepreneurs, including the state-quasi-trait debate about whether biases are evoked by conditions associated with the task

of entrepreneurship (e.g. time pressure, uncertainty, information overload; [Baron, 1998](#); [Forbes, 2005](#); [Kahneman and Tversky, 1973](#)) or are quasi-traits. Third, it brings the “great rationality debate” closer to the entrepreneurship field ([Zhang and Cueto, 2017](#)) by showing that a normative rule based on logic and probability theory does not benefit entrepreneurial behavior and performance and suggesting future research directions that can lead to better rules.

Theoretical background

Heuristics and biases

The discussion of cognitive limitations or cognitive (in)abilities tends to focus on the concepts of heuristics and biases. Heuristics are simplifying shortcuts that enable people to make quicker, easier judgments ([Bingham and Eisenhardt, 2014](#)). A judgment is influenced by a heuristic if people do not use the target attribute of the object or subject to develop that judgment but instead substitute a related attribute that comes more readily to mind ([Kahneman, 2003](#); [Maitland and Sammartino, 2015](#)). For example, the distance to an object can be determined more easily by its clarity: the more sharply an individual sees the object, the closer it appears to be. The simplifying rule may have some validity, but too much reliance on such a heuristic may lead to misinterpretations, such that, in the example, distance would be overestimated in conditions marked by poor visual clarity. Examples from the entrepreneurship field include the investment decisions in entrepreneurial opportunities by business angels. Many of the initial decisions are based on entrepreneur’s pitch presentations. The quality of the opportunity is in general overestimated when the entrepreneur is very good at pitching, while it is underestimated in the opposite situation. These misinterpretations are referred to as cognitive biases ([Tversky and Kahneman, 1974](#)). Dozens of such biases are detailed in the cognitive science literature ([Simon et al., 2000](#)). Based on the Kahneman and Tversky’s typology of cognitive biases into availability or representativeness heuristics, this study concentrates on seven cognitive biases that result from these two heuristics ([Kahneman, 2003](#)).

Thus, we study two patterns of biases, one pattern emanating from the availability heuristic, the other one rooted in the representativeness heuristic. For each of these two patterns of biases, we consider two bias profiles. In the ecological profile, each pattern shows levels of cognitive biases equal to those a successful entrepreneur exhibits, which may not be the lowest level possible. In the normative profile, for each pattern the level of cognitive biases is consistent with the normative rules of logic and probability theory, meaning that for each pattern the cognitive biases are as limited as possible. Note that in a sense the ecological and normative profiles are incompatible as they are based on two different, incongruous interpretations of the bounded rationality perspective ([Todd and Gigerenzer, 2003](#)).

Hypotheses

Bias pattern emanating from the availability heuristic

The availability heuristic is often used by people if fast answers are required with respect to the frequency of a class or the probability of an event ([Tversky and Kahneman, 1974](#), p. 1,127). The heuristic reflects decision-making based on examples or associations that come easily to mind. Thus, only a limited amount of information—that which comes readily to mind—is used to make a judgment. Three cognitive biases, hindsight bias, illusory correlation and overconfidence emanate from this heuristic.

Hindsight bias appears when, after a certain event occurs, people tend to remember their prediction about the event as being more accurate than it actually was. So, there is an inconsistency in the prediction of the outcome before and after knowing the actual outcome of

the event (Slovic and Fischhoff, 1977). Remembrance of former predictions is partly disturbed by the availability of recent, new information about the predicted event. Entrepreneurs facing hindsight bias probably will have a restrictive way of learning from less successful actions in the past.

Illusory correlation happens when people put too much weight on available instances of occurrence. They consider the instances of cooccurrence between events that come readily to mind as the correlation between the events in a wider population (Cohen, 1981). Entrepreneurs suffering from illusory correlation may incorrectly associate a certain action with a particular good result, thereby creating a too positive picture about the controllability of their situation.

Overconfidence occurs when individuals do not recognize the limits of their own knowledge (Forbes, 2005; Russo and Schoemaker, 1992). People overestimate the match between their own easily accessible, available knowledge and the knowledge that is required in a particular situation. Entrepreneurs facing overconfidence generally will not have strong intentions to acquire new, diverse information and knowledge about their current and future entrepreneurial actions and decisions. It is assumed that using the availability heuristic will trigger all three biases to some extent.

The first two hypotheses were based on the work of two cognitive science researchers. According to Cohen (1981), the availability heuristic refers to the use of available general knowledge and situational knowledge (events) for making decisions. The store of knowledge drawn upon may or may not be representative of the total population of general and situational knowledge. If it is, then making use of the availability heuristic offers advantages in terms of frugality and speed of decision-making (Todd and Gigerenzer, 2003). If it is not, there are clear disadvantages. It is suggested that successful entrepreneurs have built a representative sample of general and situational knowledge. Thus, for instance, in the case of illusory correlation, the successful entrepreneurs would be expected to build a representative picture of well-known occurrences that make clear whether certain actions taken in a particular situation are supportive for entrepreneurial behavior or performance.

Stanovich (2009) proposed that people making use of the availability heuristic apply not fully correct, “contaminated” mindware in their decision-making. Such mindware may be rooted in history or be colored by important recent events. The quality of decision-making is determined by the extent of the difference between this contaminated mindware and fully valid mindware. For successful entrepreneurs applying the availability heuristic, this distance is so small that even employing the contaminated mindware works well for current actions and decisions related to starting, forming and managing a new venture.

Therefore, it is posited that successful entrepreneurs have built a pattern of biases based on the use of the availability heuristic that sufficiently covers the general and situational knowledge that is required for current successful entrepreneurial behavior and performance. Deviation from these ecological biases profile will harm decision-making. In particular, strictly adhering to the (normative) rules of logic and probability theory will demand more (largely unnecessary) thinking, which will hurt the frugality and speed of decision-making. Therefore, it is hypothesized that:

- H1. Deviation from the ecological profile of cognitive biases emanating from the availability heuristic is negatively associated with entrepreneurial behavior and performance.
- H2. Deviation from the normative profile of cognitive biases emanating from the availability heuristic is positively associated with entrepreneurial behavior and performance.

Bias pattern emanating from the representativeness heuristic

People may use the representativeness heuristic as a shortcut when fast answers are required about the probability that an object A belongs to class B, an event A originates from class B or process B will generate event A (Tversky and Kahneman, 1974, p. 1,124). With this heuristic people make decisions based on attributes that resemble or are similar to the target attribute. Biases emanating from the representativeness heuristic tend to give an overly positive image to entrepreneurial events, like starting a venture but also going on to successfully managing it. In particular, these biases give an overly positive idea about the controllability of entrepreneurial events [1]. Four cognitive biases, base-rate fallacy, illusion of control, regression fallacy and sample size fallacy are rooted in this heuristic.

Base-rate fallacy occurs when people neglect base-rate statistics in favor of caricatural or unimportant personal information. If entrepreneurs have a high level of base-rate fallacy, they will not use base-rate statistics in their decision-making about starting a new venture or forming and managing it; they will instead rely on more personal information about caricatures of entrepreneurial reality.

Illusion of control happens when people neglect the role of chance, instead considering events that are chance determined to be skill determined. Thus, for these people, skill represents chance. Entrepreneurs with a high level of illusion of control may overestimate the level of control they have over events in their lives (Langer and Roth, 1975; Zuckerman *et al.*, 1996).

Regression fallacy appears when people try to explain a statistical phenomenon through a causal mechanism: instead of adequately considering the natural fluctuation of variables around a certain mean, they incorrectly explain the statistical phenomenon through causality. They thus assume that an outlier in the probability distribution resembles the mean of the distribution. Entrepreneurs facing regression fallacy may erroneously think that their actions will deliver particular positive outcomes, thereby regarding their entrepreneurial setting as being more controllable than it actually is. Sample size fallacy occurs when people neglect the statistical logic of drawing inferential conclusions about a population without taking the sample size into account. Thus, people assume a similarity between a (small) sample and the whole population (Tversky and Kahneman, 1974). Entrepreneurs facing sample size fallacy may base their decisions about starting, forming and managing a new venture on success stories of new ventures that are widely covered in journals and newspapers while overlooking the numerous failures that go largely unreported (Simon and Houghton, 2003). This study assumes that entrepreneurs making use of the representativeness heuristic will trigger all four biases to some extent.

The hypotheses were formulated by drawing on prior work in cognitive science again. Cohen (1981) claimed that making use of the representativeness heuristic reflects a lack of mathematical and statistical expertise. Not everyone can be expected to readily acknowledge and give consideration to these mathematical and statistical principles. But Cohen does not consider the representativeness heuristic as a potentially fallacious heuristic. Instead, it is a quite reliable, albeit somewhat crude, mode of common-sense reasoning under conditions of uncertainty (Cohen, 1981, p. 330). Similarly, Stanovich (2009) described people who use the representativeness heuristic as having a kind of mindware gap for dealing with mathematics and statistics. This mindware gap leads people to a too optimistic picture of the controllability of the entrepreneurial setting and an underestimation of risks and uncertainties. Some level of bias in dealing with risks and uncertainties may stimulate entrepreneurial behavior and performance: people who are fully averse to risks and uncertainties would never start a venture (De Carolis and Saporito, 2006; Keh *et al.*, 2002; Simon *et al.*, 2000). Successful entrepreneurs are believed to possess “just enough” bias to provide them with optimism for pursuing their new venture. Thus, for instance, in the case of illusion of control, the successful entrepreneurs are expected to possess that additional feeling of control that pushes them to

take the required risk to start a new venture. Moreover, we do not think that this required level of risk-taking is only necessary for the decision to start a new venture. We believe that especially in the early stage of a new venture, a certain level of biases is required as well to be able to take educated but risky decisions under circumstances of high market and/or technology uncertainty. Following the rules of logic and probability theory will decrease this level of willingness to deal with risks and uncertainties, thus adhering to such norms will be detrimental for starting and successfully managing a new venture. Therefore, it is hypothesized that:

- H3. Deviation from the ecological profile of cognitive biases emanating from the representativeness heuristic is negatively associated with entrepreneurial behavior and performance.
- H4. Deviation from the normative profile of cognitive biases emanating from the representativeness heuristic is positively associated with entrepreneurial behavior and performance.

Method and data

VentureOne is a leading venture capital research company located in San Francisco. It collects data from venture capital firms about recent funding activities and portfolio updates and investigates secondary resources such as company press releases and initial public offering prospectuses. For this study, a random sample of 776 entrepreneurs from VentureOne was selected as initial sample for data collection.

A scenario-based questionnaire design using survey research proposed by Dillman (1978) was adopted to collect the survey data. Four follow-up mailings were conducted and resulted in complete data from 253 entrepreneurs. The response rate was 32.6%.

Number of ventures and net worth of the last venture founded by the entrepreneur were collected. The final data included 181 male and 72 female entrepreneurs. The average age was 42.4 years. The average entrepreneurial experience is 14 years; 15% of the entrepreneurs had less than five years of experience (10% less than two years), 38% between 5 and 14 years, 32% between 15 and 24 years and 15% were very experienced with more than 24 years of entrepreneurial experience. 46 entrepreneurs were high school graduates; 124 entrepreneurs graduated from colleges; and 83 entrepreneurs with graduate degree.

Study measures and profiles of cognitive biases

The cases and measures used in survey are presented in the Appendix.

Dependent variables. The dependent variables under consideration are entrepreneurial behavior and performance. Based on the number of serial ventures (serial entrepreneurship) and the number of parallel ventures in which the participant is currently involved (portfolio entrepreneurship), entrepreneurial behavior was approximated. The net worth of the last venture was used as a proxy for entrepreneurial performance. These proxies have been shown to satisfactorily cover entrepreneurial behavior and entrepreneurial performance (Toft-Kehler *et al.*, 2014; Westhead *et al.*, 2005). Following Toft-Kehler *et al.* (2014), the logarithm of the net worth of the last venture was used to diminish skewness in the variable.

Cognitive biases. Hindsight bias. Following Bukszar and Connolly (1988) and Slovic and Fischhoff (1977), a two-item scale for hindsight bias was used (Cronbach's $\alpha = 0.65$). At the start of the survey, the participants were asked to answer two difficult general knowledge questions (e.g. "Which company was founded earlier, Nissan or Toyota?"). They were also asked to rate the probability that their answers were correct. At the end of the survey, the correct answers were provided and the participants were asked to recall their original

correctness estimates, in hindsight. A hindsight bias is manifest if participants originally gave an incorrect answer and then lowered their estimate for correctness in hindsight. Potential memory bias is not a concern in this study because it took all participants at least 30 min to fill out the questionnaire (Campbell and Tesser, 1983).

Illusory correlation. This bias was measured using three items (Cronbach's $\alpha = 0.70$), which describe common myths about co-occurrences that are statistically invalid (Tversky and Kahneman, 1974).

Overconfidence. Following Forbes (2005) and Brenner *et al.* (1996), overconfidence was measured with a four-item scale (Cronbach's $\alpha = 0.82$) that also used general knowledge questions, for example, "What is farther away from Beijing, London or New York?" The more certain participants were that they gave the correct answer, when they actually were wrong, the higher their level of overconfidence.

Base-rate fallacy. Two cases served to measure base-rate fallacy adopted from Lynch and Ofir (1989) (Cronbach's $\alpha = 0.75$). One case describes high-tech firms and asks participants to estimate the probability that a given high-tech firm would fail within its first five years. The description begins with statistical information (the base rate) about high-tech firms' failure rates (60%), along with some irrelevant information about the founder's hobbies and social life. If participants deviate in their predictions from 60%, they exhibit a base-rate fallacy, and the more they deviate, the higher the bias.

Illusion of control. For this bias, a five-item scale was adopted from Simon *et al.* (2000) and Zuckerman *et al.* (1996) (Cronbach's $\alpha = 0.89$). For example, one item asks for participants' perception that everything that happens is a result of their own doing. The more participants express this belief, the higher the level of illusion of control they exhibit.

Regression fallacy. Measures for regression fallacy were adopted from Kahneman and Tversky (1973). The case describes a firm in a stable economic environment that two years ago increased its sales by 15%, then increased its advertising budget by 25% and found that its sales dropped by 5% the next year. The stable environment suggests this outcome may be due to statistical fluctuations. If participants instead conclude that the advertising was not effective, they are suffering from regression fallacy.

Sample size fallacy. The three-item scale of sample size fallacy is based on Simon *et al.* (2000) and Mohan-Neill (1995) (Cronbach's $\alpha = 0.85$). An example item asks about basing strategic decisions on the opinions of the participants' closest friends and colleagues. The higher participants score on this item, the greater the sample size fallacy they exhibit.

Control variables. As control variables, the model included the entrepreneur's gender, maximum degree level and areas of major and entrepreneurial experience. The model also used the level of experiential thinking, which is a known determinant of heuristics and cognitive biases (Kahneman, 2003), as a control variable. Experiential thinking with five items from the "faith in intuition" scale (Epstein *et al.*, 1996; Pacini and Epstein, 1999) was adopted to measure the extent to which entrepreneurs rely on their gut feelings and instincts and believe in their hunches (Cronbach's $\alpha = 0.98$). Rational thinking was included as a control variable, because of this study's focus on bounded rationality and the conceptual relationship between rational and experiential thinking (Kahneman, 2003). The three-item scale for rational thinking was adopted from the "need for cognition" scale (Epstein *et al.*, 1996; Pacini and Epstein, 1999) (Cronbach's $\alpha = 0.93$).

Common method bias

Several remedies were applied to diminish common method bias (Podsakoff *et al.*, 2003). A "second best option" was employed by varying types of measures in the survey design. In addition, a robust test described by Malhotra *et al.* (2006) was conducted. The results indicated that the second smallest correlation, which is a conservative estimate of the

common method bias, is the correlation between regression fallacy and illusory correlation; in absolute value this correlation is 0.03 ($p = 0.67$). Therefore, there was no significant common method bias in the data.

Confirmatory factor analysis

A first-order confirmatory factor analysis was conducted to check for construct validity and obtained the following fit statistics: $\chi^2 = 276.75$, $df = 132$, normed fit index = 0.90, confirmatory fit index = 0.94, goodness of fit index = 0.90 and root mean square error of approximation = 0.066. To test whether the cognitive biases were empirically rooted in the availability and/or representativeness heuristics, a second-order confirmatory factor analysis was done. These results are presented in Table 1.

Table 1 shows that hindsight bias, illusory correlation and overconfidence are indeed triggered by the availability heuristic while illusion of control, regression fallacy and sample size fallacy are triggered by the representativeness heuristic. However, base-rate fallacy is not significantly connected to either of the heuristics. Therefore, in the subsequent profile-deviation analysis, base-rate fallacy was treated as a single bias while we continue to consider the bias patterns of the availability and representative heuristics, each now consisting of three biases.

Profile-deviation analysis procedure

A profile-deviation approach was employed to analyze the data (for this method, see Drazin and Van de Ven, 1985; Venkatraman, 1989; Venkatraman and Prescott, 1990), which involves four steps: (1) define the ecological and normative profiles; (2) calculate the distances between each participant's bias profile and the ecological and normative profiles, respectively; (3) test the relationships between the deviations and the dependent variables; and (4) check for endogeneity, in particular reversed causality.

The first step was the determination of the ecological and the normative profile, as detailed in Table 2. The ecological profiles are defined for both bias patterns by using data from a calibration sample of successful entrepreneurs (Drazin and Van de Ven, 1985; Venkatraman, 1989; Venkatraman and Prescott, 1990; Vorhies and Morgan, 2003), consisting of the top 10% of the original sample with regard to the net worth of the last venture founded. The top 10% samples thus consisted of entrepreneurs with net worth of last venture exceeding \$200,000. Then the ecological profiles were calculated using the calibration sample average of each cognitive bias. For further data analysis, the calibration sample was removed as well as the bottom 10% (corresponding to entrepreneurs with net worth of last venture below -\$60,000),

Table 1.
Confirmatory factor
analysis – second order

Second-order construct First-order construct	Standardized factor loading	T-value
<i>Availability biases</i>		
Hindsight bias	0.82	2.34
Illusory correlation	0.39	4.06
Overconfidence	0.79	4.35
<i>Representativeness biases</i>		
Base-rate fallacy	0.14	1.53
Illusion of control	0.46	5.02
Regression fallacy	0.47	6.18
Sample size fallacy	0.46	5.31
Note(s): $\chi^2 = 347.74$, $df = 145$; RMSEA = 0.074; NFI = 0.88; CFI = 0.92; GFI = 0.87		

leaving with approximately 80% of the original sample, or 207 entrepreneurs [2], for further analysis (Venkatraman and Prescott, 1990).

In the normative profile, cognitive biases are as low or neutral as possible. This means that for hindsight bias, illusory correlation, overconfidence, base rate fallacy and regression fallacy, the normative values are 0 or 1 depending on the scale used. For illusion of control and sample size fallacy, determining the normative values is less straightforward because the scales for those biases also included the undesirable extreme of feeling that one cannot influence anything in life or that one should exclusively rely on large-scale research. Thus, in a normative profile, these two cognitive biases will have a neutral score of 4.

For the second step, the distance of the entrepreneur's bias profile from the ecological or normative profile was calculated using the following Euclidian distance metric:

$$DIST = \sqrt{\sum (X_{is} - X_{js})^2},$$

where X_{is} is the ecological or normative profile score on the s th cognitive bias, and X_{js} is the score of the j th focal entrepreneur on the s th cognitive bias. The distances for the bias patterns were calculated for the (1) availability heuristic (three biases), (2) base-rate fallacy and (3) representativeness heuristic (three biases), thus adding six new study variables: deviations from the ecological or normative profile, respectively, of these three bias patterns.

In the third step to test the relationships of these six new study variables with dependent variables as measured by the number of serial ventures (serial entrepreneurship), the number of parallel ventures (portfolio entrepreneurship) and the net worth of the last venture are founded as well as the control variables. A significantly negative relationship means that the deviation of the entrepreneur's bias profile from either the ecological or the normative profile has negative consequences for entrepreneurial behavior and/or performance.

Two of the dependent variables, the number of serial ventures and the number of parallel ventures, consist of count data without any zeroes and are not normally distributed. Conventional alternatives to ordinary regression for count data are Poisson and negative binomial regression. Noting the lack of zeroes in our research data, the zero-truncated versions of these alternatives were used, applying Stata 15. Moreover, in a Poisson regression, the mean and variance of the distribution are assumed to be equal, so both the zero-truncated Poisson regression and the zero-truncated negative binomial regression were applied. To analyze entrepreneurial performance, ordinary least squares (OLS) regressions and quantile regressions were used for the top 10% of performers. In a quantile regression deviation of the observed dependent variable and its model estimate are given higher weight (higher importance) for certain quantiles of the dependent variable. A moderate quantile (0.50 quantile) regression presents results that are comparable to the OLS regression results. With focus on the top 10% of performers, a 0.90 quantile regression was conducted. The correlations, means and standard deviations of the study variables are presented in Table 3.

	Min in sample	Max in sample	Normative profile	Ecological profile
1. Hindsight bias	0.00	3.00	0.00	1.17
2. Illusory correlations	1.00	7.00	1.00	5.03
3. Overconfidence	0.50	9.75	0.00	6.59
4. Base rate fallacy	0.00	4.50	0.00	2.59
5. Illusion of control	1.20	7.00	4.00	5.31
6. Regression fallacy	0.00	10.00	0.00	6.70
7. Sample size fallacy	1.00	7.00	4.00	4.54

Table 2.
Normative and
empirical profiles for
cognitive biases

Table 3.
Correlations, means
and standard
deviations for the
study
variables ($N = 207$)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Number of serial ventures	0.86															
2. Number of parallel ventures	0.05	0.05														
3. LN (last venture worth)	-0.02	-0.00	-0.00													
4. Gender	0.01	0.05	0.05	0.05												
5. Age	0.23	0.27	0.10	-0.02	0.13											
6. Degree level	0.51	0.56	0.13	-0.01	-0.01	0.21										
7. Business degree	0.20	0.19	0.10	0.07	0.78	0.16	0.08									
8. Entrepreneurial experience	0.59	0.52	-0.11	-0.02	-0.09	0.06	0.49	0.05								
9. Experiential thinking	-0.52	-0.50	-0.03	-0.03	0.04	-0.17	-0.67	-0.06	-0.27							
10. Rational thinking	-0.32	-0.44	0.02	0.12	0.04	-0.15	-0.27	-0.05	-0.26	0.19						
11. Deviation availability biases from ecological profile	0.16	0.10	-0.16	0.10	-0.02	-0.04	-0.02	0.04	0.13	-0.08	-0.11					
12. Deviation base-rate fallacy from ecological profile	-0.12	-0.19	-0.12	0.07	0.03	-0.05	-0.14	-0.02	0.01	0.16	0.29	0.15				
13. Deviation representativeness biases from ecological profile	0.57	0.56	-0.06	-0.01	-0.02	0.12	0.33	0.11	0.37	-0.33	-0.55	0.34	0.01			
14. Deviation availability biases from normative profile	0.07	0.07	-0.02	-0.01	-0.09	0.08	0.13	-0.08	0.15	-0.09	0.02	0.07	0.07	0.11		
15. Deviation base-rate fallacy from normative profile	0.45	0.43	0.08	-0.03	-0.10	0.00	0.18	0.05	0.20	-0.26	-0.32	0.16	-0.55	0.36	0.04	
16. Deviation representativeness biases from normative profile	4.24	2.05	4.29	71%	41.94	2.15	42%	55%	4.44	3.19	2.72	0.83	2.97	7.06	2.62	5.95
Mean/ % lowest score	2.74	0.83	9.35	-	12.55	0.75	-	-	1.42	1.21	1.33	0.64	1.55	2.25	1.05	2.32
Standard deviation																

Note(s): All correlations with absolute values greater than 0.13 are significant at $p < 0.05$

In the fourth step we checked whether the results might be inflated by endogeneity and, in particular, reverse causality. An increase in entrepreneurial behavior, such as more serial or parallel ventures, and improved entrepreneurial performance may lead to deviations from ecological or normative bias profiles. A Durbin–Wu–Hausman test was performed to check whether the results could be inflated by this reverse causality by comparing the 2SLS instrumental variable regression with ordinary regression results. The model included several instruments: level of education and type of academic degree (business or not) for deviations from the normative and ecological profile, and then the worth of the last venture founded and four other variables from another segment of the database for the link from deviations from the normative and ecological profiles, respectively, to the number of serial ventures and the number of parallel ventures. Test results indicated that reverse causality is not significant ($p < 0.05$).

Results

In Panel *a* of Table 4, we summarize the results for deviations from the ecological profile. Hypothesis 1 proposed that deviations from the ecological profile of availability biases would be detrimental for entrepreneurial behavior and performance. The results confirm Hypothesis 1 for the number of serial ventures and the number of parallel ventures as well as for entrepreneurial performance but only for the top 10% of performers (coefficients are -0.08 , $p < 0.05$; -0.16 , $p < 0.01$; and -0.31 , $p < 0.01$, respectively) and not for the lower-performing entrepreneurs. Hypothesis 3 suggested that deviation from the ecological profile of representativeness biases is detrimental for entrepreneurial behavior and performance. The results support this hypothesis only for the number of serial ventures (coefficient is -0.06 , $p < 0.05$). All other results are insignificant, except that deviation from the ecological profile of base-rate fallacy is positively associated with the number of serial ventures (coefficient is 0.11 , $p < 0.10$).

In Panel *b* of Table 4, we report the results of the deviations from the normative profile. Hypothesis 2 predicted that deviations of the availability biases would be beneficial for entrepreneurial behavior and performance. The results confirm this hypothesis for entrepreneurial behavior (numbers of serial ventures and parallel ventures) as well as for entrepreneurial performance of the top 10% of performers (coefficients are 0.07 , $p < 0.01$; 0.08 , $p < 0.05$; and 0.12 , $p < 0.10$, respectively) but not for the lower-performing entrepreneurs. Hypothesis 4 suggested that deviations from the normative profile of representativeness biases are beneficial for entrepreneurial behavior (numbers of serial ventures and parallel ventures) and performance (net worth of last venture). The results support this hypothesis (coefficients are 0.08 , $p < 0.001$; 0.07 , $p < 0.05$; and 0.53 , $p < 0.10$, respectively). Results for base-rate fallacy were insignificant.

In the ecological profile-deviation analysis, it can be found that having a business degree is positively related to the number of serial ventures and the level of education is positively related to entrepreneurial performance, while entrepreneurial experience is positively related to the number of serial ventures and entrepreneurial performance. Experiential thinking is positively related to entrepreneurial behavior but negatively associated with entrepreneurial performance. Rational thinking is negatively related to entrepreneurial behavior. In the normative profile-deviation analysis, both the level of education and entrepreneurial experience are positively related to entrepreneurial performance, while the level of education is positively related to the number of parallel ventures and business degree is positively related to the number of serial ventures. Experiential thinking is positively related to entrepreneurial behavior and has a negative impact on entrepreneurial performance. Rational thinking is negatively related to the number of serial ventures.

a. Ecological profile deviation analysis

Independent variables	Number of serial ventures Model 1	Number of parallel ventures Model 2	Logarithm of worth of last venture founded	
	Zero-truncated Poisson ^a	Zero-truncated Poisson ^a	Model 3 OLS regression	Model 4 Quantile regression (top 10% performers)
Gender	−0.04 (0.08)	−0.08 (0.14)	0.08 (1.41)	0.10 (0.26)
Age	−0.00 (0.00)	−0.01 (0.01)	−0.11 (0.08)	−0.01 (0.02)
Degree level	0.09 (0.12)	0.33 (0.22)	5.62** (1.97)	0.34 (0.37)
Business degree	0.11* (0.05)	0.11 (0.09)	0.78 (0.88)	−0.04 (0.17)
Entrepreneurial experience	0.27* (0.11)	0.29 (0.20)	3.88† (2.08)	0.50 (0.39)
Experiential thinking	0.23*** (0.03)	0.14* (0.06)	−1.47** (0.54)	−0.17 (0.10)
Rational thinking	−0.22*** (0.05)	−0.15† (0.08)	1.02 (0.72)	−0.03 (0.14)
Deviation availability biases from ecological profile	−0.08* (0.03)	−0.16** (0.06)	0.44 (0.54)	−0.31** (0.10)
Deviation base-rate fallacy from ecological profile	0.11† (0.06)	0.09 (0.10)	−1.46 (1.04)	−0.25 (0.20)
Deviation representativeness biases from ecological profile	−0.06* (0.02)	−0.05 (0.04)	−0.55 (0.44)	−0.10 (0.08)
N	207	207	207	207
Log likelihood	−374.46	−231.31		
Pseudo R ²	0.24	0.15		0.02
R ²			0.11	
Adj. R ²			0.06	
F-value			2.37*	

b. Normative profile deviation analysis

Independent variables	Number of serial ventures Model 1	Number of parallel ventures Model 2	Logarithm of worth of last venture founded	
	Zero- truncated Poisson ^a	Zero-truncated Poisson ^a	Model 3 OLS regression	Model 4 Quantile regression (top 10% performers)
Gender	−0.08 (0.08)	−0.14 (0.14)	0.05 (1.39)	0.28 (0.30)
Age	−0.00 (0.00)	−0.00 (0.01)	−0.09 (0.08)	−0.01 (0.02)
Degree level	0.16 (0.12)	0.43* (0.21)	6.29** (1.94)	0.38 (0.42)
Business degree	0.13* (0.05)	0.15 (0.09)	0.90 (0.88)	0.28 (0.19)
Entrepreneurial experience	0.17 (0.12)	0.21 (0.20)	3.49† (2.11)	0.50 (0.45)
Experiential thinking	0.18*** (0.03)	0.09† (0.06)	−1.62** (0.54)	−0.29* (0.12)
Rational thinking	−0.16** (0.05)	−0.08 (0.08)	1.16 (0.73)	−0.00 (0.16)
Deviation availability biases from normative profile	0.07** (0.02)	0.08* (0.04)	−0.46 (0.33)	0.12† (0.07)
Deviation base-rate fallacy from normative profile	0.01 (0.03)	0.01 (0.06)	−0.04 (0.62)	−0.03 (0.13)
Deviation representativeness biases from normative profile	0.08*** (0.02)	0.07* (0.03)	0.53† (0.31)	0.01 (0.07)
N	207	207	207	207
Log likelihood	−360.61	−230.35		
Pseudo R ²	0.27	0.16		0.02

Table 4.
Regression results

(continued)

b. Normative profile deviation analysis

Independent variables	Number of serial ventures Model 1 Zero- truncated Poisson ^a	Number of parallel ventures Model 2 Zero-truncated Poisson ^a	Logarithm of worth of last venture founded	
			Model 3 OLS regression	Model 4 Quantile regression (top 10% performers)
R^2			0.10	
Adj. R^2			0.06	
F-value			2.27*	

Note(s): OLS = ordinary least squares. [†] $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; ^a: Only results of the zero-truncated Poisson regression are presented as the results of the zero-truncated negative binomial regression are the same

Table 4.

Discussion

This study proposes four hypotheses that predict that for each pattern a particular level of cognitive biases might stimulate entrepreneurial behavior and entrepreneurial performance, in which case the bias profile of an excellent entrepreneur exhibits some particular level of biases, which may not be the lowest level possible. Moreover, it is hypothesized that limiting the level of biases within each pattern as much as possible is detrimental for entrepreneurial behavior and performance, because information overload, or the limited time an entrepreneur has available to search for information, reflects the entrepreneur's bounded rationality.

Theoretical implications

The results present several implications for entrepreneurial cognition research. First, this study examined patterns of cognitive biases of entrepreneurs instead of single biases. Using Kahneman and Tversky's typology (Kahneman, 2003), this study distinguished between biases emanating from the availability heuristic (in hypotheses 1 and 2) and biases triggered by the representativeness heuristic (hypotheses 3 and 4).

Following ideas about ecological rationality (Burnmeister and Schade, 2007; Todd and Gigerenzer, 2003) and the profile-deviation approach (Drazin and Van de Ven, 1985; Venkatraman, 1989; Venkatraman and Prescott, 1990), the research findings reveal some positive associations between a particular level of cognitive biases in each of the two patterns and entrepreneurial behavior and performance. Thus, these patterns of biases often stimulate and never dampen entrepreneurial action. The opposite holds for a lack of cognitive biases, that is, having the lowest level of biases possible in each pattern often hinders and never helps entrepreneurial behavior and performance. These results enriched current understanding of cognitive biases (Burnmeister and Schade, 2007; Drazin and Van de Ven, 1985; Todd and Gigerenzer, 2003; Venkatraman, 1989; Venkatraman and Prescott, 1990).

Second, there were differences between the two patterns of cognitive bias. In general, a particular level of biases emanating from the availability heuristic is associated with an increased number of serial ventures (serial entrepreneurship), number of parallel ventures (portfolio entrepreneurship) and entrepreneurial performance for the top 10% of performers. A lack of these biases diminishes entrepreneurial behavior as well as performance of the top 10% of performers. In general, a particular level of biases rooted in the representativeness heuristic stimulates the number of serial ventures and does not dampen the number of parallel ventures and the venture performance. A lack of these biases does dampen the number of serial ventures and the number of parallel ventures and does not stimulate

entrepreneurial performance. Apparently, successful entrepreneurs exhibit enough available knowledge and examples of co-occurrences for a particular, new entrepreneurial setting: making use of the availability heuristic has no clear disadvantages and stimulates the frugality and speed of entrepreneurial decision-making.

In contrast, the too optimistic sense of control that successful entrepreneurs possess only stimulates the number of serial ventures and does not hinder any other aspect of entrepreneurial behavior and performance. Thus, the advantages and disadvantages of applying the representativeness heuristic are more balanced, which contributes to the existing entrepreneurial cognition research (Burmeister and Schade, 2007; Simon *et al.*, 2000; Simon and Houghton, 2003).

Practical implications

In addition to the two theoretical contributions, this study has some practical implications for entrepreneurs. Due to the high levels of risk and uncertainty, time pressure and emotional intensity of an entrepreneurial setting, entrepreneurs usually apply heuristics in their work to compensate for a lack of general and situational knowledge and to make fast decisions. Heuristics also trigger cognitive biases. Some researchers have considered cognitive biases to be systematic errors and argue that although biases can be good for starting new ventures, they can be detrimental for the entrepreneurial performance. Cognitive biases can be considered as a predisposition of entrepreneurs. Yet, some researchers suggest that the entrepreneurial setting will induce the levels of cognitive biases used. In this study, we focus on cognitive biases as predispositions of entrepreneurs. The results of this study must be interpreted accordingly. Moreover, in this study we follow recent work on cognitive biases (e.g. Zhang and Cueto, 2017) and suggest that entrepreneurs do not deal with one single cognitive bias but with patterns of cognitive biases. We consider two patterns: one emanating from the use of the availability heuristic (with hindsight bias, illusory correlation and overconfidence) and the other one rooted in the representativeness heuristic (including base-rate fallacy, illusion of control, regression fallacy and sample size fallacy). We find that a certain level of cognitive biases, which is not the lowest level possible, can be advantageous for both entrepreneurial behavior and performance. A particular level of cognitive biases triggered by the availability heuristic may stimulate serial and portfolio entrepreneurship, as well as entrepreneurial performance. A certain level of cognitive biases triggered by the representativeness heuristic stimulates serial entrepreneurship and does not hinder portfolio entrepreneurship and entrepreneurial performance. This means that fully eliminating cognitive biases will hurt serial and portfolio entrepreneurship and entrepreneurial performance in some cases, while a lack of cognitive biases never stimulates entrepreneurial action. On the other hand, unlimited use of cognitive biases will hurt both entrepreneurial behavior and performance. To get a “well-balanced” level of cognitive biases, entrepreneurs may try to calibrate their levels of cognitive biases with those of successful entrepreneurs.

Research limitations and future research directions

There are several future research directions. First, the findings from testing four hypotheses (i.e. H1–H4) endorse the call of Zhang and Cueto (2017) for additional research into performance consequences of cognitive biases. However, the empirical results suggest examining patterns of biases instead of single biases and different dimensions of entrepreneurial performance. This study found some empirical evidence for the clustering of biases in a second-order factor analysis. However, base-rate fallacy (triggered by the representativeness heuristic) did not empirically fit. Therefore, more in-depth research is required to determine which biases emanate from which heuristic (Kahneman, 2003).

Although we considered the largest set of cognitive biases ever empirically studied in the entrepreneurial field, we still did not consider all cognitive biases. So, future research should consider other cognitive biases such as overoptimism, the planning fallacy (Zhang and Cueto, 2017) and counterfactual thinking (Kahneman and Tversky, 1982). More generally, future research should study other typologies of biases and the antecedents and consequences (Baron, 2007; Zhang and Cueto, 2017). This study examined four cognitive biases, hindsight bias, illusory correlation, regression fallacy and base-rate fallacy, that have previously received only limited attention in entrepreneurial cognition research. More research is needed to examine their inclusion in other typologies of biases and their consequences in entrepreneurial decision-making.

Second, the results from testing hypotheses 1–4 suggest that particular patterns of biases make a difference for entrepreneurial behavior and performance, the question is “what are the important next steps for the research into the cognitive biases of entrepreneurs?” Following the ideas of ecological rationality (Burmeister and Schade, 2007; Todd and Gigerenzer, 2003) and the configurational perspective in more detail, it is suggested not to focus on a more general entrepreneurial setting but distinguishing between different entrepreneurial actions/decisions such as opportunity identification, opportunity exploitation, forming the new venture, managing the new venture and so on. Do different patterns and levels of biases within each pattern have different impacts on the different decisions? Researchers should also focus on contingencies of the whole entrepreneurial setting or the different entrepreneurial actions/decisions. For instance, what are the influences of the context and the nature of the opportunity on the effects of patterns of biases.

Third, this study focused on experienced entrepreneurs (5–24 years of experience). The results might not generalize to novice entrepreneurs. Future research could collect additional data on less experienced entrepreneurs and examine differences in the patterns of cognitive biases. This stream of research could be done using the measures developed in this paper to collect new data.

Fourth, this study used the number of past and current ventures as proxies of entrepreneurial behavior and the worth of the last venture the entrepreneur founded as a proxy of entrepreneurial performance. Although these proxies seem to be valid (Toft-Kehler, 2014; Westhead *et al.*, 2005), an interesting and doable future research is to investigate other measures of entrepreneurial behavior and performance. This stream of future research could significantly add to theoretical development in the literature.

Fifth, this study examined the effects of a particular level of cognitive biases in two patterns of biases in a general entrepreneurial setting. The study did not distinguish between different entrepreneurial actions/decisions. It may be productive to examine the effects of cognitive biases in different entrepreneurial settings such as risky market-entry decisions and major product introduction decisions.

Sixth, the aforementioned research directions would offer new insights into the state–quasi-trait debate about patterns of cognitive biases. The question is whether cognitive biases of entrepreneurs are induced by the task environment (Forbes, 2005). Some argue that people become entrepreneurs according to a kind of self-selection process, based on their patterns of cognitive biases, because their cognitive processes fit the entrepreneurial task (Busenitz and Barney, 1997). Others suggest that the entrepreneurial task environment induces the use of cognitive biases by people who are involved in it (Baron, 1998), such that the state induces the level of cognitive biases actually used. This study focused on patterns of biases as quasi-traits. The proposed research will give more insight into patterns of biases induced by state. An intriguing question to be addressed is whether the quasi-trait component of cognitive biases is more important for entrepreneurial decision-making or if the induced state component is more important. Experimental designs would be useful to examine this question.

Conclusion

This study brings the “great rationality debate” (Cohen, 1981; Gigerenzer, 1996; Tetloch and Mellers, 2002) closer to the entrepreneurship field (Zhang and Cueto, 2017). Clearly, normative rules that are purely based on rules of logic and probability theory do not work. Cohen mentioned in 1981 that you need an interpretation of the rules in a particular context, which is most often inspired by people’s intuition (Cohen, 1981). However, this study finds that unlimited levels of cognitive biases are detrimental for entrepreneurial behavior and performance. Thus, what are “good” levels of biases in each pattern of biases? Possibly, dual process research may bring us some steps forward to ultimately answer this question. There are still needs for more insight in the intuitive system, the rational system and the relationships between these systems (see also Bargh and Chartrand, 1999 for a better understanding of the intuitive system). Future research may ultimately add more insight in the “good” levels of biases of different populations and how to influence biases in the “good” direction.

Notes

1. Base-rate fallacy may be an exception here, dependent on whether the caricatural description is positive or negative for the entrepreneur. This exception in the empirical analysis and results are also be found.
2. Whether the calibration sample significantly differentiated was checked from the study sample with 80% of the respondents. There are no differences between the calibration sample and the top 10% of the study sample with respect to gender, age, entrepreneurial experience, level of education, type of education and level of experiential and rational thinking with a probability of 99%.

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Further reading

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- Rauch, A. and Frese, M. (2000), "Psychological approaches to entrepreneurial success: a general model and an overview of findings", in Cooper, C.L. and Robertson, I.T. (Eds), *International Review of Industrial and Organizational Psychology*, Wiley, Chichester, pp. 101-142.
- Ucbasaran, D., Westhead, P., Wright, M. and Flores, M. (2010), "The nature of entrepreneurial experience, business failure and comparative optimism", *Journal of Business Venturing*, Vol. 25 No. 6, pp. 541-555.

Appendix

Measurements of cognitive biases

Hindsight bias ($\alpha = 0.75$) (New items, following [Bukszar and Connolly, 1988](#); [Slovic and Fischhoff, 1977](#))
(On the last page of the survey)

Following are three questions that assess your confidence on your answer to earlier questions (please do not turn the pages back and change any answers).

- (1) HIN1. Earlier we asked you which country (Canada or New Zealand) has a higher percentage of entrepreneurs. Let's assume that the correct answer is New Zealand. Knowing this new information, please answer the following question (score: 0–100%; anchor: 0% = 0; 10% = 1; ... 100% = 10):
 - If your answer was New Zealand, how confident were you that New Zealand would be the correct answer?
 - If your answer was Canada, how confident were you that Canada would be the correct answer?
- (2) HIN2. Earlier we asked you whether Nissan or Toyota was founded earlier. Let's assume that the correct answer is Nissan. Knowing this new information, please answer the following question (score: 0–100%; anchor: 0% = 0; 10% = 1; ... 100% = 10):
 - If your answer was Nissan, how confident were you that Nissan would be the correct answer?
 - If your answer was Toyota, how confident were you that Toyota would be the correct answer?

Coding algorithm: IF answer on the question from overconfidence measure was correct, THEN coding = 0; ELSE coding = (score from overconfidence – score from hindsight).

Illusory correlation ($\alpha = 0.67$) (New items based on existing data from different fields; following [Tversky and Kahneman, 1974](#))

Further we list some personality characteristics. Please circle the number next to each statement that best represents your degree of disagreement or agreement (where 1 = Strongly Disagree; 4 = Neutral; 7 = Strongly Agree; and numbers between 1 and 7 represent the varying degrees).

COR1. Big businesses will often ruin the small ones.

COR2. Universities are more likely to license to big companies.

COR3. Cats that are spayed or neutered automatically gain weight.

Overconfidence bias ($\alpha = 0.82$) (New items, following [Forbes, 2005](#); and [Brenner et al., 1996](#))

(On the first page of the survey)

Following are some challenging questions. One of the two possible answers is correct. Please work through the questions quickly and check the box with response that best represents your answer.

OV1. Which country has a higher percentage of entrepreneurs: Canada or New Zealand? How sure are you? (score: 50% ... 100%; anchor: 50% = 5; ... 100% = 10)

OV2. What is farther away from Seattle: London or Beijing? How sure are you with your answer to this question? (score: 50% ... 100%; anchor: 50% = 5; ... 100% = 10)

OV3. Which company was founded earlier: Nissan or Toyota? How sure are you with your answer to this question? (score: 50% ... 100%; anchor: 50% = 5; ... 100% = 10)

Coding algorithm: IF answer is correct, THEN coding = score-5; ELSE coding = score.

Base-rate fallacy ($\alpha = 0.73$)

We present some hypothetical scenarios further. Please give us your opinion for each of the scenarios.

BAS1. (New case)

National statistics show that around 60% of funded high-tech start-ups failed in the first five years. John has just received funding from a VC to start up a high-tech firm. During your lunch today, one of John's friends told you that he and John like to watch NFL games together and that John is well liked by his friends. What is your estimated probability that John's company will fail within the first five years? (0–100%)

Coding algorithm: IF score ≥ 6 , THEN coding = score-6; ELSE coding = 6-score.

BAS2. (case taken from [Lynch and Ofir, 1989](#); and adjusted based on pretest)

Your friend Tom is looking for a five-year-old used car and asks for your help. "Consumer Reports" suggests that 50% of this model will require some major repairs during the sixth year. Tom just called you to let you know that he went to look at the car. He really likes the exterior color and the leather seats. What is your estimated probability that Tom will need some major repairs next year? (0–100%)

Coding algorithm: IF score ≥ 5 , THEN coding = score-5; ELSE coding = 5-score.

Illusion of control ($\alpha = 0.88$) (Taken from [Simon et al., 2000](#); [Zuckerman et al., 1996](#))

Further we list some personality characteristics. Please circle the number next to each statement that best represents your degree of disagreement or agreement (where 1 = Strongly Disagree; 4 = Neutral; 7 = Strongly Agree; and numbers between 1 and 7 represent the varying degrees).

IC1. I can accurately predict total market demand for my venture's product and services for the next 3 years.

IC2. I can accurately predict when larger competitors would enter the market.

IC3. I can succeed at making this venture a success, even though many others would fail.

IC4. There is no such thing as misfortune; everything that happens to us is the result of our own doing.

IC5. In each and every task, not finishing successfully reflects a lack of motivation.

Law of small numbers ($\alpha = 0.85$) (Modified from [Simon et al., 2000](#); and [Mohan-Neill, 1995](#))

Further we list some personality characteristics. Please circle the number next to each statement that best represents your degree of disagreement or agreement (where 1 = Strongly Disagree; 4 = Neutral; 7 = Strongly Agree; and numbers between 1 and 7 represent the varying degrees).

SN1. When making strategic decisions, it is sufficient to ask the opinion of a few of my closest friends and colleagues.

SN2. When making strategic decisions, I always use more than one source of information. (R)

SN3. I do not make decisions until I have results of large-scale market research. (R)

Regression fallacy (New, following the example from [Kahneman and Tversky, 1973](#))

We present some hypothetical scenarios further. Please give us your opinion for each of the scenarios.

Assuming that your firm operates in a stable economic environment. Two years ago, the sales of your products increased by 15%. You made a decision to increase your advertising budget by 25% last

year. However, you just got a report showing that the sales decreased by 5% last year. How likely would you conclude that the advertising was not effective? (0–100%)

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