

Fossen, Frank M.; Neyse, Levent

**Article — Published Version**

## Entrepreneurship, Management, and Cognitive Reflection: A Preregistered Replication Study With Extensions

Entrepreneurship Theory and Practice

**Provided in Cooperation with:**

WZB Berlin Social Science Center

*Suggested Citation:* Fossen, Frank M.; Neyse, Levent (2024) : Entrepreneurship, Management, and Cognitive Reflection: A Preregistered Replication Study With Extensions, Entrepreneurship Theory and Practice, ISSN 1540-6520, Sage, Thousand Oaks, CA, Vol. 48, Iss. 4, pp. 1082-1109, <https://doi.org/10.1177/10422587231211005>

This Version is available at:

<https://hdl.handle.net/10419/319867>

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# Entrepreneurship, Management, and Cognitive Reflection: A Preregistered Replication Study With Extensions

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2024, Vol. 48(4) 1082–1109

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DOI: 10.1177/10422587231211005

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Frank M. Fossen<sup>1,2</sup>  and Levent Neyse<sup>2,3,4</sup>

## Abstract

Intuition is a central element of entrepreneurial decision-making. We conceptually replicate a published study by using new representative data from 1961 adults and the widely used Cognitive Reflection Test, which assesses the ability to avoid intuitive decisions and to switch to an analytical process. We extend the analysis by exploring occupational sorting versus environmental influence as mechanisms, the role of overconfidence, and heterogeneity. Our results confirm that entrepreneurs do not resist intuitive (but potentially wrong) decisions as much as hired managers do. Our extensions suggest that this difference is not fully explained by occupational sorting, but partially by overconfidence.

## Keywords

entrepreneurs, managers, cognitive reflection, intuition, overconfidence, personality

**JEL classification:** L26, D91.

## Introduction

Many strategic decisions rely on heuristics and intuition rather than thorough analytical thinking. Intuition is often inevitable because people need to make quick decisions under uncertainty or ambiguity. It is also at the core of entrepreneurial decisions, as these decisions are innovative by nature and made without clear market information, such as historical trends or clear data about the current market structure (see Baldacchino et al., 2015;

<sup>1</sup>Department of Economics, University of Nevada-Reno, Reno, NV, USA

<sup>2</sup>Institute of Labor Economics (IZA), Bonn, Germany

<sup>3</sup>Berlin Social Science Center (WZB), Berlin, Germany

<sup>4</sup>SOEP at German Institute of Economic Research (DIW Berlin), Berlin, Germany

## Corresponding Author:

Frank M. Fossen, Department of Economics, University of Nevada-Reno, 1664 N. Virginia Street, Reno, NV 89557, USA.

Email: [ffossen@unr.edu](mailto:ffossen@unr.edu)

Busenitz & Barney, 1997; Mitchell et al., 2005). While intuitive decision-making is practical, relying too much on it can yield biased decisions. Entrepreneurship research explores a range of cognitive biases that might affect the decisions of entrepreneurs. Those include overconfidence and optimism (e.g., Camerer & Lovallo, 1999; Forbes, 2005; Koellinger et al., 2007; McCarthy et al., 1993), status-quo bias (Burmeister & Schade, 2007), illusion of control (Carr & Blettner, 2010; Simon et al., 2000), and representativeness (Bryant, 2007; Wickham, 2003).<sup>1</sup> Analyzing potentially biased decision-making by entrepreneurs is important because the insights may contribute to understanding the entrepreneurial earnings puzzle, that is, the observation that individuals become and remain entrepreneurs despite low average returns and high risk (e.g., Astebro et al., 2014). Empirical research on intuitive decision-making by entrepreneurs is scarce, and entrepreneurial intuition is especially interesting: while it can lead to bias, it may be advantageous in entrepreneurial decision-making when time is critical.

A distinction between intuitive and contemplative thinking styles is made in dual-process theories (Epstein, 1994; Evans, 2010; Kahneman & Frederick, 2002; Sloman, 1996). System I decisions are fast, intuitive, and effortless, relying on certain heuristics. However, they have a high risk of being wrong. System II, on the other hand, is slow and needs more cognitive effort, yet decisions based on System II are analytical and have lower risk of being wrong. The cognitive ability to switch from System I to System II when necessary is called cognitive reflection. This two-system approach is quite influential in psychology, behavioral economics, and management studies, but is understudied in empirical entrepreneurship research.

Koudstaal et al. (2019) provide the most rigorous prior empirical study of the relationship between intuitive versus contemplative decision-making and entrepreneurship. They use a sample of 1928 working respondents, while other research is limited to small samples, often comprising solely of students.<sup>2</sup> Koudstaal et al. (2019) collect responses to three choice problems of the Contemplative Index (CI hereafter; Rubinstein, 2016) along with response time data and find that entrepreneurs make more intuitive choices than hired managers do. Their analyses do not detect any statistically significant differences between the choices of entrepreneurs and nonmanagerial employees. Using a set of survey questions, they also show that entrepreneurs have stronger faith in intuition (FI) than hired managers and other employees. While Koudstaal et al. (2019) pioneer this research with a reasonably sized sample of working individuals in the Netherlands, a limitation is that they use a nonrepresentative online survey.<sup>3</sup> Thus, their study provides important initial, but not yet conclusive results.

In light of the replication crisis in science in general (e.g., Anderson et al., 2019; Baker, 2016; Shrout & Rodgers, 2018) and the social sciences in particular (Dreber & Johannesson, 2019), the stability of empirical results must be tested to avoid wasting resources on misguided research and policies. For example, the costs associated with irreproducible preclinical research are estimated at US\$28 billion a year in the United States (Freedman et al., 2015). Replications can be run directly by using exactly the same methodology with different samples or conceptually by using different methods and sample characteristics. This article provides a conceptual replication with major extensions.

In this preregistered study, we retest the original research question of Koudstaal et al. (2019) on whether entrepreneurs are more intuitive decision-makers than hired managers and employees. We use the German Socio-Economic Panel's Innovation Sample (SOEP-IS), a survey representative for the German population collected by professional interviewers.<sup>4</sup> Using this sample with 1961 respondents, we can assess whether the estimated

relationship between cognitive reflection and entrepreneurship is valid for a general population or potentially driven by sample selectivity in the original study.

Our study involves several extensions, which are based on discussions and suggestions in Koudstaal et al.'s (2019) study and the wider literature. They address important research questions that dig deeper and provide a bridge into future research.

First, we ask whether the results hold when using the Cognitive Reflection Test (CRT hereafter; Frederick, 2005) to measure intuitive versus contemplative thinking style instead of the CI. The CRT is one of the essential tools of dual-process theories.

In the second extension, we aim to contribute to answering the question whether the differences between entrepreneurs and managers are primarily due to *nature*, that is, innate differences between individuals who subsequently self-select into their occupations, or *nurture*, that is, influence from the environment after making the occupational choice. We address this question by largely shutting down the nature channel in our regressions by controlling for the individual's personality and family background. If differences in cognitive decision-making between the occupational groups persist, at least some portions of these differences are likely due to learning from experience in entrepreneurship or management.

Third, we explore the role of overconfidence in the relationship between cognitive reflection and entrepreneurship or management. We control for overconfidence measures to test whether the inclusion of these variables weakens the association between occupation and CRT performance. This would indicate that overconfidence, an omitted variable in Koudstaal et al. (2019), is an important interrelated factor.

Lastly, we acknowledge the large heterogeneity within entrepreneurs and ask whether the results hold for important subgroups of entrepreneurs. We start by distinguishing between nonemployers and employers. This dimension is meaningful because many self-employed individuals have no intention to grow their businesses (Hurst & Pugsley, 2011), whereas those entrepreneurs who create jobs have a bigger impact on the economy and are the focus of policymaking (Caliendo et al., 2022; Fairlie & Miranda, 2017). Further, we explore heterogeneity by formal education and by gender.<sup>5</sup> We also conduct extensive robustness checks.

Our primary results are in line with Koudstaal et al.'s (2019) study: entrepreneurs perform significantly worse in the CRT than managers, which implies a more intuitive cognitive style, but there is no significant difference between entrepreneurs and nonmanagerial employees. Our replication study substantially increases the confidence that the community can have in these results. For example, if the prior probability after the study by Koudstaal et al. (2019) that entrepreneurs make more intuitive decisions than managers was 75%, after our replication study this probability has increased to 98% (based on a statistical power of the replication of 80% and a statistical significance threshold of 0.05). Thereby, we illustrate for entrepreneurship research that "independent replications dramatically increase the chances that the original finding is true" (Maniadi et al., 2014, p. 289).

Our extensions reveal that the differences in cognitive reflection remain when controlling for the individuals' nature through personality and family background variables, which suggests that these differences are not likely to be fully explained by self-selection into occupations but may partially be due to learning on the job. Accounting for overconfidence weakens the differences in the CRT score between the occupational groups, so overconfidence seems to be an important factor related to cognitive reflection that should be considered in future research. There are no significant differences between employers and nonemployers with respect to CRT performance. We document the same relationships

between the CRT score and the occupational groups across education levels, in contrast to Koudstaal et al.'s (2019) study, which report that the differences in CI between the occupational groups vanish at higher levels of education.

## Literature and Theoretical Expectations

### *Primary Hypotheses*

Replicating Koudstaal et al. (2019), our three primary hypothesis tests are whether (i) entrepreneurs are more intuitive (and thereby less contemplative) thinkers in comparison to hired managers; (ii) entrepreneurs are more intuitive thinkers in comparison to nonmanagerial employees; and (iii) hired managers are more intuitive thinkers in comparison to nonmanagerial employees, keeping age, gender, and education constant. Entrepreneurs are expected to rely more on intuition than non-entrepreneurs because they operate under high uncertainty, and they have to make rapid decisions to take advantage of the short windows of opportunity. While entrepreneurs and hired managers are responsible for many similar functional tasks and responsibilities, in particular for making complex strategic choices, managers are often able to use more information for their decisions, such as historical trends, previous levels of performance, and market information, reducing uncertainty and complexity (Busenitz & Barney, 1997). Therefore, slow, contemplative thinking may be more cost effective for hired managers than for entrepreneurs. Differences between the occupational groups could be due to being exposed to the different environments on the job or due to occupational sorting. The decision to start a business is made under high uncertainty and with little information available, so it is plausible that intuitive thinking already plays a role for the decision to become an entrepreneur (Koudstaal et al., 2019). Our primary hypotheses do not distinguish between sorting and learning, but we come back to this question in an extension below.

### *Comparison of Tests of Cognitive Styles*

While we follow the methodology of Koudstaal et al. (2019), we assess whether the findings are stable with an alternative test of cognitive style. This should not imply a strict dominance of one test over the other as both have their own strengths. Koudstaal et al. (2019) use Rubinstein's (2016) CI framework.<sup>6</sup> The CI was designed to offer a typology of players' contemplative and instinctive behaviors in economic games. To do so, it uses 10 games, where players need to respond to various problems, including standard economic games and quasi-vignettes, with response times tracked to distinguish between thinking styles.

The CRT we use instead is one of the essential tools of dual-process theories, which underlies a large proportion of intuition research (see Baldacchino et al., 2015 for a review). The CRT is short with only three items. It elicits a particular type of cognitive skill, that is, the skill to resist the intuitive response and switch to more analytical reasoning. The CRT is the most frequently employed test of cognitive styles to study various economic and social decisions and behaviors. These include economic decisions (Brañas-Garza et al., 2012), social preferences (Corgnet et al., 2015), and even political orientation (Deppe et al., 2015). Therefore, using the CRT creates a bridge between entrepreneurship research and the vast literature using the CRT in neighboring disciplines.

One of the most established dual-process theories, cognitive-experiential self-theory (Epstein et al., 1996; Epstein & Pacini, 1999), underlies the FI and need for cognition (NFC) scales, which Koudstaal et al. (2019) also include in their study. FI and NFC are

principal tools that are used in entrepreneurship research. CRT scores correlate with the NFC scale in a number of studies, including Frederick (2005), Toplak et al. (2014), and Pennycook et al. (2016), with a shorter version of the NFC scale (Lins de Holanda Coelho et al., 2020), and also with the FI, although the results are slightly weaker than for the NFC (Alós-Ferrer & Hügelschäfer, 2016; Pennycook et al., 2016). Despite the theoretical and conceptual similarities between NFC, FI, and CRT, CRT remains under-investigated in entrepreneurship research, and we aim to fill this gap.

The CI is more time-demanding than the CRT and, in contrast to the CRT, it requires precise, preferably computerized time tracking. Moreover, monetary incentives do not change CRT performance, which makes the CRT very cost-efficient (Brañas-Garza et al., 2019). For these reasons, whether the CRT is conducted via pen and paper or computerized, it lends itself for use in large population surveys.

Koudstaal et al. (2019) note that they are not aware of any prior study comparing the CRT scores of entrepreneurs, managers, and employees.<sup>7</sup> They explain that they had two reasons for choosing the CI over CRT in their study. First, they argue that survey respondents may nowadays be familiar with the CRT questions (see also Haigh, 2016), which might have constituted a potential risk in their design. Second, as their data were collected in an online survey, the participants could easily search for the correct answers on the web. Both are highly valid concerns. Since the CRT is a widely used tool in behavioral economics and psychology research, researchers are attempting to develop new versions of the CRT with alternative or more questions (e.g., Capraro et al., 2017; Sirota et al., 2021; Toplak et al., 2014). The overuse of the CRT is particularly problematic in student samples: students might have prior exposure to the CRT because recruitment of participants for experiments in economics and psychology usually takes place on university campuses. Prior exposure to the CRT is also more likely among respondents recruited from research participation forums as in Haigh (2016).

Our data collection largely overcomes these two issues. We use a general population sample as opposed to a student or research-affine sample. We also asked respondents whether they knew the answers to the CRT questions before, and we exclude them from the main analysis if they did. Among 2070 participants without missing values in the variables used in our main analysis, 109 reported that they had known the CRT questions before. Yet only 49 of them answered all questions correctly. There is also evidence suggesting that the CRT is robust to multiple exposures (Bialek & Pennycook, 2018; Meyer et al., 2018). Finally, SOEP-IS data are collected with an interviewer present (mostly in person, sometimes via phone), so it is very unlikely that respondents search for the answers online.

Besides retesting the findings of Koudstaal et al. (2019) with the CRT, we continue our analysis with further preregistered extensions, as it is equally important to widen our understanding of the underlying mechanisms and heterogeneities behind the original findings.

### *Occupational Sorting Versus Environmental Influence*

In their discussion, Koudstaal et al. (2019, p. 915–916) note that, “a second limitation is that our study cannot disentangle personality traits (i.e., nature) from environmental effects (i.e., nurture).” In other words, the differences in cognitive style between the occupational groups could be explained by occupational sorting determined by personality traits (which are stable over time for adults), or they could evolve due to exposure to the job. To advance the literature, we control for personality traits and family background in

exploratory regression analyses. This largely shuts down the occupational sorting channel due to nature. If significant differences between the occupational groups persist, at least some of these differences are likely due to experience on the job.

We include personality variables based on the Big Five inventory in our models.<sup>8</sup> Evidence has accumulated that entrepreneurs on an average score higher in openness to experience, conscientiousness, and extraversion but lower in agreeableness and neuroticism than managers and paid employees, although results in the literature are not fully consistent (Brandstätter, 2011; Caliendo et al., 2014; Zhao & Seibert, 2006). Concerning cognitive reflection, Juanchich et al. (2016) report that CRT performance is negatively correlated with extraversion, but not with the other Big Five traits. Thus, the occupational sorting channel could unfold as follows: Extraverted individuals self-select into entrepreneurship, and they also score low on the CRT, leading to a negative correlation of the CRT score with entrepreneurship when not controlling for the Big Five traits.

Another potential way to shut down the occupational sorting channel is by controlling for the family background that adult survey respondents had during their adolescence. By including a parental entrepreneurship variable in another exploratory regression, we follow a further suggestion by Koudstaal et al. (2019, p. 916). Parental entrepreneurship is a strong predictor of the offspring's entrepreneurial choice (Dunn & Holtz-Eakin, 2000). Lindquist et al. (2015) show that biological children of entrepreneurial parents are 60% more likely to be entrepreneurs as well. This can be due to genetic inheritance (e.g., Nicolaou et al., 2008) or social learning through role modeling, as Lindquist et al. (2015) and Chlosta et al. (2012) suggest.<sup>9</sup> As the family environment during childhood is known to strongly influence the development of cognitive and noncognitive skills (Heckman, 2006), it also plausibly affects cognitive reflection. It is unclear whether one should expect higher or lower CRT performance among entrepreneurial offspring, but no hypothesis on the sign is necessary to test the relevance of the occupational sorting channel through family background. This channel would unfold this way: Offspring of entrepreneurial parents self-select into entrepreneurship, and they also score differently on the CRT on average than others, leading to a nonzero correlation between the CRT performance and entrepreneurship that moves closer to zero or disappears when controlling for entrepreneurial parents. In an additional, not-preregistered regression, we control for the Big Five personality traits and entrepreneurial parents simultaneously to shut down the occupational sorting channel as much as we can.

### *The Role of Overconfidence*

Overconfidence is related to entrepreneurship (Bernoster et al., 2018; Busenitz & Barney, 1997; Cooper et al., 1988; Koellinger et al., 2007) and excess market entry (Camerer & Lovo, 1999) as well as to intuitive thinking. Regarding the latter, Pennycook et al. (2017) and Coutinho et al. (2021) report higher overconfidence among intuitive thinkers, who achieve low performance scores on the CRT. This suggests that the Dunning–Kruger effect, which states that the unskilled tend to be unaware of their incompetence (Kruger & Dunning, 1999), carries over to cognitive reflection. Therefore, overconfidence could be an important mechanism or an omitted factor in the relationship between cognitive styles and entrepreneurship. Koudstaal et al. (2019, p. 916), whose dataset lacks a measure of overconfidence, note that, “the relationship between decision-making style and overconfidence/optimism thus also seems worthwhile to explore further.”

We analyze the role of overconfidence in a preregistered extension. Our CRT module in the SOEP-IS also elicits the respondents' beliefs about their own and the others' performance in the CRT, which allows us to generate two types of overconfidence variables. In our regressions of the CRT score on occupation dummies, we include these overconfidence variables as additional controls in this extension. If overconfidence is a relevant factor interrelated with both cognitive reflection and entrepreneurship, we expect the estimated coefficient of the entrepreneurship dummy variable to move closer to zero in comparison to the regressions omitting overconfidence.

To explore the role of overconfidence further, we run additional, not-preregistered analyses. We analyze whether entrepreneurs differ from hired managers and nonmanagerial employees in terms of overconfidence by estimating models where the overconfidence variables appear as the dependent variables.

### ***Potential Heterogeneity***

We address the heterogeneity among entrepreneurs by estimating whether there are differences in cognitive reflection across different types of entrepreneurs. In a preregistered analysis, we distinguish between nonemployers and employers. On the one hand, as employers are more committed entrepreneurs and take larger risks, one might expect that any differences in cognitive styles between entrepreneurs and other occupational groups are more pronounced among employers than among nonemployers. On the other hand, it is possible that employers are more similar to hired managers than nonemployers because employers and managers have in common that they are responsible for larger organizations and that they hire and manage personnel (Busenitz & Barney, 1997; Koudstaal et al., 2019). It is even possible that many nonemployers started their businesses due to biased, potentially intuitive decision-making, and, consequently, they are often not successful enough to grow to the hiring stage. Such a bias could also be due to overconfidence if overconfidence goes along with an intuitive thinking style, as we also explore. Thus, theoretical expectations on differences in cognitive reflection between employers and nonemployers are ambiguous and we offer an empirical analysis in the hope to break ground for further research.

In another preregistered test, we follow Koudstaal et al. (2019) and analyze heterogeneity by formal education. Individuals with higher education are expected to be more contemplative thinkers because education provides training in analytic thinking or due to selection of contemplative thinkers into higher education. Indeed, CRT performance is connected to mathematical abilities (Campitelli & Gerrans, 2014). Based on these considerations, Koudstaal et al. (2019) formulate the expectation that differences in cognitive style between occupational groups may be smaller among the highly educated, which is what they find in an extension of their main analysis. We test whether this result can be replicated in our sample.

### **Methods**

We follow the methodology of Koudstaal et al. (2019) to ensure comparability of the results. Our pre-analysis plan was registered to the Open Science Framework before we gained access to the SOEP-IS 2020 wave, including the CRT data (<https://osf.io/afhnm>), following recommendations by Anderson et al. (2019). The pre-analysis plan specifies the full details of our primary analysis and most extensions and robustness checks. Further



extensions and robustness checks were added during the peer-review process following suggestions of the reviewers and are clearly marked as not preregistered.

### *Data and Sample*

Our data collection was performed within the 2020 wave of the SOEP-IS. SOEP-IS is a household panel study that has been running since 2012 with around 4,500 respondents representative of the German population. We included the CRT in a subsample of SOEP-IS. The CRT (Frederick, 2005) consists of three questions that have an intuitive but wrong answer and a correct answer that requires more deliberate thinking. This way, the test is able to separate intuitive from contemplative thinkers. We added three questions to elicit performance predictions for both oneself and others as well as potential previous knowledge of the CRT questions. We did not monetarily incentivize correct answers in the CRT as the meta-analysis of Brañas-Garza et al. (2019) did not find a significant effect of monetary incentives on the CRT performance. Table C1 in Online Appendix C shows all six items of our CRT module.

Our main analysis is based on 1961 respondents without missing values in the variables used in our primary hypothesis tests and who indicated that they had not known the CRT questions before. Our sample included 1,032 females: 183 entrepreneurs, 334 hired managers, and 1,444 nonmanagerial employees. Thus, the entrepreneurship rate in the sample is 9.3%, which is close to the self-employment rate of 9.3% (8.6%) in Germany in 2019 (2020) reported by the Institut für Mittelstandsforschung (2022) based on the Census data. In contrast, Koudstaal et al. (2019) deliberately targeted entrepreneurs, which led to a share of 36% in their sample.

*Dependent variable:* We follow an analogous empirical strategy to Koudstaal et al. (2019), who used the CI as the dependent variable in their regression analyses. Our dependent variable is the number of correct answers in the 3-item CRT, which ranges from 0 to 3. Higher values signify more contemplative thinkers, and lower values signify more intuitive thinkers.

*Occupation variables:* We define three binary variables to identify entrepreneurs, hired managers, and nonmanagerial employees. We classify respondents based on their main occupation. *Entrepreneurs* are operationalized as those who are self-employed with or without employees and with or without partners, but not including those who indicate that they are solely helping family members in a family business. Self-employment is often used in the literature as a measurable proxy of entrepreneurship (see Congregado et al., 2012; for a discussion); we address the heterogeneity within self-employment by distinguishing between nonemployers and employers in an extension. We include self-employed farmers among the group of self-employed in the main analysis but exclude them from the sample in a robustness check. Hired managers are defined as the subgroup of paid employees with highly qualified duties or managerial functions (examples include department heads and managing directors), as in Caliendo et al.'s (2012) study.<sup>10</sup> While Koudstaal et al. (2019) require managers to have at least two direct subordinates, we do not observe the number of subordinates, and we cannot rule out that some of those who we define as managers have only one or no direct subordinates. All other paid employees are classified as *nonmanagerial employees*.

For those working in 2020, the year when the CRT was administered, the occupation variables are based on the current occupational status in 2020, while for those not working in 2020, we use information about the individual's most recent occupational status

observed in prior survey waves, as in Fossen et al.'s (2022) study. In a robustness check, we instead categorize respondents based on whether they were ever an entrepreneur or a manager during the observation period in the panel data. We exclude individuals from our analysis who were never observed as self-employed, as a manager, or as a nonmanagerial employee in the panel data.

*Control variables:* We use similar control variables as Koudstaal et al.'s (2019) study. We control for age (divided by 10), gender, and three dummy variables capturing the highest formal educational degree attained: (i) upper secondary school degree qualifying for university entrance, or apprenticeship; (ii) vocational degree beyond apprenticeship; and (iii) university degree. Education below these attainments is the omitted base category. More details on the generation of all the variables used in this article are documented in the pre-analysis plan.

### Primary Hypothesis Test

We run a set of ordinary least squares (OLS) regressions to compare the CRT scores of entrepreneurs, hired managers, and nonmanagerial employees. In our main analysis, we regress the CRT performance score of individual  $i$  on two dummy variables identifying entrepreneurs and managers (nonmanagerial employees are the omitted base category) along with a set of control variables:

$$\text{CRT}_i = \alpha + \beta_1 \text{entrepreneur}_i + \beta_2 \text{manager}_i + X_i' \gamma + \varepsilon_i \quad (1)$$

We test the null hypotheses (i) that  $\beta_1 = 0$  (indicating that the CRT performance of entrepreneurs equals that of nonmanagerial employees); (ii) that  $\beta_2 = 0$  (indicating that the CRT performance of managers equals that of nonmanagerial employees); and (iii) that  $\beta_1 = \beta_2$  (indicating that the CRT performance of entrepreneurs equals that of managers). We report heteroscedasticity robust standard errors. Following recommendations by Benjamin et al. (2018), we refer to a rejection of a null hypothesis at the 0.5% significance level ( $p$ -value below 0.005) as “statistically significant evidence” and to a rejection at the 5% level ( $p$ -value below 0.05) as “suggestive evidence.” We conduct two-sided hypothesis tests. In a robustness check, we estimate an ordered probit model instead of OLS.

### Exploratory Hypothesis Tests

*Father's Occupation and Own Personality.* In our first exploratory analysis, we aim to assess whether differences in cognitive reflection between the occupational groups are due to occupational sorting or the influence of the occupational environment. To do so, we test whether the differences in CRT scores between the three occupational groups prevail when controlling (i) for a family background of entrepreneurship; (ii) for the individual's personality traits; and (iii) both. The aim of these control variables is to keep the nature component (family background and personality) largely constant. We expect the differences in the CRT scores between the occupational groups to become smaller in comparison to the main regression to the extent that they are due to occupational sorting based on nature; differences that prevail are likely due to the adoption of a thinking style due to the experience of entrepreneurship or management.

The family background is controlled by adding a dummy variable capturing an intergenerational link in entrepreneurship, *father entrepreneur*, which takes the value 1 if the father of the respondent was self-employed when the respondent was 15 years old, otherwise 0.

The personality traits are controlled using the Big Five personality model, that is, five variables with scores for each of the five traits. The 2019 SOEP-IS contains 15 items asking respondents to indicate their agreement with statements about themselves on a 7-point Likert scale. Three statements belong to each of the Big Five traits, and we take the average scores as in Caliendo et al.'s (2014) study, which confirm this method using a factor analysis. The number of observations is lower in this exploratory analysis than in the primary regression due to panel attrition between 2019 and 2020.

**Overconfidence.** In their conclusion, Koudstaal et al. (2019) speculate that the intuitive decision-making style of entrepreneurs could be derived from overconfidence in the sense that entrepreneurs have high trust in their gut feelings; thus, the authors call for further research. Therefore, in our second exploratory analysis, we run the same regression as in the primary hypothesis test but additionally include variables capturing overconfidence as controls. To the extent that overconfidence is interrelated with cognitive styles, any significant differences in cognitive styles between the entrepreneurs and the other occupational groups are expected to disappear.

We include two overconfidence variables in our analysis, which are based on the definitions of overconfidence by Moore and Healy (2008). Overestimation is overconfidence in one's own abilities in absolute terms and overplacement is a type of overconfidence relative to other individuals.<sup>11</sup> We calculate overestimation by subtracting the respondents' actual CRT score from his/her guess about his/her own score:  $\text{Overestimation} = \text{guess}_{\text{self}} - \text{actual}_{\text{self}}$ .

In the pre-analysis plan, we defined overplacement in a simple way as the respondent's guess about his or her own number of correct answers in the CRT test minus the respondent's guess about the number of correct answers of the others in the CRT test (allowable answers to both questions were integers between 0 and 3), following Neyse et al.'s (2016) and Ring et al.'s (2016) studies:  $\text{Overplacement}_{\text{pre-registered}} = \text{guess}_{\text{self}} - \text{guess}_{\text{other}}$ . An alternative but not-preregistered way of defining overplacement corrects for how much the respondent really performs better than the others by subtracting the difference between the respondent's actual CRT score and the other respondents' mean CRT score (cf. Moore & Healy, 2008):  $\text{Overplacement}_{\text{not pre-registered}} = \text{guess}_{\text{self}} - \text{guess}_{\text{other}} - (\text{actual}_{\text{self}} - \overline{\text{actual}_{\text{other}}})$ . We present results based on both definitions of overplacement. A caveat is that the CRT score, which is the dependent variable in our regressions, is used in the construction of *overestimation* and *overplacement*<sub>not preregistered</sub>. If there is measurement error in the CRT score, this would lead to biased coefficients (see Section B.6 in Online Appendix B for details).

To explore the role of overconfidence further, we also run regressions like Equation (1), but with the three overconfidence variables as dependent variables instead of the CRT score. This allows us to test for differences in overconfidence between the occupational groups, holding other factors constant (not preregistered).

**Heterogeneity.** To address the heterogeneity within self-employment, we distinguish between employers (who have hired at least one worker) and nonemployers (without any employees). To test for differences in the CRT score, we run a regression replacing the *entrepreneur* variable with two dummy variables identifying employers and nonemployers, respectively. We also explore heterogeneity in the CRT differences between the main occupational groups by means of subsample analysis. In a preregistered analysis, we split the sample by the level of formal education, following Koudstaal et al.'s (2019) study. The first subsample includes only those respondents whose highest educational attainment is an upper

secondary high school degree or an apprenticeship or below; the other subsample includes those who have a higher level of education, that is, higher vocational education or a university degree. We reestimate our regressions based on both subsamples.

### Minimum Detectable Effect Size

The statistical power depends on the hypothesized size of the regression coefficients of interest and the standard error of these coefficients. As we wrote in our pre-analysis plan, we did not conduct an *ex-ante* power estimation because predicting the standard error in a multivariate regression is not straightforward. Instead, we announced in our pre-analysis plan to report the minimum detectable effect size (MDE) based on the estimated standard errors of the main regression coefficients. This serves two main purposes. First, this allows us to assess whether our study is reasonably powered. Second, we can follow Maniadis et al. (2017) and Neyse et al. (2023) by calculating the post-study probability (PSP-rep) that each of the main hypotheses is true after our replication (not preregistered).

We estimate the MDE (i) for being an entrepreneur versus being a nonmanagerial employee; (ii) for being a manager versus being a nonmanagerial employee; and (iii) for being an entrepreneur versus being a manager. We calculate the MDE by multiplying the standard error of the entrepreneur coefficient, the manager coefficient, and the estimated difference between these two coefficients, respectively, by 3.65 (2.8) for 80% power to detect an effect at the  $p < .005$  ( $p < .05$ ) level (e.g., Fossen et al., 2022).

## Results

### Descriptive Statistics

Table 1 shows descriptive statistics separately for the entrepreneurs, hired managers, and nonmanagerial employees in our analysis sample.<sup>12</sup> The mean CRT performance score, that is, the number of correct answers to the three CRT questions revealing more contemplative answers, is largest for hired managers (1.43) and lower for entrepreneurs (0.95) and nonmanagerial employees (0.86). We reject equality of the CRT scores across the three occupational groups using an ANOVA test ( $p < .001$ ). Welch's *t*-test rejects equal CRT scores between hired managers and entrepreneurs ( $p < .001$ ) and between hired managers and nonmanagerial employees ( $p < .001$ ), but does not reject equal CRT scores between entrepreneurs and nonmanagerial employees ( $p = .260$ ). These descriptive results for the CRT replicate the descriptive findings of Koudstaal et al. (2019) for the CI. Figure D1 in Appendix D provides a histogram of the CRT scores in the overall analysis sample.<sup>13</sup>

Table 1 further documents that less than a third of the entrepreneurs are employers. The female share is lowest among the hired managers (37%). The share of individuals with a university degree is highest among hired managers (63%) and lowest among nonmanagerial employees (15%). A quarter of the entrepreneurs had a self-employed father when they were 15 years old; this share is 16% among managers and 11% among nonmanagerial employees, and the differences are significant ( $p < .001$ ).

Entrepreneurs score higher than both managers and nonmanagerial employees in the Big Five personality trait "openness to experience" and lower in neuroticism, or in other words, they are more emotionally stable, which is consistent with the literature (Brandstätter, 2011; Caliendo et al., 2014; Zhao & Seibert, 2006). The ANOVA test reveals that there are no significant differences between the three occupational groups regarding the other three traits of the Big Five in this sample, although some of the literature reports

**Table 1.** Descriptive Statistics.

Variable	Entrepreneurs			Hired Managers			Nonmanagerial Employees			Equal Means (ANOVA)	
	Mean	SD	N	Mean	SD	N	Mean	SD	N		p-Value
CRT score	0.951	1.029	183	1.425	1.068	334	0.860	0.981	1444		<0.001
Employer	0.301		183	0			0				
Nonemployer	0.699		183	0			0				
Age	57.4	14.2	183	47.4	12.9	334	50.7	14.9	1444		<0.001
Female	0.475		183	0.368		334	0.569		1444		<0.001
University	0.421		183	0.626		334	0.153		1444		<0.001
Higher vocational degree	0.164		183	0.162		334	0.224		1444		0.013
Upper secondary schooling	0.393		183	0.210		334	0.523		1444		<0.001
Father entrepreneur	0.249		169	0.158		317	0.111		1314		<0.001
Openness to experience	5.141	1.038	182	5.001	1.069	331	4.739	1.133	1433		<0.001
Extraversion	5.027	1.130	182	5.077	1.095	331	4.989	1.121	1433		0.421
Conscientiousness	5.731	0.904	182	5.814	0.743	331	5.758	0.906	1433		0.504
Agreeableness	5.476	0.922	182	5.321	0.933	331	5.413	0.936	1433		0.149
Neuroticism	3.372	1.103	182	3.512	1.185	331	3.854	1.250	1433		<0.001
Overestimation	0.851	0.989	154	0.553	0.890	313	0.810	1.030	1226		<0.001
Overplacement pre reg.	0.173	0.989	133	0.315	1.091	295	-0.057	1.043	1104		<0.001
Overplacement not pre reg.	0.053	0.962	133	-0.217	0.921	295	-0.073	1.026	1104		0.021

Notes: Welch's t-test rejects equal CRT scores between hired managers and entrepreneurs ( $p\text{-value} < .001$ ) and between hired managers and nonmanagerial employees ( $p\text{-value} < .001$ ), but does not reject equal CRT scores between entrepreneurs and nonmanagerial employees ( $p\text{-value} = .260$ ). The last column shows p-values for ANOVA tests of equal means across the three groups. The ANOVA test was preregistered only for the CRT score. Standard deviations (SD) are not shown for binary variables.

differences. In particular, we do not find significantly higher extraversion scores among entrepreneurs than among the other groups. This is in line with the meta-analysis by Zhao and Seibert (2006), who hypothesized a positive correlation, but did not find evidence. The absence of a significant correlation between extraversion and entrepreneurship speaks against our expectation that entrepreneurs might have lower CRT scores due to occupational sorting based on higher extraversion (which is expected to be negatively correlated with CRT performance).

Hired managers overestimate their own CRT performance less than entrepreneurs and nonmanagerial employees. This may be due to higher average cognitive abilities of managers, as reflected in their higher levels of education, because people with lower skills tend to have inflated self-assessments in general (Kruger & Dunning, 1999) and in relation to the CRT specifically (Pennycook et al., 2017). The finding that entrepreneurs overestimate themselves more than managers is also consistent with the literature reporting general overconfidence of entrepreneurs (Busenitz & Barney, 1997; Koellinger et al., 2007). Our data also show that managers overplace themselves more than the other groups when not correcting for their actually better performance (preregistered measure of overplacement), but less when correcting for it (not preregistered measure).

A pairwise correlation matrix appears in Table C2 in Online Appendix C. Women perform worse on the CRT than men on average (consistent with Frederick, 2005), and respondents with a university degree get more questions right than those without. At the 5% significance level, CRT performance is negatively correlated with the Big Five personality traits conscientiousness, agreeableness, and neuroticism. In contrast, among the Big Five traits, Juanchich et al. (2016) found only extraversion to be significantly correlated with the CRT score at the 5% level. Like these authors, we find a negative correlation coefficient, but the  $p$ -value is .099 in our case, so there is no suggestive evidence according to our thresholds. This again speaks against occupational sorting due to extraversion as a relevant explanation of CRT differences.<sup>14</sup>

Overestimation and overplacement corrected for actual performance (not-preregistered definition) are negatively correlated with the CRT scores. This is again consistent with the Dunning–Kruger effect in the CRT performance (Pennycook et al., 2017). As our descriptive results show that the overconfidence variables are correlated with the occupational groups as well as the CRT score, overconfidence could be an important factor to explain the occupational CRT differences.<sup>15</sup>

According to the correlation coefficients, hired managers have higher CRT scores on average than others, but there is no significant difference between entrepreneurs and others or, more specifically, between employers and others or nonemployers and others. Note that these bivariate results do not test our hypotheses; instead, our hypotheses are tested next in multivariate regressions, as specified in the pre-analysis plan.

### *Primary Hypothesis Test*

The results of our primary hypothesis test appear in Column 1 of Table 2. The regression controls for age, gender, and formal education. The coefficient of the entrepreneur dummy variable is close to zero, and a Wald test does not reject the null hypothesis that the CRT score for entrepreneurs equals the CRT score for nonmanagerial employees, which is the omitted base category ( $p = .817$ , shown at the bottom of the table). In contrast, hired managers score significantly higher in the CRT than nonmanagerial employees ( $p = .001$ ): on average, managers have 0.221 more correct answers, which corresponds to 22% of the

**Table 2.** Primary Hypothesis Test and Exploratory Analysis Results.

Variable	Primary		Exploratory Analysis			
	(1)	(2)	(3)	(4)	(5)	(6)
Entrepreneur	0.018 (0.078)	0.010 (0.084)	-0.029 (0.078)	-0.028 (0.050)	0.062 (0.080)	
Hired manager	0.221** (0.069)	0.202** (0.070)	0.224** (0.069)	0.030 (0.041)	0.128* (0.065)	0.221** (0.069)
Age	-0.014** (0.001)	-0.015** (0.001)	-0.014** (0.001)	-0.003** (0.001)	-0.010** (0.001)	-0.014** (0.001)
Female	-0.262** (0.044)	-0.267** (0.046)	-0.200** (0.045)	-0.062* (0.029)	-0.326** (0.044)	-0.263** (0.044)
University	0.702** (0.087)	0.671** (0.094)	0.645** (0.088)	0.119 (0.063)	0.585** (0.095)	0.701** (0.087)
Higher vocational degree	0.319** (0.081)	0.268** (0.089)	0.300** (0.081)	0.044 (0.060)	0.293** (0.092)	0.318** (0.081)
Upper secondary schooling	0.214** (0.072)	0.185* (0.081)	0.206** (0.073)	0.042 (0.056)	0.212* (0.084)	0.214** (0.072)
Father entrepreneur		0.090 (0.066)				
Openness			0.043* (0.020)			
Extraversion			-0.049* (0.021)			
Conscientiousness			-0.067* (0.026)			
Agreeableness			-0.029 (0.023)			
Neuroticism			-0.081** (0.018)			
Overestimation				-0.684** (0.013)	-0.336** (0.032)	
Overplacement pre reg.				0.665** (0.013)		

(continued)

Table 2. (continued)

Variable	Primary		Exploratory Analysis			
	(1)	(2)	(3)	(4)	(5)	(6)
Overplacement not pre reg.					-0.202** (0.035)	
Employer						-0.037 (0.137) 0.042 (0.092)
Nonemployer						1.427** (0.104) 1961 0.133
Constant	1.425** (0.104) 1961 0.133	1.518** (0.111) 1800 0.138	2.322** (0.234) 1946 0.148	1.672** (0.069) 1532 0.732	1.604** (0.112) 1532 0.360	
Observations						
R <sup>2</sup>						
Wald coeff. tests (p-values)						
Test entrepreneur = 0	0.817	0.902	0.715	0.579	0.442	
Test manager = 0	0.001	0.004	0.001	0.456	0.049	0.001
Diff. entrepreneur-manager	-0.203	-0.192	-0.252	-0.058	-0.067	
Test entrepreneur = manager	0.031	0.051	0.007	0.290	0.469	
Test employer = 0						0.788
Test nonemployer = 0						0.645
Diff. employer-manager						-0.258
Test employer = manager						0.079
Diff. nonemployer-manager						-0.179
Test nonemployer = manager						0.088
Diff. employer-nonemployer						-0.079
Test employer = nonemployer						0.621

Notes: OLS regressions. Dependent variable: CRT score. Robust standard errors in parentheses below coefficients.

\*\*Significant (p-value < .005). \*Suggestive (p-value < .05).



standard deviation of the CRT score in the full analysis sample (1.022). The point estimate of the controlled difference in the CRT scores between managers and entrepreneurs is 0.203 (20% of a standard deviation), and there is suggestive evidence that this difference is not zero ( $p = .031$ ). These results successfully replicate the regression results reported by Koudstaal et al. (2019), and the estimated effect sizes are remarkably similar: Koudstaal et al. (2019), who used the CI instead of the CRT, report that managers score higher in the CI than nonmanagerial employees (entrepreneurs) by 19% (21%) of a standard deviation of the CI scale.<sup>16</sup> The results for the control variables confirm expectations from the literature: The CRT score of women is significantly lower than that of men (Frederick, 2005), and the higher the level of formal education is, the higher is the CRT score (the omitted base category is schooling below the upper secondary level).

### Exploratory Analysis

*Father's Occupation and Own Personality.* The remaining columns of Table 2 present the results from our exploratory analyses. In Column 2, we add a control variable indicating whether the respondent's father was an entrepreneur when the respondent was 15 years old. The difference in the CRT scores between managers and nonmanagerial employees remains similar in magnitude and significant; however, the statistical significance of the difference between managers and entrepreneurs just fails to pass the threshold of representing suggestive evidence here ( $p = .051$ ). In Column 3, we instead control for the Big Five personality traits. The differences in the CRT scores between the occupational groups remain similar, as in Column 1, in terms of the point estimates and significance levels, that is, the difference between managers and nonmanagerial employees remains significant and the difference between managers and entrepreneurs suggestive. We obtain the same results when controlling for an entrepreneurial father and the Big Five traits simultaneously (Column 1 of Table C3 in Appendix C, not preregistered). Taken together, these additional three regressions suggest that the CRT differences between the occupational groups are mostly robust to controlling for variables capturing an individual's nature, so occupational sorting based on personality or family background does not explain the CRT differences.

*Overconfidence.* Next, we account for the two components of overconfidence: overestimation and overplacement. Column 4 of Table 2 uses the simple preregistered definition of overplacement, whereas Column 5 uses the not-preregistered definition that corrects for how much the respondent really performs better than the average other respondent. It turns out that the definition makes a difference. In Column 5, the differences in the CRT score between managers and the other occupational groups are closer to 0 than in Column 1, and the significance level falls from significant to suggestive for the difference between managers and nonmanagerial employees ( $p = .049$ ) and below the suggestive level for the difference between managers and entrepreneurs ( $p = .469$ ). In Column 4, the point estimates of the differences are even closer to zero, and none of them remains statistically suggestive.<sup>17</sup> A caveat is that the overconfidence variables are closely related to the CRT score by definition (see section "Overconfidence"), which is likely to contribute to the high  $R^2$  as well as the opposite signs of the estimated coefficients of *overestimation* and *overplacement*. Overall, we cannot confidently rule out that the differences in the CRT scores between the occupational groups that we found in the primary hypothesis test and that are also reported by Koudstaal et al. (2019) are due to differences in overconfidence. We explore the differences in overconfidence further in Online Appendix A.1.

**Heterogeneity.** In the next extension, we distinguish between employers and nonemployers among the entrepreneurs. Column 6 of Table 2 shows that neither employers nor nonemployers differ in their CRT scores from nonmanagerial employees at the significant or suggestive levels ( $p$ -values are .788 and .645), whereas managers score significantly higher than nonmanagerial employees ( $p = .001$ ). These results confirm the results from our primary hypothesis test and do not suggest the existence of further important heterogeneity within the entrepreneurs with respect to the CRT.<sup>18</sup> In contrast to the primary hypothesis test results, the significance of the differences between employers or nonemployers and managers do not reach the suggestive level ( $p = .079$  for employers and  $p = .088$  for nonemployers). Clearly, the coefficient of the combined entrepreneur dummy variable is estimated more precisely than the separate coefficients of the employer and nonemployer dummy variables, as reflected in the standard errors, so there is no contradiction in these results.

Next, we split the sample by the level of formal education, as preregistered. Table C4 in Appendix C shows the results for the respondents whose highest educational attainment is high school or apprenticeship and Table C5 for those with a higher education level. The point estimates of the differences in the CRT scores between the occupational groups are remarkably similar across education levels. While Koudstaal et al. (2019) report that differences in the CI between the occupational groups diminish at higher levels of formal education, our point estimates of the coefficient of the hired manager dummy are generally only slightly lower in Table C5 than in Table C4. However, when splitting our sample by education, the estimated standard errors generally increase, and the significance levels drop due to the smaller sample sizes. In both Tables C4 and C5, in Columns 1, 2, 3, and 6, the significance level of the difference between managers and nonmanagerial employees drops from significant (in Table 2) to suggestive, and in Column 5, it no longer reaches the suggestive threshold. The difference between managers and entrepreneurs is no longer suggestive in either Table C4 or C5 except for Column 3 controlling for the Big Five traits (this difference was significant in the main Table 2). Heterogeneity with respect to gender is explored in Online Appendix A.2.

### Robustness Tests

We assess the sensitivity of the results to sample and variable definitions as well as estimation methods. To do so, we conduct several robustness tests for our primary hypothesis test and exploratory analyses. In preregistered robustness checks, we include respondents with previous knowledge of the CRT questions in the sample; exclude self-employed farmers from the sample; measure whether a respondent was ever observed as an entrepreneur or manager; and estimate ordered probit regressions. In further, not-preregistered robustness checks, we define hired managers in an alternative way, and we use the count of intuitive (incorrect) answers in the CRT as the dependent variable instead of the count of correct (contemplative) answers.<sup>19</sup>

The results are presented and discussed in detail in Online Appendix B. In summary, from all the preregistered robustness checks, we conclude that the findings from the primary and exploratory analysis shown in Table 2 are robust overall, with one notable exception concerning the exploratory analysis controlling for an entrepreneurial father: here, the positive difference in the CRT score between managers and entrepreneurs, which failed to reach the suggestive significance level in Column 2 of the main Table 2, is found to be suggestive in the first three of the four preregistered robustness checks. The two sets

**Table 3.** Minimum Detectable Effect Size (MDE).

Test	Primary	Exploratory Analysis			
	(1)	(2)	(3)	(4)	(5)
Entrepreneur					
p-value < .005	0.286	0.306	0.286	0.183	0.292
p-value < .05	0.220	0.235	0.219	0.140	0.224
Hired manager					
p-value < .005	0.250	0.256	0.251	0.149	0.237
p-value < .05	0.192	0.196	0.193	0.114	0.182
Diff. entrepreneur-manager					
p-value < .005	0.343	0.358	0.342	0.201	0.336
p-value < .05	0.263	0.275	0.262	0.154	0.258

Notes. Minimum detectable effect size based on the estimated standard errors in Table 2 for 80% power to detect an effect at the indicated significance level.

of robustness checks that were not preregistered also confirm the overall pattern of results, with two deviations. First, the significance levels decrease somewhat when using the alternative definition of managers, which we believe is less sharp than our preregistered definition. Second, when using the number of intuitive answers as the dependent variable, the differences between the occupational groups remain more stable even when controlling for our overconfidence variables (see Section B.6 of Appendix B).

*MDE and Post-Study Probability*

Table 3 shows the MDE for the differences in CRT scores between the occupational groups based on the estimated standard errors of the OLS coefficients in the main Table 2. We show the MDE for 80% power to detect an effect at the significant level ( $p < .005$ ) and at the suggestive level ( $p < .05$ ) in the primary and exploratory analyses. The MDEs indicate that we have the power to detect smaller effects for hired managers than for entrepreneurs (vs. nonmanagerial employees), and the MDE for the difference between entrepreneurs and managers is the largest. The reason is that the number of nonmanagerial employees is the largest and the number of entrepreneurs is the smallest in the sample. Overall, all MDEs are reasonably small, given that the standard deviation of the dependent variable, the CRT score, is 1.022 in the analysis sample. For example, using the MDE in the primary hypothesis tests, we have 80% power to detect an effect of being a hired manager versus a nonmanagerial employee of at least 18.8% of a standard deviation of the CRT at the suggestive level (referring to the smallest MDE in Column 1) or an effect of being an entrepreneur versus a manager of 33.6% of a standard deviation of the CRT at the significant level (referring to the largest MDE in Column 1). Larger samples would be needed to detect smaller potential effects with a high probability.

How much has this replication study changed our knowledge about the relationship between cognitive styles and entrepreneurship or management? In Table 4, we show how much more (or less) confident we can be after this replication that each of the primary hypotheses is true, that is, that the controlled cognitive style differs between entrepreneurs (ENT) and nonmanagerial employees (EMP), between managers (MAN) and nonmanagerial employees, and between entrepreneurs and managers. We calculate Post-study

**Table 4.** Post-Study Probability (PSP-rep) that the Hypothesis is True After Our Replication.

Power Hypothesis	80% Power			90% Power		
	ENT $\neq$ EMP	MAN $\neq$ EMP	ENT $\neq$ MAN	ENT $\neq$ EMP	MAN $\neq$ EMP	ENT $\neq$ MAN
Effect size	0.263	0.220	0.192	0.295	0.247	0.215
Prior						
0.10	0.023	0.640	0.640	0.012	0.667	0.667
0.25	0.066	0.842	0.842	0.034	0.857	0.857
0.50	0.174	0.941	0.941	0.095	0.947	0.947
0.75	0.387	0.980	0.980	0.240	0.982	0.982
0.90	0.655	0.993	0.993	0.486	0.994	0.994

Notes. PSP-rep is based on Equation (2). The PSP-rep is shown for different priors (the probability of the hypothesis being true prior to the replication), a statistical power of the replication of 80% (left three columns) and 90% (right three columns), and a statistical significance threshold of 0.05. The three primary hypotheses shown in this table are that the controlled cognitive style differs between entrepreneurs (ENT) and nonmanagerial employees (EMP), between managers (MAN) and EMP and between MAN and ENT. Using 80% (90%) power implies that the estimations are done for a hypothesized effect size equal to the effect size we had 80% (90%) power to detect for  $p < .05$  (see Table 3 for 80% power). The effect size is measured as the difference in CRT score units between the occupational groups. This table was not preregistered in our pre-analysis plan.

Probabilities (PSP-rep) according to the formula provided in Maniadis et al.'s (2017) study:

$$\text{PSP-rep} = \frac{b(1 - \beta, r, n)\pi}{b(1 - \beta, r, n)\pi + b(\alpha, r, n)(1 - \pi)}, \text{ where } b(\alpha, r, n) = \binom{n}{r} \alpha^r (1 - \alpha)^{n-r} \quad (2)$$

The table presents the PSP-rep for different priors  $\pi$ , that is, different beliefs we might have had that each hypothesis was true prior to this replication. We show the PSP-rep for a statistical significance threshold of  $\alpha = .05$ , because this was the threshold Koudstaal et al. (2019) used (e.g., see their Table 3), and for a statistical power of the replication of  $1 - \beta = 80\%$  and  $90\%$ . The different statistical powers imply that the estimations are done for different hypothesized effect sizes as given by the corresponding MDEs (for  $p < .05$ ), which are also provided in the table. Since this is the first replication,  $n = 1$ , and the number of successes is  $r = 1$  for the tests that  $\text{MAN} \neq \text{EMP}$  and  $\text{ENT} \neq \text{MAN}$  and  $r = 0$  for the test that  $\text{ENT} \neq \text{EMP}$ .

The table shows that the probabilities that the cognitive style of entrepreneurs differs from that of managers and that the cognitive style of managers differs from that of other employees increase dramatically due to this replication. For example, if prior to this replication, the probability that entrepreneurs differ from managers was  $75\%$ , after this replication this probability has increased to  $98.0\%$  (for  $80\%$  power) or  $98.2\%$  (for  $90\%$  power).<sup>20</sup> At the same time, the PSP-rep is much lower than the prior for the hypothesis that entrepreneurs differ from nonmanagerial employees because the null hypothesis of no difference between these two groups could not be rejected neither in Koudstaal et al.'s (2019) study nor in this replication.

## Discussion and Conclusion

Intuition is vital for entrepreneurs as they frequently make decisions under uncertainty (McMullen & Shepherd, 2006) as well as risk, time pressure, or deep emotional

involvement (Baron, 2008). It is suggested that intuition is “potentially as important as rationality in fast moving and uncertain environments” (Khatri & Ng, 2000; Sadler-Smith, 2004), with Dutta and Crossan (2005, p. 436) commenting that intuition is “the seed of any entrepreneurial action” (see also Baldacchino et al., 2015).

In this preregistered replication study, we used the CRT to retest the findings of Koudstaal et al.’s (2019) study, which shows that entrepreneurs are more intuitive thinkers than hired managers but equally intuitive as other employees. We confirm the main results from their analysis. The estimated differences in cognitive styles between the occupational groups are remarkably similar, given that the results are based on different measurements, samples, and countries. Our replication substantially increases the confidence the community can have in these results.

We use both new and existing data from SOEP-IS and follow the methodology of the original study. In addition to the replication, we present various extensions and robustness tests. Most of our preregistered extensions are based on suggestions and discussion in Koudstaal et al.’s (2019) study. Our first extension is to use the CRT to measure contemplative versus intuitive decision-making instead of the CI. The second extension addresses the relevance of occupational sorting versus environmental influence as mechanisms by including the individual’s personality and father’s occupation in the analyses. Third, we explore the role of overconfidence. In the final extension, we investigate heterogeneity by distinguishing between employers and nonemployers, by education, and by gender.

While our choice to use the CRT as a proxy of intuitive decision-making is based on the discussion of Koudstaal et al. (2019), we are aware of the fact that there are different views on what the CRT measures. Several studies show that it is not a type of numeracy test (e.g., Campitelli & Gerrans, 2014). In another study, Alós-Ferrer and Hügelschäfer (2016) compare CRT and FI scores in three datasets and find correlations in two of the datasets, although the correlations are weak. Studies that use the CRT as a measure of intuitive decision-making have used two different scoring methods to do so. The majority of the literature uses the sum of correct responses to identify reflective decision-makers. Some studies use the sum of intuitive incorrect answers instead (e.g., Brosnan et al., 2014; Shenhav et al., 2012), although Pennycook et al. (2016) suggest that the latter scoring method might not be an adequate measure of intuition. The difference between counting the number of correct or intuitive incorrect answers in the CRT is the treatment of other (nonintuitive) incorrect answers. We use the number of intuitive incorrect answers in a robustness check (not preregistered) and find that the differences between the occupational groups become even more stable when using this measure.

Our study provides additional evidence that the CRT is still an effective measure despite concerns about multiple exposure in the scientific community (Haigh, 2016). While this concern is plausible in student or research-affine samples due to frequent participation of these groups in experiments, only a small proportion of our general adult population sample reported previous knowledge of the task. Moreover, even among those who reported previous knowledge, less than half gave correct answers to all items. In fact, only 2.4% of all respondents said they knew and actually knew the answers. This suggests that multiple exposures should not hinder the data quality in general population samples as long as there are no online search and communication possibilities. To be cautious, we exclude individuals who indicate that they knew the CRT questions in our main analysis and only include them in a robustness check.

Koudstaal et al. (2019) noted that their study could not distinguish nature from nurture, suggesting that intuitive thinkers could self-select to be entrepreneurs, or intuitive thinking

could be shaped through entrepreneurial activities (Busenitz & Barney, 1997). As a way to disentangle these potential mechanisms, Koudstaal et al. (2019) suggest that future research could include personality traits and parental entrepreneurship. We follow this suggestion by adding these variables as controls in our exploratory analyses. Our results remain largely robust, although we cannot completely rule out that parental entrepreneurship plays a role. The findings from this extension suggest that occupational sorting based on nature does not explain CRT differences between the occupational groups alone. Instead, exposure to the occupational environment (nurture) may explain the differences, at least to some extent. This is consistent with Ucbasaran et al.'s (2010) study, which shows that repeat entrepreneurs who have not experienced failure are more likely to report optimism than novice entrepreneurs. Furthermore, serial entrepreneurs are shown to be more successful in business, suggesting a significant impact of learning by doing (Lafontaine & Shaw, 2016).

Our attempt of disentangling the nature from nurture with personality traits and parental entrepreneurship is not conclusive as several other observable and unobservable variables might be at play. Several studies suggest that there might be a biological component of the nature of entrepreneurs through genetics (e.g. Nicolaou et al., 2008; Zhang et al., 2009) or testosterone (e.g. Greene et al., 2014; Nicolaou et al., 2018), but results are inconclusive (Fossen et al., 2022; Van der Loos et al., 2013). Numerous other variables could potentially contribute to the nature versus nurture discussion such as identity aspiration (Farmer et al., 2011), windfalls and inherited wealth (Georgellis et al., 2005), or utility expectations (Douglas & Shepherd, 2002). Yet, all these mechanisms are subject to endogeneity issues, which makes it difficult to clearly distinguish social learning from inherited and biological factors.

Our results indicate that overconfidence might be an important element of intuitive decisions of entrepreneurs. Previous evidence also suggests this. First, overconfidence is shown to be a common characteristic of entrepreneurs and to influence market entry (e.g., Bernoster et al., 2018; Koellinger et al., 2007). Second, intuitive decision-makers in the CRT are subject to a set of biases, including overconfidence (Hoppe & Kusterer, 2011). The results indeed suggest that overconfidence might be an important driver of the CRT scores. Our descriptive analysis shows that entrepreneurs overestimate themselves more than managers, with the regression results revealing that they are also more intuitive decision-makers. It is possible that entrepreneurs give intuitive answers because they overestimate their ability and overly trust their intuition. Then the underlying difference between managers and entrepreneurs is really their level of overconfidence and the intuitive decision-making style is a consequence of that. This possibility finds support in our regression results showing that the difference in CRT between the occupational groups becomes weaker when controlling for overconfidence. A caveat is that the CRT score is used in the construction of our overconfidence variables, which may lead to bias in case of measurement error. When we use an alternative measure of intuitive thinking style that mitigates this potential bias, the differences in cognitive style between the occupational groups remain more stable when controlling for overconfidence. Therefore, further studies are needed to fully understand the relationship between intuitive cognitive style and overconfidence in entrepreneurial decisions. To establish causal models, panel data with independent measurements of overconfidence, cognitive reflection, and entrepreneurial decisions at different points in time as well as exogenous instruments may be needed.

In contrast to Koudstaal et al. (2019), we do not find that the differences in cognitive style between the occupational groups diminish at high levels of formal education. Thus,

even highly educated entrepreneurs, despite their training in analytic thinking, resort more to intuitive thinking than equally educated managers.

Although we followed the methodology of Koudstaal et al. (2019), our dataset also has limitations. First, SOEP-IS does not include NFC and FI scales. Considering the strict time constraints in household panel studies, including these scales along with the CRT and over-confidence items was infeasible. Second, SOEP-IS is run in a general population sample that aims to represent the German population rather than a certain occupational group. This is why our sample does not have a very large subset of entrepreneurs. Future studies could also investigate different measurement methods of intuitive thinking style. Moreover, they could provide additional subsample analyses based on larger samples, for example, distinguishing between entrepreneurs active in different industries such as innovative and creative industries. Another important direction would be to account for the experience of entrepreneurs. This could contribute to further disentangling the role of nurture and nature in the cognitive styles of entrepreneurs. Finally, the rise of behavioral and experimental approaches in entrepreneurship research (see Astebro et al., 2014) calls for more replication studies and preregistrations in the field.

### **Acknowledgments**

We thank Randolph Sloof, Roberto Hernan Gonzales, Valerio Capraro, and Brice Corgnet for their valuable comments on our pre-analysis plan, the editor and anonymous reviewers for constructive comments on the article, and Thomas Astebro and participants at the 2023 Annual Conference of the Western Economic Association International in San Diego for inspiring conversations on the topic.


### **Declaration of Conflicting Interests**

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### **Funding**

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Frank Fossen thanks the Ewing Marion Kauffman Foundation for funding the research project RG-202204-12283, HEC Paris and University of Huelva, where he conducted a part of this research as a visiting scholar, and University of Nevada, Reno, for research sabbatical assistance. Levent Neyse acknowledges the financial support of Leibniz Association (SAW10868) and German Research Foundation (DFG) through project CRC TRR 190 Rationality and Competition. The contents of this article are solely the responsibility of the authors.

### **ORCID iD**

Frank M. Fossen  <https://orcid.org/0000-0002-5908-8049>

### **Data Availability**

The data used in this study are available from [https://www.diw.de/en/diw\\_01.c.678568.en/research\\_data\\_center\\_soep.html](https://www.diw.de/en/diw_01.c.678568.en/research_data_center_soep.html)

### **Supplemental Material**

Supplemental material for this article is available online.

## Notes

1. See Busenitz and Barney (1997), Cossette (2014), and Zhang and Cueto (2017) for extensive reviews.
2. For example, Kickul et al. (2009) estimate the influence of cognitive style, as measured by the Cognitive Style Index, on the relationship between perceived entrepreneurial self-efficacy and entrepreneurial intentions, using a sample of 138 part-time MBA students at one university. Ma et al. (2023) use an online survey based on 125 participants from Qualtrics.
3. The response rate was between 5% and 12%. Koudstaal et al. (2016) provide more details on their sampling approach.
4. Two-thirds of the respondents were visited at home, one-third chose to answer by phone due to the Covid-19 pandemic. The response rate when SOEP panel households are initially contacted is about 25%, and the probability of remaining in the panel from year to year is about 85% (Zweck & Glemser, 2018; Zweck & Rathje, 2021).
5. In contrast to the other extensions, the heterogeneity analysis by gender was not preregistered; we present it in the Online Appendix.
6. Kickul et al. (2009) employ the Cognitive Style Index (Allinson & Hayes, 1996), a 38-item measure of analytic versus intuitive cognitive styles.
7. They note that De Mel et al. (2010) compare the CRT scores of wage workers, own-account workers, and small- and medium-sized enterprise owners along with a set of other characteristics.
8. See Kerr et al. (2018) for a review on personality traits of entrepreneurs.
9. See also Rietveld et al. (2021) for a review and methodological discussion of the literature on genetics and entrepreneurship.
10. See our pre-analysis plan (<https://osf.io/afhnm>, Section 2.2.2.1) for details. Executive civil servants are not coded as “hired managers” because career paths in civil service are different from those in the private sector in Germany; for example, tenure usually plays an important role for career advancement in civil service. We conduct a robustness check with an alternative definition of managers.
11. A third type of overconfidence is overprecision, which refers to one’s certainty in his/her decisions. We do not use overprecision in this study.
12. As specified in our pre-analysis plan, this analysis sample excludes those who indicate that they knew the CRT questions before and those with missing values in the variables needed in our primary hypothesis test. The observation numbers ( $N$ ) for some variables used only in the exploratory analyses are lower due to additional missing values.
13. Figure D2 shows an additional histogram, including those respondents who knew the CRT questions before. The distribution is very similar.
14. Given the results reviewed so far, occupational sorting due to the Big Five could still be relevant, although in ways unexpected by means of our literature review. Entrepreneurs score lower in neuroticism than managers and nonmanagerial employees (Table 1), and neuroticism is negatively correlated with CRT performance (Table C2 in Appendix C). This means that those who self-select into entrepreneurship due to low neuroticism perform better on the CRT. However, our regression analysis, as reported below, shows that the inclusion of the Big Five traits as control variables does not reduce the CRT differences between the occupational groups, so occupational sorting based on the Big Five is not practically relevant to explain the CRT differences.
15. Note that the correlations between the CRT score and the three overconfidence variables are very large; for example, the coefficient of correlation between *overestimation* and *overplacement*<sub>not preregistered</sub> is 0.779. This is likely due to the fact, at least in part, that these two variables both include the CRT score in their definition (see section “Overconfidence”). This may lead to multicollinearity when including these variables simultaneously, as we do in our exploratory analysis.
16. Koudstaal et al. (2019) only report that the  $p$ -value of their Wald test of equal coefficients between entrepreneurs and managers is below 0.01, but not the exact  $p$ -value, so we cannot tell whether their test delivered a significant result using our definition ( $p < .005$ ) or only a suggestive result.



17. This result is similar when we account for all control variables simultaneously, including the pre-registered overplacement variable as in Column 4; the similarity of these results is not surprising given the large influence of this overplacement variable. This regression is shown in Column 2 of Table C3.
18. The controlled CRT scores do not differ between employers and nonemployers ( $p = .621$ ).
19. We thank the anonymous reviewers for suggesting these additional robustness checks.
20. In fact, Maniadis et al. (2014) discuss that it is plausible that the PSP after an initial positive result is only 0.5; using this prior, the increase in the PSP is even more dramatic, as shown in Table 4.

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### Author Biographies

**Frank M. Fossen** is a Professor of Economics and the Charles N. Mathewson Professor in Entrepreneurship in the Department of Economics at the University of Nevada, Reno. He is also a Research Fellow of IZA.

**Levent Neyse** is a postdoctoral researcher at German Socio- Economic Panel (SOEP) at the German Institute for Economic Research (DIW) and at Berlin Social Science Center (WZB). He is also a Research Fellow of IZA.