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Are behavioral and electrophysiological measures of impulsivity useful for predicting entrepreneurship?

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ABSTRACT

We examine the association between several behavioral and electrophysiological indices of impulsivity-related constructs and multiple entrepreneurial constructs. Specifically, we investigate if these behavioral and electrophysiological measures are more useful as predictors of entrepreneurship than self-reported measures of impulsivity. Our findings are based on two datasets ($n = 133$ and $n = 142$) and indicate that behavioral and electrophysiological impulsivity measures are not robustly associated with entrepreneurship constructs, in contrast to self-reported measures of impulsivity. Though disappointing at first, our findings pave the way for future research on the relevance of behavioral and electrophysiological measures for entrepreneurship.

1. Introduction

Scholarly interest in the association between impulsivity and entrepreneurship has surged recently. For example, Wiklund et al. (2017a) argue that impulsivity may be an asset in an entrepreneurial career and that uncertain contexts such as entrepreneurship attract impulsive individuals. In line with this, impulsivity and impulsivity-related constructs such as sensation seeking (Wiklund et al., 2017a) and symptoms of Attention Deficit/Hyperactivity Disorder (ADHD; Antshel, 2017; Verheul et al., 2015; Wismans et al., 2020) have been associated with entrepreneurial intention (Antshel, 2017; Geenen et al., 2016; Verheul et al., 2015), preferences (Wiklund et al., 2017b), action (Antshel, 2017; Wiklund et al., 2017a), and orientation (Wismans et al., 2020).

These studies typically use self-report scales to operationalize impulsivity, which are constructed to have convergent and discriminant validity as well as high reliability. Nevertheless, these scales also have their limitations and could even introduce biases for example stemming from social desirability or a consistency motive (Fairburn and Beglin, 1994; Zimmerman and Coryell, 1990). Suggestions to avoid these problems build on recent advances on the intersection of entrepreneurship and biology and include measures such as behavioral assessment and electrophysiology (i.e., EEG measures; Krueger and Welpe, 2014). Indeed, the advantage of behavioral and electrophysiological measures in comparison to self-reports is that they are implicit and can be more objective (Bernoster et al., 2019).

We will use behavioral and electrophysiological indices that have been associated with impulsivity, sensation seeking, reward

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responsiveness, and ADHD symptoms in prior research (for a detailed explanation, see Bernoster et al., 2019). For example, impulsivity has been associated with lower behavioral inhibition in a Go/No-Go task (Littel et al., 2012), riskier behavior in decision-making tasks (Lejuez et al., 2003), and slower reaction times in stop-signal tasks (Logan et al., 1997). With regard to the relationship between self-report and electrophysiology, impulsivity has for example been related to reduced error-related signals in Go/No-Go tasks (Littel et al., 2012), Eriksen Flanker tasks (Potts et al., 2006a), and decision-making tasks (Martin and Potts, 2009). Moreover, sensation seeking has been associated with riskier behavior in a decision-making task (Lejuez et al., 2003), and with reduced error-related signals in an Eriksen Flanker task (Zheng et al., 2014). Also, reward responsiveness has been related to shorter reaction times in a Go/No-Go task (De Pascalis et al., 2010). Finally, people scoring high on ADHD symptoms make more mistakes and have attenuated error signals in the Eriksen Flanker and Go/No-Go task (Geburek et al., 2013).

In the present paper, we will explore the association between self-report scales and behavioral and electrophysiological indices of impulsivity-related constructs on the one hand and several entrepreneurship constructs (e.g., entrepreneurial intention, entrepreneurial orientation, entrepreneurial choice) on the other. We will do so considering that the contribution of impulsivity-related behavioral and electrophysiological measures could unfold in two ways: they may explain variance in these entrepreneurial constructs (1) *above* the variance explained by the conventional self-report measures of impulsivity (complements), or (2) *instead of* the variance explained by these measures (substitutes).

Our findings are based on two relatively large datasets ($n = 133$ and $n = 142$). While the first dataset serves as our main analysis, the second dataset serves as an internal replication that underlines the robustness of our findings. Both datasets show that self-reported impulsivity-related measures are associated with several entrepreneurial constructs. However, the variance in these entrepreneurial constructs could not significantly be explained by the behavioral and electrophysiological measures that were associated with the same impulsivity-related measures. This indicates that behavioral and electrophysiological impulsivity measures are not associated with entrepreneurship variables and do not substitute or complement self-measures of impulsivity.

2. Method

We use partly the same data as Bernoster et al. (2019), who study the associations between self-report measures, behavioral measures, and electrophysiological measures for impulsivity and related constructs. Below, we briefly summarize the important characteristics of the sample and the measures. A more detailed description is outlined by Bernoster et al. (2019). Additionally, we describe the entrepreneurship measures used in our study, which were not used by Bernoster et al. (2019). Since we use the same datasets, we cannot avoid a small overlap in the description of the samples and measures used between the present study and Bernoster et al. (2019). Also, part of the data reported for dataset 1 is reported in a previous study by Rietdijk et al. (2014).

2.1. Dataset 1

2.1.1. Sample and session design

The sample of dataset 1 comprises 169 university students ($N = 169$). After dropping incomplete observations, the final sample was reduced to 133 individuals. The average age of our respondents is 22.2 years and the majority of the respondents are male (61%).

The data was collected between September 2013 and May 2014 in a two-step process. First, we conducted an online survey, which we used to collect a range of self-report variables (including our entrepreneurship variables). Second, we conducted an extensive EEG experiment, in which we collected our behavioral and electrophysiological variables. All measurements took place at the Erasmus Behavioral Lab and lasted 2 h on average.

2.1.2. Measures and variables

Our self-reported entrepreneurial measures include Entrepreneurial Personal Attitude, Entrepreneurial Subjective Norm, Entrepreneurial Internal Locus of Control, Entrepreneurial Self-Efficacy, Entrepreneurial Fit, Entrepreneurial Intention Percentage, and

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

						Correlations and Cronbach's alpha																				
	Mean	SD	Min	Max	VIF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. Entrepreneurial Personal Attitude (self-report)	3.98	0.92	1.00	5.00		0.91																					
2. Entrepreneurial Subjective Norm (self-report)	5.81	1.01	2.00	7.00		0.45***	0.81																				
3. Entrepreneurial Internal Locus of Control (self-report)	5.4	0.81	3.33	7.00		0.09	0.08	0.49																			
4. Entrepreneurial Self-Efficacy (self-report)	3.7	0.48	2.09	4.73		0.47***	0.49***	0.38***	0.74																		
5. Entrepreneurial Fit (self-report)	3.51	0.94	1.00	5.00		0.65***	0.46***	0.18*	0.61***	-																	
6. Entrepreneurial Intention Percentage (self-report)	56.04	26.33	0.00	100.00		0.59***	0.45***	0.17	0.47***	0.68***	-																
7. Entrepreneurial Choice (self-report)	0.08	0.26	0.00	1.00		0.03	0.11	0.1	0.22*	0.24**	0.27**	-															
8. Age	22.23	2.46	17.00	32.00		0.1	-0.01	0.1	0.06	-0.02	0.18*	0.08	-														
9. Gender	0.39	0.49	0.00	1.00		-0.25**	-0.06	0.06	-0.13	-0.24**	-0.08	-0.05	-0.11	-													
10. Impulsivity (self-report)	3.55	0.91	1.25	5.5	1.53	0.14	0.26**	-0.16	0.08	0.18*	0.19*	-0.03	-0.05	0.04	0.5												
11. Sensation Seeking (self-report)	5.12	1.03	2.00	7.00	1.29	0.33***	0.31***	0.16	0.30***	0.22*	0.27**	-0.07	0.08	-0.11	0.39***	0.71											
12. ADHD symptoms (self-report)	2.79	0.52	1.67	5.00	1.32	0.04	0.02	-0.15	-0.17	0.03	0.00	-0.08	0.03	-0.19*	0.39***	0.18*	0.52										
13. GNG Number Incorrect NoGo (behavior)	40.81	17.69	9.00	97.00	1.62	-0.07	0.00	-0.04	-0.15	-0.06	0.03	0.07	0.03	0.04	0.07	-0.06	0.00	-									
14. GNG Number Incorrect Go (behavior)	8.74	17.33	0.00	186.00	2.75	0.06	-0.1	-0.02	-0.1	-0.12	-0.12	-0.06	0.15	0.01	-0.17*	-0.13	-0.19*	0.08	-								
15. GNG Number Post-Incorrect Incorrect (behavior)	4.35	5.59	0.00	39.00	3.34	-0.03	-0.12	-0.08	-0.22*	-0.16	-0.09	-0.09	0.08	0.07	-0.09	-0.19*	-0.12	0.34***	0.76***	-							
16. GNG Average Response Time (behavior)	348.91	50.13	230.69	489.65	1.55	-0.14	-0.13	-0.11	-0.13	-0.1	-0.13	-0.04	0.01	0.11	-0.08	-0.18*	-0.14	-0.17*	0.26**	0.25**	-						
17. EF Number Incorrect (behavior)	35.86	25.43	2.00	148.00	1.59	-0.20*	-0.08	-0.11	-0.13	-0.05	0.00	-0.05	-0.09	0.13	0.08	-0.12	-0.1	0.34***	0.13	0.31***	0.11	-					
18. EF Average Response Time Incongruent (behavior)	429.81	41.26	320.14	543.44	1.37	0.09	0.14	-0.02	0.11	0.02	0.05	0.09	0.05	0.18*	-0.04	0.05	-0.12	-0.1	-0.03	-0.13	0.22*	-0.22*	-				
19. EF Difference Average Response Time Post-Incorrect - Post-Correct (behavior)	19.05	28.53	-60.46	131.24	1.37	0.14	0.20*	-0.04	0.14	0.06	0.09	0.06	0.17	-0.02	0.05	0.16	0.08	-0.17*	0.12	0.03	0.06	-0.32***	0.36***	-			
20. GNG N2 (electrophysiology)	-0.7	2.18	-5.13	5.2	1.65	0.11	-0.05	0.03	0.07	0.01	0.09	-0.05	0.14	0.08	0.13	0.03	-0.07	-0.27**	0.15	0.05	0.13	0.06	0.06	0.09	-		
21. GNG P3 (electrophysiology)	5.00	4.37	-5.7	19.4	1.9	0.21*	0.16	0.12	0.15	0.15	0.18*	0.00	-0.02	-0.03	0.19*	0.16	0.12	0.01	-0.13	-0.21*	-0.40***	-0.03	-0.07	0.03	0.38***	-	
22. EF ERN (electrophysiology)	-7.74	5.19	-20.62	5.00	1.32	-0.11	-0.15	-0.02	-0.08	-0.05	-0.06	0.06	-0.07	0.11	-0.09	-0.14	0.02	0.08	0.09	0.11	0.12	0.25**	0.1	-0.08	0.13	-0.07	-
23. EF Pe (electrophysiology)	10.17	6.18	-3.82	30.52	1.35	0.09	0.1	0.06	0.00	0.09	0.09	0.01	-0.23**	0.12	-0.09	0.05	0.08	-0.08	-0.04	-0.1	-0.12	-0.24**	0.06	0.11	0.01	0.29***	0.20*

Entrepreneurial Choice. Details on these variables and their measurement are summarized in Table A1 (Appendix). In addition to Age and Gender (1 = female), our online survey included self-reported impulsivity(-related) measures. These measures comprise Impulsivity, Sensation Seeking (measured via the ImpSS-8 scale, Webster and Crysel, 2012), and ADHD Symptoms (measured via the ASRS-6, Kessler et al., 2005).

Our behavioral and electrophysiological measures were collected in our EEG experiment. In the EEG experiment, respondents participated in a Go/No-Go task (Donders, 1868/1969; Littel et al., 2012), which enabled us to record four behavioral measures (*GNG Number Incorrect No Go, GNG Number Incorrect Go*, *GNG Number Post-Incorrect Incorrect, GNG Average Response Time*). Another set of three behavioral variables were collected in our EEG experiment using an Eriksen Flanker task (Eriksen and Eriksen, 1974; Marhe et al., 2013). We obtained three additional behavioral variables from the Eriksen Flanker Task test (*EF Number Incorrect, EF Average Response Time Incongruent*, *EF Difference Average Response Time Post-Incorrect - Post-Correct*). In addition, we obtained a range of electrophysiological measures from the EEG experiment. We used a Biosemi Active-Two amplifier system (Amsterdam, the Netherlands) to record EEG data and transformed the raw EEG signals recorded in the experiment (during the Go/No-Go task and Eriksen Flanker) with Brain Vision Analyzer 2.0. These variables were collected during the Go/No-Go task (*GNG N2*, *GNG P3*) and the Eriksen Flanker task (*EF ERN, EF Pe*). We provide more information on our behavioral and electrophysiological measures in Table A2 (Appendix).

2.2. Dataset 2

2.2.1. Sample and session design

To assess the robustness of our main results obtained from dataset 1, we perform an internal replication using a different sample (dataset 2) that comprises 181 university students. After dropping incomplete observations, the final sample was reduced to 142 respondents. The respondents in dataset 2 are younger (the average age is 20.6 years) and the share of male respondents is smaller (46%).

The data was collected between May 2015 and April 2016. In line with the data collection strategy of dataset 1, we first conducted an online survey to collect self-report variables. Then, we conducted an EEG experiment to collect behavioral and electrophysiological variables. In contrast to dataset 1, we conducted a Reward task and an automatic Balloon Analogue Risk Task (BART). The EEG experiment took place in our EEG laboratory using Biosemi (Amsterdam, the Netherlands) EEG equipment and lasted 2 h on average.

2.2.2. Measures and variables

The self-reported entrepreneurial measures are in line with dataset 1. However, we added additional variables (e.g., *Entrepreneurial Orientation*) and also changed varied the measurement of some variables slightly, as outlined in Table A1 (Appendix). We collected additional information on the respondent's *Age* and *Gender* (1=female). We captured self-reported impulsivity via the measures *Reward Responsiveness* (modified RR scale, Van den Berg et al., 2010), *Sensation Seeking* (measured via the Brief Sensation Seeking Scale; Hoyle et al., 2002), and *ADHD Symptoms* (measured via the ASRS-6, Kessler et al., 2005).

The behavioral and electrophysiological measures differ from dataset 1. Participants underwent a Reward task (Franken et al., 2010; Potts et al., 2006b) and an automatic BART (Euser et al., 2011; Lejuez et al., 2002; Pleskac et al., 2008). In the BART, respondents were tasked to inflate a balloon by preselecting a number of pumps that filled the fictional balloon with as much air as possible without bursting it. Participants were awarded reward points for a more accurate solution which linearly translated to the monetary reward participants received. The behavioral measures derived from the BART are (1) the average number of pumps (*BART Average Pumps)* and the average response time (*BART Average Response Time*). The electrophysiological measures in dataset 2 are obtained from the Reward task (*REWARD N2, REWARD P3*) and the BART task (*BART FRN, BART P3*). Additional information is included in Table A2 (Appendix).

3. Results

3.1. Descriptives

Table 1 displays descriptive statistics for dataset 1. We observe multiple high and significant correlations within self-report measures of entrepreneurship and the self-report impulsivity-related measures. For the behavioral and electrophysiological measures, the correlations are lower but still substantial. However, only a small fraction of the correlations between behavioral as well as electrophysiological measures and self-reported entrepreneurship measures are significant. Also, the VIFs indicate that multicollinearity does not seem to be a severe issue (Hair et al., 2010).

Table 2 shows the descriptive statistics for the variables in dataset 2. The highest VIF is 4.55 for *REWARD N2*, which indicates no serious danger of multicollinearity (Hair et al., 2010). Many correlations within self-report measures of entrepreneurship and within our self-report measures of impulsivity, our behavioral, and electrophysiological measures are considerable. Further, many correlations between self-report impulsivity-related measures and self-report entrepreneurship measures are significant. However, none of the correlations between behavior and self-reported entrepreneurship measures and none of the correlations between electrophysiology and self-reported entrepreneurship measures are significant.

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

	Mean	SD	Min	Max	VIF	Correlations and Cronbach's alpha				
						1	2	3	4	5
1. Entrepreneurial Personal Attitude (self-report)	3.56	1.58	1	7		0.95				
2. Entrepreneurial Subjective Norm (self-report)	5.47	0.88	3	7		0.37***	0.79			
3. Entrepreneurial Internal Locus of Control (self-report)	4.99	0.98	1	7		0.19*	0.42***	0.75		
4. Entrepreneurial Intention (self-report)	3.22	1.6	1	7		0.91***	0.39***	0.23**	0.95	
5. Entrepreneurial Intention Percentage (self-report)	20.33	22.2	0	100		0.73***	0.35***	0.20*	0.76***	–
6. Entrepreneurial Choice (self-report)	0.07	0.26	0	1		0.29***	0.15	−0.01	0.34***	0.58***
7. Entrepreneurial Orientation (self-report)	3.53	0.5	2.3	5		0.50***	0.38***	0.35***	0.53***	0.52***
8. Age	20.63	2.04	18	30		0.20*	0.18*	0.04	0.19*	0.23**
9. Gender	0.54	0.5	0	1		−0.08	0.03	−0.07	−0.01	−0.08
10. Reward Responsiveness (large) (self-report)	3.24	0.38	2.25	4	1.14	0.22**	0.30***	0.38***	0.30***	0.33***
11. Sensation Seeking (self-report)	3.2	0.71	1.25	4.75	1.2	0.35***	0.17*	0.14	0.39***	0.41***
12. ADHD symptoms (self-report)	2.75	0.54	1.67	4	1.14	0.13	−0.12	−0.20*	0.1	0
13. BART Average Pumps (behavior)	61.86	10.09	24.87	90.83	1.18	−0.11	−0.1	−0.02	−0.15	−0.04
14. BART Average Response Time (behavior)	6457.59	29574.15	1853.38	355985	1.18	−0.04	0.04	0.01	0.02	−0.07
15. REWARD N2 (electrophysiology)	−0.27	4.94	−16.32	13.21	4.55	−0.07	−0.06	0.05	−0.1	−0.11
16. REWARD P2 (electrophysiology)	0.68	4.47	−10.06	13.12	3.5	−0.03	−0.02	0.05	−0.09	−0.06
17. REWARD P3 (electrophysiology)	0.9	5.93	−14.87	14.51	2.81	−0.04	0	0.12	−0.06	−0.11
18. BART FRN (electrophysiology)	0.26	2.46	−7.32	5.56	1.04	0.06	0.12	0.07	0.07	0.07
19. BART P3 (electrophysiology)	4.09	4.58	−8.39	21.15	1.09	0.03	0.00	−0.08	0.12	0.03

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

3.2. Multivariate results

We perform four regression models for each entrepreneurial construct. Model 1 is the baseline that model that considers control variables and impulsivity-related self-report measures. Models 2 and 3 replace the measures by respectively behavioral (Model 2) and electrophysiological measures (Model 3). Thus, these models assess whether behavioral and electrophysiological measures associated with impulsivity predict entrepreneurial constructs instead of self-reported measures of impulsivity-related constructs. Finally, Model 4 includes all variables jointly and assesses whether behavior and electrophysiology play a complementing and/or substituting role to self-reported impulsivity-related constructs in explaining entrepreneurial constructs. All variables are estimated with an OLS approach except for the binary variable Entrepreneurial Choice, which is estimated with a logistic regression approach. To allow a comparison between the OLS regression models, we standardized the coefficients. The results are presented in Table 3 (dataset 1) and Table 4 (dataset 2).

Both tables show significant associations between self-reported impulsivity-related measures and self-reported entrepreneurial measures (Model 1). We then assess whether behavioral (Model 2) and electrophysiological measures (Model 3) can substitute these effects. For dataset 1 (Table 3), there are 84 relevant coefficients (i.e., those including behavioral/electrophysiological measures in Models 2 and 3 for each dependent variable). However, there is not even one significant coefficient ($p < .05$). Similarly, for dataset 2 (Table 4), there are 49 relevant coefficients and only three of them are significant ($p < .05$). Taken together, these findings indicate that the behavioral and electrophysiological measures, in contrast to the self-reported measures, do not contribute to explaining the entrepreneurship variables in a meaningful way.

Models 4 in Tables 3 and 4 test a complementing role of behavioral and electrophysiological measures. The tables show that the coefficients of the self-reported impulsivity-related measures in Models 4 are slightly less prominent than the coefficients of these measures in Models 1. However, this 'loss' in coefficients is not compensated by the joint addition of our behavioral and electrophysiological measures: none of the coefficients for behavior/electrophysiology in Models 4 of dataset 1 are significant; only one of the coefficients for behavior/electrophysiology in Models 4 of dataset 2 is significant. This shows again that there is no functional significance of behavioral and electrophysiological measures *above* self-reported impulsivity-related measures in explaining entrepreneurship.

4. Discussion

Our results show no functional significance for behavioral and electrophysiological measures in explaining self-reported entrepreneurial constructs above or instead of self-reported impulsivity. Previous studies hypothesized that behavioral and electrophysiological measures may add predictive value to self-reports, or even substitute them. Our present findings could not support this view, at least with the specific measures we used in this study. Relatedly, several previous studies (e.g., Bernoster et al., 2019) show that it is very difficult in general to find correlations between self-report measures (i.e., impulsivity) and electrophysiological measures that theoretically tap the same psychological construct.

Several factors may help explain our findings. A *first* explanation is that some of the previous positive results on the relationship

Correlations and Cronbach's alpha												
6	7	8	9	10	11	12	13	14	15	16	17	18
–												
0.26**	0.75											
0.13	0.09	–										
−0.02	−0.03	−0.02	–									
0.19*	0.43***	0.09	0.13	0.78								
0.19*	0.45***	0.20*	−0.07	0.19*	0.78							
0.04	−0.01	0.25**	0.09	−0.06	0.27**	0.5						
−0.01	−0.03	0.14	−0.22**	−0.09	0.03	0.14	–					
−0.02	0.08	−0.11	0.07	0.11	−0.08	−0.15	−0.31***	–				
−0.04	−0.01	−0.01	−0.05	−0.17*	−0.01	0.05	0.05	0.02	–			
−0.09	−0.05	−0.05	0.03	−0.11	−0.05	0.08	0.03	−0.04	0.83***	–		
−0.14	0.04	−0.01	−0.05	−0.09	0.04	0.04	0.04	0.03	0.79***	0.71***	–	
0.02	0.15	0.08	−0.03	−0.04	0.13	0.01	0.01	−0.06	−0.01	0	−0.05	–
0.01	−0.04	0.03	0.09	−0.15	0.01	0.01	−0.17*	−0.06	0.07	0.01	0.08	0.08

between self-reported impulsivity and behavior/electrophysiology are not genuine positives but the results of small samples (Button et al., 2013; Forstmeier et al., 2017; Ioannidis, 2005), which are particularly common in studies using electrophysiology. Because we use two relatively large samples, we are in a better position to address this problem. Findings from other studies employing large samples have so far been equivocal: some have difficulty finding substantial associations between self-report, behavior, and electrophysiology (Brenner et al., 2005; Dittmar et al., 2011; Moser et al., 2015), whereas others do report significant associations between these measurement levels (Ait Oumeziane and Foti, 2016). Hence, the available literature can neither confirm nor reject the possibility that previous positive findings have arisen as a result of small samples.

A *second* possible explanation concerns the difference between implicit and explicit measures. It has been argued that behavior and electrophysiology are implicit measures because they represent automatic processes and that self-reports represent the conscious result of these implicit processes and are therefore explicit (Dittmar et al., 2011; Eysenck, 1992). This could explain the lack of significant associations between self-reports on the one hand and behavioral/electrophysiology on the other. However, our present data do not support this explanation as the associations between behavior and electrophysiology (which are both implicit) do not clearly outperform the associations between these implicit measures and the (explicit) self-reports.

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

5. Contributions

We first contribute to research on the role of impulsivity in entrepreneurship. The default mode to study this is by self-reported data, using questionnaires that capture aspects of impulsivity such as the UPPS impulsive Behavior Scale. By utilizing a more experimental approach that allows to capture impulsivity-related behavioral and electrophysiological indices in addition to the standard self-reported measures of impulsivity, we are able to overcome the potential limitations of self-report measures. This approach is in line with Krueger and Welpe (2014, p. 2) who mention that 'the entrepreneurial mindset is decidedly not a set of facts to be learned or even a set of skills to be taught, it is a way of thinking and feeling', and suggest to 'look deeper', for instance at the neuroscience behind entrepreneurship. This sentiment is also echoed in other recent studies on the intersection of biology and entrepreneurship (Nicolaou et al., 2019, 2020; Pérez-Centeno, 2017). The present study follows this advice and focuses on new measurement levels to avoid the biases inherent to self-reports (Podsakoff and Organ, 1986).

Relatedly, we contribute to entrepreneurship research by using an approach that is multidimensional in several ways: we focus on *multiple* constructs using *multiple* levels of measurement. That is, we investigate a total of nine self-reported entrepreneurial outcomes which we relate to four impulsivity-related self-report measures, nine behavioral measures, and nine electrophysiological measures. The use of multiple self-report measures is not new: Antshel (2017) discusses entrepreneurial orientation, intention, and action, and Wiklund et al. (2017b) examine multiple dimensions of impulsivity. However, the combination of self-report measures and electrophysiological measures for the same construct (here: impulsivity), allows to provide a more complete view on the relationship between impulsivity and several entrepreneurship constructs.

In doing so, we also contribute to the small amount of literature that uses electrophysiology (i.e., EEG) in entrepreneurship, which has primarily assessed entrepreneurial intuition so far (Bradley, 2006; Bradley et al., 2011). More broadly, our research also contributes to research on the intersection of biology and entrepreneurship (Nicolaou et al., 2020), which often draws on novel

Table 3
Regression results (standard errors in brackets) for dataset 1 ($n = 133$).

	Entrepreneurial Personal Attitude (self-report)				Entrepreneurial Subjective Norm (self-report)				Entrepreneurial Internal Locus of Control (self-report)			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Intercept	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.09)	(0.09)	(0.08)	(0.08)	(0.09)	(0.09)	(0.09)
Age	0.06	0.03	0.08	0.04	−0.03	−0.05	0.01	0.00	0.08	0.12	0.13	0.10
	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
Gender	−0.23**	−0.23**	−0.24**	−0.25**	−0.07	−0.07	−0.05	−0.10	0.09	0.11	0.08	0.12
	(0.08)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
Impulsivity (self-report)	0.08			0.11	0.21*			0.24*	−0.22*			−0.22*
	(0.10)			(0.10)	(0.10)			(0.10)	(0.10)			(0.11)
Sensation Seeking (self-report)	0.28**			0.23*	0.25**			0.17	0.27**			0.26*
	(0.09)			(0.09)	(0.09)			(0.09)	(0.09)			(0.10)
ADHD (self-report)	−0.09			−0.09	−0.12			−0.16	−0.10			−0.13
	(0.09)			(0.10)	(0.09)			(0.10)	(0.09)			(0.10)
GNG Number Incorrect No-Go (behavior)		−0.05		−0.05		0.05		−0.01		−0.03		−0.02
		(0.10)		(0.10)		(0.10)		(0.11)		(0.11)		(0.11)
GNG Number Incorrect Go (behavior)		0.12		0.09		−0.04		−0.03		0.08		−0.01
		(0.14)		(0.14)		(0.14)		(0.14)		(0.14)		(0.14)
GNG Number Post-Incorrect Incorrect (behavior)		0.01		0.09		−0.07		0.00		−0.09		−0.02
		(0.15)		(0.15)		(0.16)		(0.15)		(0.16)		(0.16)
GNG Average Response Time (behavior)		−0.18		−0.09		−0.12		−0.04		−0.11		−0.03
		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.11)
EF Number Incorrect (behavior)		−0.10		−0.11		0.03		0.06		−0.11		−0.12
		(0.10)		(0.10)		(0.10)		(0.11)		(0.10)		(0.11)
EF Average Response Time Incongruent (behavior)		0.14		0.14		0.12		0.13		−0.02		−0.07
		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)
EF Difference Average Response Time Post-Incorrect - Post-Correct (behavior)		0.04		−0.03		0.20*		0.14		−0.09		−0.08
		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)
GNG N2 (electrophysiology)			0.08	0.04			−0.10	−0.14			−0.04	−0.02
			(0.09)	(0.11)			(0.10)	(0.11)			(0.10)	(0.11)
GNG P3 (electrophysiology)			0.13	0.12			0.16	0.11			0.12	0.13
			(0.10)	(0.11)			(0.10)	(0.11)			(0.10)	(0.12)
EF ERN (electrophysiology)			−0.10	−0.04			−0.14	−0.09			−0.01	0.05
			(0.09)	(0.09)			(0.09)	(0.09)			(0.09)	(0.10)
EF Pe (electrophysiology)			0.12	0.08			0.09	0.11			0.05	−0.02
			(0.09)	(0.10)			(0.10)	(0.10)			(0.10)	(0.11)
F-value	4.92	2.13	3.02	2.36	3.93	1.32	1.42	2.04	3.11	0.76	0.73	1.28
p-value	0.00	0.03	0.01	0.01	0.00	0.24	0.21	0.02	0.01	0.65	0.63	0.22
R-squared (adj.)	0.13	0.07	0.08	0.14	0.10	0.02	0.02	0.11	0.07	−0.02	−0.01	0.03
n	133	133	133	133	133	133	133	133	133	133	133	133

Note: ***: p<.001, **: p<.01, *:p<.05.
aInstead of the results of an F-test, we present the results of the more appropriate LR-test for logistic regressions.

methodological approaches to deliver novel insights to the domain of entrepreneurship. For example, prior studies assess entrepreneurship-related questions using fMRI (functional magnetic resonance imaging; Shane et al., 2020) or assessments of hormones (Wolfe and Patel, 2017). We add to this research by exploring how electrophysiological approaches could be applied to the domain of entrepreneurship.

Finally, it is important to consider the study of Bernoster et al. (2019) who explored the association between self-report, behavioral, and electrophysiological measures of impulsivity and related constructs using the same two large samples of completed questionnaires and behavioral tasks. Importantly, Bernoster et al. (2019) show that the self-report, behavioral, and electrophysiological indices of impulsivity are largely independent, suggesting that they could potentially have different contributions to the entrepreneurial indices. It is a matter of empirical testing which of these indices is most closely related to entrepreneurship. And that is exactly the goal of the present study. We want to stress that Bernoster et al. (2019) did not include any entrepreneurial variables.

6. Limitations

First, although our samples are large in terms of general sample size, they are concise when it comes to other dimensions such as

Entrepreneurial Self-Efficacy (self-report)				Entrepreneurial Fit (self-report)				Entrepreneurial Intention Percentage (self-report)				Entrepreneurial Choice (self-report)			
Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	−2.65***	−2.89***	−2.63***	−3.22***
(0.08)	(0.09)	(0.09)	(0.08)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.08)	(0.37)	(0.47)	(0.37)	(0.59)
0.04	0.04	0.04	0.04	−0.04	−0.04	−0.02	0.01	0.16	0.18*	0.19*	0.22*	0.31	0.20	0.35	0.40
(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)	(0.32)	(0.34)	(0.34)	(0.38)
−0.16	−0.12	−0.12	−0.15	−0.26**	−0.24**	−0.25**	−0.28**	−0.07	−0.08	−0.07	−0.12	−0.32	−0.21	−0.20	−0.35
(0.08)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.38)	(0.37)	(0.36)	(0.42)
0.08			0.09	0.17			0.20	0.16			0.16	0.23			0.29
(0.10)			(0.10)	(0.10)			(0.11)	(0.10)			(0.11)	(0.41)			(0.45)
0.30***			0.23*	0.15			0.10	0.21*			0.18	−0.35			−0.57
(0.09)			(0.09)	(0.09)			(0.10)	(0.09)			(0.10)	(0.38)			(0.46)
−0.28**			−0.31***	−0.11			−0.15	−0.12			−0.16	−0.40			−0.59
(0.09)			(0.10)	(0.09)			(0.10)	(0.09)			(0.10)	(0.40)			(0.46)
	−0.09		−0.10		−0.03		−0.05		−0.01		−0.01		0.51		0.51
	(0.10)		(0.11)		(0.10)		(0.11)		(0.10)		(0.11)		(0.39)		(0.46)
	0.08		0.00		−0.03		−0.04		−0.17		−0.22		0.19		−0.18
	(0.14)		(0.14)		(0.14)		(0.14)		(0.14)		(0.14)		(2.13)		(2.58)
	−0.21		−0.13		−0.11		−0.05		0.05		0.13		−1.25		−1.27
	(0.15)		(0.15)		(0.16)		(0.16)		(0.16)		(0.15)		(1.43)		(1.66)
	−0.13		−0.08		−0.07		−0.02		−0.12		−0.06		0.01		−0.12
	(0.10)		(0.10)		(0.10)		(0.11)		(0.10)		(0.10)		(0.42)		(0.53)
	0.04		−0.01		0.06		0.06		0.09		0.10		−0.22		−0.28
	(0.10)		(0.10)		(0.10)		(0.11)		(0.10)		(0.11)		(0.50)		(0.58)
	0.09		0.05		0.05		0.05		0.07		0.07		0.30		0.16
	(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.40)		(0.44)
	0.10		0.09		0.07		0.03		0.09		0.03		0.18		0.45
	(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.10)		(0.37)		(0.42)
		0.03	−0.03			−0.01	−0.04			0.02	0.03			−0.32	−0.36
		(0.10)	(0.11)			(0.10)	(0.11)			(0.10)	(0.11)			(0.40)	(0.54)
		0.13	0.10			0.12	0.07			0.14	0.06			0.14	−0.02
		(0.10)	(0.11)			(0.10)	(0.12)			(0.10)	(0.12)			(0.39)	(0.53)
		−0.05	0.04			−0.03	−0.00			−0.05	−0.04			0.33	0.30
		(0.09)	(0.09)			(0.09)	(0.10)			(0.09)	(0.10)			(0.36)	(0.39)
		−0.01	−0.04			0.09	0.13			0.11	0.17			0.06	0.09
		(0.10)	(0.10)			(0.10)	(0.11)			(0.10)	(0.10)			(0.37)	(0.45)
5.04	1.59	0.98	2.17	3.54	1.34	1.98	1.38	3.57	1.23	1.81	1.67	2.99[a]	6.27[a]	2.54[a]	10.76[a]
0.00	0.13	0.44	0.01	0.01	0.22	0.07	0.17	0.01	0.28	0.10	0.06	0.70	0.71	0.86	0.82
0.13	0.04	−0.00	0.12	0.09	0.02	0.04	0.04	0.09	0.02	0.04	0.08	–	–	–	–
133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133

participant type and geographical spread. For example, our samples may be unable to capture all actual entrepreneurial aspects given that our subjects were not actual entrepreneurs. We are therefore eager to see our study be replicated in other research labs without the limitation of selecting students only.

Second, raw electrophysiological data require much pre-processing, which makes the outcomes partly dependent on analytical choices that are sometimes relatively arbitrary (i.e., have no one right answer). For example, in the present study, we opted for using the subtraction method to calculate the electrophysiological measures, resulting in difference scores, which have upsides (Miltner et al., 1997) and downsides (Meyer et al., 2017). Future studies should therefore try to replicate our findings using an approach different from subtraction.

Third, the measures in our two samples are overlapping, but are not entirely similar. When it comes to the self-report measures, using the same constructs could lead to more consistent results. For example, we adopted reward responsiveness as an impulsivity-related construct, whereas Franken and Muris (2006) explain that the original reward responsiveness dimension by Gray (1987) consists of reward sensitivity and rash impulsivity, two separate dimensions that are differentially related to impulsivity. Future research could benefit from using well-defined models for deciding what constructs to use, such as the UPPS model (Whiteside and Lynam, 2001).

Table 4
Regression results (standard errors in brackets) for dataset 2 ($n = 142$).

	Entrepreneurial Personal Attitude (self-report)				Entrepreneurial Subjective Norm (self-report)				Entrepreneurial Internal Locus of Control (self-report)			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Intercept	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.09)	(0.08)	(0.08)
Age	0.11	0.21*	0.19*	0.13	0.18*	0.20*	0.17*	0.19*	0.03	0.04	0.03	0.03
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.09)	(0.08)	(0.09)	(0.09)	(0.08)
Gender	−0.09	−0.12	−0.10	−0.14	0.03	0.00	0.03	0.00	−0.09	−0.08	−0.05	−0.08
	(0.08)	(0.08)	(0.09)	(0.08)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.08)
Reward Responsiveness (self-report)	0.17*			0.16	0.25**			0.25**	0.35***			0.37***
	(0.08)			(0.09)	(0.08)			(0.09)	(0.08)			(0.08)
Sensation Seeking (self-report)	0.28***			0.28***	0.14			0.13	0.12			0.10
	(0.08)			(0.09)	(0.09)			(0.09)	(0.08)			(0.09)
ADHD (self-report)	0.04			0.05	−0.19*			−0.18*	−0.22*			−0.22**
	(0.08)			(0.09)	(0.09)			(0.09)	(0.08)			(0.09)
BART Average Pumps (behavior)		−0.18*		−0.16		−0.11		−0.07		−0.05		−0.02
		(0.09)		(0.09)		(0.09)		(0.09)		(0.09)		(0.09)
BART Average Response Time (behavior)		−0.06		−0.04		0.03		0.01		0.00		−0.06
		(0.09)		(0.09)		(0.09)		(0.09)		(0.09)		(0.08)
BART FRN (electrophysiology)			0.04	0.01			0.12	0.11			0.08	0.08
			(0.09)	(0.08)			(0.09)	(0.08)			(0.09)	(0.08)
BART P3 (electrophysiology)			0.04	0.04			−0.02	0.01			−0.09	−0.04
			(0.09)	(0.08)			(0.09)	(0.08)			(0.09)	(0.08)
REWARD N2 (electrophysiology)			−0.22	−0.15			−0.22	−0.15			−0.13	−0.03
			(0.18)	(0.17)			(0.18)	(0.17)			(0.18)	(0.17)
REWARD P2 (electrophysiology)			0.15	0.17			0.08	0.12			−0.01	0.02
			(0.16)	(0.15)			(0.16)	(0.15)			(0.16)	(0.15)
REWARD P3 (electrophysiology)			0.02	−0.04			0.13	0.07			0.24	0.18
			(0.14)	(0.13)			(0.14)	(0.13)			(0.14)	(0.13)
F-value	5.65	2.69	1.23	2.81	4.99	1.72	1.15	2.34	6.89	0.27	0.81	3.33
p-value	0.00	0.03	0.29	0.00	0.00	0.15	0.34	0.01	0.00	0.90	0.58	0.00
R-squared (adj.)	0.14	0.05	0.01	0.13	0.12	0.02	0.01	0.10	0.17	−0.02	−0.01	0.17
n	142	142	142	142	142	142	142	142	142	142	142	142

Note: ***: p<.001, **: p<.01, *:p<.05.
aInstead of the results of an F-test, we present the results of the more appropriate LR-test for logistic regressions.

7. The way forward

The present findings indicate that behavioral and electrophysiological measures lack functional significance in predicting entrepreneurial concepts. An obvious reason for this null-finding is a true lack of associations between behavior/electrophysiology and self-reported entrepreneurial constructs. However, the discussed alternative explanations and limitations indicate that it is too early to draw this conclusion. In addition, the link between behavioral/electrophysiological measures and entrepreneurship has been postulated in theoretical scholarly work (e.g., Krueger and Welpe, 2014). We provide some considerations for studying the intersection of psychological measures and entrepreneurship.

First, a vast number of studies report associations between self-reports and behavioral/electrophysiological measures (e.g., De Pascalis et al., 2010; Lansbergen et al., 2007; Littel et al., 2012; Van den Berg et al., 2011; Zheng et al., 2014). Given our null-finding, it is important to identify differences between these studies and our study. One key difference concerns sample size, which is often low in studies that include time- and money-consuming physiology. For example, a recent systematic review on EEGs in relation to risk-taking reported an average sample size of only 29.0 (SD = 18.5) across 81 samples (Chandrakumar et al., 2018). However, small samples decrease the chance that discovered findings are genuinely true (Button et al., 2013; Forstmeier et al., 2017). Therefore, the use of larger electrophysiology samples to determine the reliability of the current body of literature is recommended (Moser et al., 2015). If our comparatively large sample size indeed contributes to our lack of significant associations, the implication is that previous findings on electrophysiology should be interpreted very carefully and that electrophysiological research should shift towards using larger samples.

Second, the use of these measures in entrepreneurship is relatively new and hence requires some exploration. For example, the particular tasks used in the present study may not be not optimally suited for this purpose. Several other tasks can provide behavioral and electrophysiological data, such as the Columbia Card Task (CCT). An advantage of the CCT is that it can systematically vary all parameters in a full-factorial design, thereby providing separate data on how the win amount, loss amount, and loss probability

Entrepreneurial Intention (self-report)				Entrepreneurial Intention Percentage (self-report)				Entrepreneurial Choice (self-report)				Entrepreneurial Orientation (self-report)			
Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	−3.13***	−2.68***	−3.06***	−3.59***	0.00	0.00	0.00	0.00
(0.08)	(0.08)	(0.08)	(0.08)	(0.07)	(0.08)	(0.08)	(0.07)	(0.49)	(0.36)	(0.48)	(0.63)	(0.07)	(0.08)	(0.08)	(0.07)
0.11	0.22*	0.19*	0.12	0.16*	0.23**	0.23**	0.17*	0.24	0.44	0.50	0.25	0.00	0.11	0.08	−0.00
(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.31)	(0.29)	(0.30)	(0.34)	(0.07)	(0.09)	(0.09)	(0.08)
−0.02	−0.05	−0.03	−0.08	−0.08	−0.10	−0.10	−0.11	−0.12	−0.09	−0.06	−0.19	−0.04	−0.04	−0.01	−0.04
(0.08)	(0.08)	(0.09)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.36)	(0.34)	(0.35)	(0.41)	(0.07)	(0.09)	(0.09)	(0.08)
0.23**			0.23**	0.25***			0.26**	0.78			0.87	0.35***			0.36***
(0.08)			(0.08)	(0.08)			(0.08)	(0.42)			(0.47)	(0.07)			(0.08)
0.32***			0.32***	0.36***			0.37***	0.69			0.87	0.41***			0.39***
(0.08)			(0.08)	(0.08)			(0.08)	(0.41)			(0.50)	(0.08)			(0.08)
0.00			0.03	−0.12			−0.13	−0.04			−0.07	−0.09			−0.08
(0.08)			(0.08)	(0.08)			(0.08)	(0.39)			(0.46)	(0.08)			(0.08)
	−0.20*		−0.15		−0.11		−0.06		−0.17		−0.09		−0.03		0.01
	(0.09)		(0.08)		(0.09)		(0.08)		(0.37)		(0.47)		(0.09)		(0.08)
	−0.01		0.02		−0.08		−0.06		−0.21		−0.20		0.09		0.06
	(0.09)		(0.08)		(0.09)		(0.08)		(1.12)		(1.52)		(0.09)		(0.08)
		0.04	0.01			0.04	−0.00			−0.02	−0.17			0.15	0.12
		(0.08)	(0.08)			(0.08)	(0.08)			(0.35)	(0.39)			(0.09)	(0.07)
		0.12	0.14			0.05	0.08			−0.08	0.15			−0.06	0.01
		(0.09)	(0.08)			(0.08)	(0.08)			(0.35)	(0.40)			(0.09)	(0.07)
		−0.18	−0.11			−0.17	−0.09			1.35	1.47			0.01	0.10
		(0.18)	(0.16)			(0.17)	(0.16)			(0.82)	(0.86)			(0.18)	(0.15)
		0.04	0.08			0.16	0.21			−0.50	−0.32			−0.16	−0.09
		(0.16)	(0.14)			(0.15)	(0.14)			(0.65)	(0.74)			(0.16)	(0.13)
		0.04	−0.04			−0.10	−0.19			−1.47*	−1.60*			0.16	0.05
		(0.14)	(0.13)			(0.14)	(0.12)			(0.71)	(0.69)			(0.14)	(0.12)
7.44	2.70	1.34	3.89	10.16	2.61	1.73	4.81	10.37[a]	2.43[a]	8.60[a]	17.92[a]	13.72	0.66	0.92	6.00
0.00	0.03	0.24	0.00	0.00	0.04	0.11	0.00	0.07	0.66	0.28	0.12	0.00	0.62	0.49	0.00
0.19	0.05	0.02	0.20	0.25	0.04	0.04	0.25	–	–	–	–	0.31	−0.01	−0.00	0.30
142	142	142	142	142	142	142	142	142	142	142	142	142	142	142	142

impacted participants' decisions (De Groot and Van Strien, 2019). Hence, future research should extend the present design to other experimental tasks.

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

Finally, although behavior and electrophysiology are among the most commonly used measures in psychology, many other measures exist, including other types of physiology (such as electrodermal activity, heartbeat, and blood pressure), hormones (Van der Loos et al., 2013b), and genetic information (Koellinger et al., 2010; Van der Loos et al., 2013a; Rietveld et al., 2021), but also more ethnographic measures such as language analysis, peer-reports, and social media analysis (Fisch and Block, 2021; Kosinski et al., 2015). Future research should explore which (combination of) measurement levels offers little bias and high predictive value against a low investment of time and money, and combine these measurement levels in examining the drivers of entrepreneurship.

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9. Appendix

Table A1
Entrepreneurship measures.

Variable	Scale	Source	Cronbach's alpha/ Study
Entrepreneurial Personal Attitude	Items: "Being an entrepreneur implies more advantages than disadvantages to me", "A career as entrepreneur is attractive for me", "If I had the opportunity and resources, I would became an entrepreneur", and "Being an entrepreneur would entail great satisfactions for me"; 5-point scale.	Liñán and Chen (2009)	0.91 (Study 1), 0.95 (Study 2)
Entrepreneurial Subjective Norm	Items: "If you would pursue a career as an entrepreneur, how would people in your environment react?" (asked separately for close family, friends, and colleagues); 7-point scale (1 =total disapproval to 7 =total approval).	Liñán and Chen (2009)	0.81 (Study 1), 0.79 (Study 2)
Entrepreneurial Internal Locus of Control	Items: "I am usually able to protect my personal interests", "When I make plans, I am almost certain to make them work", and "I can pretty much determine what will happen in my life"; 7-point scale.	Levenson (1973)	0.49 (Study 1), 0.75 (Study 2)
Entrepreneurial Self-Efficacy	Participant's degree of certainty regarding the tasks "establish and achieve goals and objects", "generate new ideas", "develop new products and services", "perform financial analysis", "reduce risk and uncertainty", "take calculated risks", "make decisions under uncertainty and risk", "manage time by setting goals", "take responsibility for ideas and decisions", "start my own firm", "lead my own firm to success"; 5-paint scale (1= completely unsure to 5 = completely sure).	Adapted from Chen et al. (1998)	0.74 (Study 1)
Entrepreneurial Fit	Item: "When you think of the word 'entrepreneur', how closely do you fit that image?"; 7-point scale (1 = 0% to 7 = 100%).	–	Study 1
Entrepreneurial Intention Percentage	Item: "How likely is it (in %) that in 5 years you will have your own company?"; in %.	–	Study 1, Study 2
Entrepreneurial Intention	Items: "I am ready to do anything to be an entrepreneur", "My professional goal is to become an entrepreneur", "I will make every effort to start and run my own firm", "I am determined to create a firm in the future", "I have very seriously thought of starting a firm", "I have the firm intention to start a firm someday". 7-point scale.	Liñán and Chen (2009)	0.95 (Study 2)
Entrepreneurial Choice	Item: "Currently, do you have your own company?; 1= yes, 0 = 0.	–	Study 1
Entrepreneurial Choice	Items: "Are you currently starting a venture?" or "Do you currently have your own venture?"; 1= yes to one of those items, 0 = otherwise.		Study 2
Entrepreneurial Orientation	Items: "I like to take bold action by venturing into the unknown", "I am willing to invest a lot of time and/or money on something that might yield a high return", "I tend to act 'boldly' in situations where risk is involved", "I often like to try new and unusual activities that are not typical but not necessarily risky", "In general, I prefer a strong emphasis in projects on unique, one-of-a-kind approaches rather than revisiting tried and true approaches used before", "I prefer to try my own unique way when learning new things rather than doing it like everyone else does", "I favor experimentation and original approaches to problem than using methods others generally use for solving their problems", "I usually act in anticipation of future problems, needs, or solving rather changes", "I tend to plan ahead on projects", "I prefer to 'step-up' and get things going on projects rather than sit and wait for someone else to do it"; 5-point scale.	Langkamp Bolton and Lane (2012)	0.75 (Study 2)

Table A2
Electrophysiological and behavioral measures used.

	Dataset 1 (n = 133)	Dataset 2 (n = 142)
Behavioral variables	**Obtained from Go/No-Go task (GNG)** • *GNG Number Incorrect No Go:* number of incorrect No-Go trials, higher value indicates impulsiveness. • *GNG Number Incorrect Go:* number of incorrect Go trials, benchmark. • *GNG Number Post-Incorrect Incorrect:* number two incorrect trials in a row, higher value indicates impulsiveness. • *GNG Average Response Time:* average response time on the correct Go trials and incorrect No-Go trials, lower response times indicate impulsiveness. **Obtained from Eriksen Flanker Task (EF)** • *EF Number Incorrect*: number of incorrect trials, indicates quick and imprecise responding. • *EF Average Response Time Incongruent*: average response time for incongruent trials, indicates impulsiveness. • *EF Difference Average Response Time Post-Incorrect - Post-Correct*: difference in the average response time after incorrect trials and correct trials, indicates impulsiveness	**Obtained from an automatic BART task** • *BART Average Pumps*: average number of pumps to inflate balloon, higher value indicates risk-taking. • *BART Average Response Time*: time respondents took to choose the number of pumps, lower values indicate higher impulsivity

(*continued on next page*)

Table A2 (*continued*)

	Dataset 1 (n = 133)	Dataset 2 (n = 142)
Electro-physiological variables	**Obtained from Go/No-Go task (GNG)** • *GNG N2:* difference between the mean amplitude on No-Go trials vs. Go trials (175-250 ms interval), represents mismatch detection. • *GNG P3:* difference between the mean amplitude on No-Go trials vs. Go trials (300-500 ms interval), indicates response inhibition. **Obtained from Eriksen Flanker Task (EF)** • *EF ERN:* difference in mean amplitudes on incorrect vs. correct trials (25-75 ms interval), indicates early error processing • *EF Pe: difference in mean amplitudes on incorrect vs. correct trials (200-400 ms interval), indicates conscious error processing.*	**Obtained from the BART task:** • *BART FRN:* difference between the mean amplitude (200-275 ms interval), indicates error processing. • *BART P3:* difference between the mean amplitude (250-400 ms interval), indicates elaborate stimulus appraisal. **Obtained from reward task** • *REWARD N2:* difference between midline electrodes (200-300 ms interval), indicates mismatch detection. • *REWARD P2:* difference between midline electrodes (150-230 ms interval), indicates attention to (deviating) stimuli. • *REWARD P3:* difference between midline electrodes (300-400 ms interval), indicates elaborate stimulus appraisal.

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