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The Biological Perspective in Entrepreneurship Research

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The Biological Perspective in Entrepreneurship Research

The past decade has experienced a significant increase in the number of papers on the biology of entrepreneurship. This trend is aligned with the general interest in the biology of management studies as evidenced by the more than 300 articles already published (Nofal et al., 2018). It illustrates the progression of science along two dimensions. First is the drive to seek smaller units of analyses to identify the core mechanisms of action. Second is the opposing drive to seek larger units of analyses to identify general principles. These simultaneous processes move our understanding of social and natural phenomena closer to a unified theory. In this note, we reflect on how the biology of why, how, what, when, and where of entrepreneurship represents a natural progression from the institutional, organizational, and psychological explanations. We call this the Biological Perspective in Entrepreneurship (BPE), which is illustrated by the papers in this volume. We examine the key domains of inquiry, various methodologies, and reflect on the directions that future research should take.

We define the Biological Perspective in Entrepreneurship as the body of research that examines the role of genetics (Nicolaou & Shane, 2009), physiology (White et al., 2007), neuroscience (Martin de Holan, 2014; Shane et al., 2019) and neurodevelopmental conditions (Wiklund et al., 2017; Lerner et al., 2018) in entrepreneurial behavior. We first clarify the conceptual and theoretical boundaries of the BPE. BPE research is, by definition, multidisciplinary (genomics, physiology, neuroscience, clinical psychology) and multilevel (high order phenomena (occupational choice, entrepreneurial performance) explained by lower order mechanisms (e.g., neurotransmitters)), which can cause confusion when scholars from different disciplinary traditions collaborate.

First, the theorized associations between biology and entrepreneurship are probabilistic, not deterministic. Further, to attribute causality in these associations is

premature or even wrong. At the broadest level, biology does not *cause* people to become entrepreneurs. Speculations concerning the biology-behavior complex go back at least 200 years to the pseudoscience of phrenology (Colbert, 1997). As Shane and Nicolaou (2015) put it, "biological factors influence all aspects of human behavior and are solely responsible for *none* of them" [italics added]. The key word is *influence*. Research in this domain should be about unpacking the relative strengths and combinations of the myriad factors that might affect choice and behavior. In the world of biology and behavior, humans still have agency.

Second, it is the *interaction* between human biology and the environment that accounts for the behaviors observed. More critically, these interactions may provide useful explanations for the apparent contradictions in the linear relationships in our traditional models. For example, the simple question of whether entrepreneurs are more stressed than non-entrepreneurs is still the subject of inquiry to which physiologic measures of stress can offer new insights (Lee, Patel & Phan, 2020). We do not claim that biological explanations, because they refer to fundamental mechanisms, make economic, sociological, and psychological explanations less important. In fact, to maximize the variance explained, our models may need to include biological factors *and* their hypothesized interactions with the economic, sociological, and psychological explanations of entrepreneurial behavior.

Entrepreneurship occurs at the nexus of enterprising individuals and valuable opportunities (Venkataraman, 1997). Considering the biology of enterprising individuals can enhance our understanding of why some individuals and not others are likely to engage in entrepreneurship and reap the resulting pecuniary and non-pecuniary benefits. Additionally, because opportunities may themselves be socially constructed (Alvarez & Barney, 2020), recognizing opportunities may also be endogenously influenced by the biology of the individual, for example, in the way dopamine affects perception of risk and uncertainty (e.g. Muda et al., 2018). Accordingly, we next briefly review the four strands - genetics,

physiology, neuroscience, and neurodevelopmental conditions - that constitute the BPE (See Table 1 for a summary).

INSERT TABLE 1 ABOUT HERE

Genetics

Research on the genetics strand of the BPE has examined the role of genes on the likelihood of individuals engaging in entrepreneurship (Nicolaou et al., 2008; Zhang et al., 2009). Genes are the basic building blocks of DNA and the basis for the human body (Nicolaou and Shane, 2009: 2). Increasingly, we are realizing that genes may also be correlated with behaviors through the action of the mind-brain complex. Two methodological approaches have been used to study the relationship between genes and behavior. The first approach involves studies of twins and adoptees, in which individuals that are otherwise similar in biology or environmental experiences are compared to isolate the explanatory factors for certain behaviors (such as the tendency to take risks). The second approach involves the use of molecular genetics to identify specific genetic polymorphisms that are associated with entrepreneurial behaviors and tendencies (Rietveld, Slob & Thurik, 2020). In both approaches, the goal is to understand the relative importance of inherited traits versus environmental influences or the interactions between these factors in explaining why some individuals or groups of individuals engage in entrepreneurship more than others.

Twin and adoption studies are quasi-experiments that have been used to examine the heritability of entrepreneurial traits. Heritability refers to the proportion of individual differences in entrepreneurship that can be attributed to the genetic profile of a particular population (Plomin et al., 2012). Twin studies across the UK, US, Singapore, Italy and Sweden have shown that there is a genetic predisposition to entrepreneurship with heritability

estimates of around 30-40% (Nicolaou et al., 2008; Shane et al., 2010; Zhang et al., 2009; Zunino, 2019; Kuechle, 2019).

Adoption studies have also examined the relative contributions of genetic and environmental factors in entrepreneurship. Lindquist et al. (2015) used a sample of adoptive and non-adoptive children and biological and adoptive parents from Sweden and found that a biological parent's entrepreneurship status significantly influenced the entrepreneurship status of their adopted biological children.

The second approach to the study of genetic influences on entrepreneurial behavior involves the use of molecular genetics techniques to identify specific gene variants. These techniques include candidate gene and genome-wide association studies (GWAS). Candidate gene studies were prevalent until the beginning of last decade but have now been largely replaced by GWAS. Candidate gene studies make *a priori* hypotheses about the association between specific candidate genes and entrepreneurship, while GWAS involve a hypothesis free approach in which the whole genome is tested for associations with entrepreneurship. In the case of entrepreneurial behaviors, genetic polymorphisms that reach genome-wide significance have not yet been identified (Quaye et al., 2012; van der Loos, 2013).

Physiology

The second strand of the BPE involves the study of physiology, which refers to the biochemical and physical processes in living organisms (Silverthorn, 2001). Studies in physiology usually start with hypotheses of why entrepreneurs might be different from the general population (e.g., less sensitive to perceptions of risk), and then proceed to look for the biological mechanisms to explain the differences. Research in this strand began by examining the influence of hormones in entrepreneurship, beginning with testosterone, which is known to be associated with aggression and related traits. Testosterone is a steroid

hormone that is mainly produced in the testicles of males, the ovaries of females and the adrenal glands of both sexes. Studies have found that testosterone is associated with the likelihood of engaging in entrepreneurship, primarily through risk-taking (White et al., 2006; Bönte, Procher & Urbig, 2015; Unger, Rauch, Weis and Frese, 2015; Greene et al., 2014; Nicolaou et al., 2018). These studies examined serum and prenatal testosterone levels as well as testosterone transfer in same-sex and opposite-sex twins. Other research has investigated the interaction of cortisol and epinephrine (Wolfe and Patel, 2017) and that of testosterone and the need for achievement (nAch) (Unger et al., 2015) in entrepreneurs.

A further line of research seeks to examine the biology-environmental complex by studying how physiological recovery during night-time sleep affect entrepreneurs' creativity (Weinberger, Wach, Stephan, Wegge, 2018) and well-being (Wach et al., 2020). Related emerging research has used physiological biomarkers of stress to understand whether entrepreneurship is a more demanding occupation than organizational employment (Patel, Wolfe & Williams, 2019; Lee, Patel & Phan, 2020) and to evaluate interventions to improve entrepreneurs' well-being after business failure (Schermuly et al., 2020).

Neuroscience

Neuroscience - the study of the nervous system and the brain - is the third strand of the biological perspective in entrepreneurship (Martin de holan, 2014; Krueger & Welpe, 2014; McMullen, Wood & Palich, 2014; Nicolaou & Shane, 2014; Lahti, Halko, Karagozoglu and Wincent, 2018; Shane, Drover, Clingingsmith & Cerf, 2019). Neuroscience attempts to bridge the mind-brain complex by elucidating the biochemical influences in the brain on cognition and emotion. Researchers have suggested that neuroscience can inform entrepreneurship in four different ways. By, 1) identifying hidden mental processes, (2) examining the discriminant and convergent validity of entrepreneurship measures, (3)

investigating the antecedents and temporal ordering of entrepreneurship variables and (4) distinguishing between different theoretical perspectives (Nicolaou et al., 2019).

To date, most research on neuroscience in entrepreneurship has been conceptual, drawing implications from empirical studies in other domains and comparing them to what we already know about entrepreneurial tendencies (e.g., Martin de holan, 2014; Krueger & Welpe, 2014; McMullen, Wood & Palich, 2014). That said, there has been recent empirical work using functional Magnetic Resonance Imaging (fMRI) to assess neural activity during entrepreneurial tasks. For example, Shane et al. (2019) found that when founders display their passion in front of investors, the latter's neural engagement is elevated, which in turn influenced their interest in investing into the new venture. Lahti et al. (2018) investigated entrepreneurs' affective bonds with their start-ups and found that they were similar to the affective bonds between parents and children.

Neurodevelopmental conditions and neurodiversity

Research on neurodevelopmental conditions constitute the fourth strand of the BPE. Thus far, this line of work has examined the role of attention deficit hyperactivity disorder (ADHD), obsessive compulsive disorder (OCD), and dyslexia in entrepreneurs. This is a relatively new strand of work and to the extent other neurodevelopment conditions may be candidates for understanding entrepreneurial behaviors, those are likely to be studied in the future. ADHD is a behavioral disorder characterized by inattentiveness, impulsivity, and hyperactivity[1]. Wiklund et al. (2017) found that attention deficit is positively whereas hyperactivity negatively correlated with some aspects of entrepreneurial behaviors such as persistence in action. Wolfe and Patel (2017) found that individuals with OCD are more likely to engage in self-employment, partly because it provides them more control over their

[1] https://www.nhs.uk/conditions/attention-deficit-hyperactivity-disorder-adhd/ (accessed: 9/14/2020)

immediate environment. Logan (2009) found a higher incidence of dyslexia among entrepreneurs than managers and proposed that dyslexics developed coping strategies that confer advantages in their entrepreneurial endeavors. The insight from this line of inquiry is that conditions such as dyslexia and ADHD, which are generally considered disadvantages, may in fact be strengths for an entrepreneurial career (Wiklund, Patzelt & Dimov, 2016; Shane & Nicolaou, 2015; Wiklund, Hatak, Patzelt & Shepherd, 2018). These studies illustrate the occupational context (entrepreneurship vs. occupational employment) matters when it comes to how one should think about the social implications of mental health.

Methodologies

BPE research is characterized by a diversity of methods and techniques. For example, researchers have used twin studies that involve a comparison of monozygotic and dizygotic twins to disentangle the variance in entrepreneurship into genetic and environmental factors (Nicolaou et al., 2008; Zhang et al., 2009). They draw on the fact that identical twins have 100 percent of their genes in common, while non-identical twins share on average half of their segregating genes. As a result, any differences in the twin concordances for entrepreneurship between pairs of monozygotic and pairs of dizygotic twins is explained by the genes. Other research on the genetics of entrepreneurship has examined the relationship between the career choices (entrepreneurship or otherwise) of adoptees and that of their biological and adoptive parents (Lindquist et al., 2015). Molecular genetics research in entrepreneurship use GWAS, which involves testing hundreds of thousands of single nucleotide polymorphisms for association with entrepreneurial behaviors (Quaye et al., 2011; van der Loos, 2013). Because of the large numbers of tests involved, the analyses resort to Bonferroni correction for p-values of 10^{-8} to achieve genome-wide significance.

Neuroscience studies in entrepreneurship have mainly used fMRI, which measures haemodynamic (blood flow) changes in the brain following neural activity (Logothetis, 2008). The problem with this technique is that blood flow is an indicator of activity but does explain the mechanism. The mechanism still lies in the realm of theory. The use of such techniques in entrepreneurship are still in its infancy but growing. More direct assays of actual brain mechanisms come in the form of in-vivo positron emission tomography (PET) and single-photon emission computer tomography (SPECT) technologies in which neurotransmitters implicated in the mechanism of action (e.g., dopamine in the pleasure response due to unexpected reward in uncertain situations) are bound to a radiological tracer to ascertain the precise receptors being activated by the perceptual, cognitive or emotional response of the subject. Such technologies have existed for a long time but are costly, up to 5 times the cost of a typical fMRI. Another challenge in using such technologies for entrepreneurship research is the hurdle in getting institutional review board (IRB) approval. Infusing subjects with radiotracers when there is no imminent medical need, such as to diagnose Alzheimer's disease, and for the purposes of academic research is considered risky by many IRBs. Therefore, the arguments must be compelling why the technique is *necessary*. This is a very high bar for most IRBs. One work around is to collect the data as part of routine medical examinations, and to prospectively obtain permission from subjects to use the data for such research.

Physiological studies in entrepreneurship have examined the association between prenatal testosterone exposure and entrepreneurship using the 2d:4d ratio. This is the ratio of the length of the index finger (second digit) to the length of the ring finger (fourth digit) (Unger et al., 2015). Other physiological studies have used actigraphic devices to measure entrepreneur's sleep efficiency (Weinberger et al., 2018) or hair cortisol level to indicate stress (Schermuly et al., 2020). Again, these are indirect methods, while direct methods of

measurement exist, they are costly and face IRB hurdles. For example, circulating testosterone can be measure by with blood tests and sleep efficiency can be measured with blood metabolites known to be affected by sleep deprivation, such as oxalic acid and diacylglycerol 36:3 (Weljie, et. al., 2015), or sleep deprivation can be induced. Again, costs and IRB objections are non-trivial. Thus, highlighting a role of prospective data collection as part of routine medical procedures that call for blood draws.

Future Research Directions

Finally, there are several future research directions that we would like to explore. Our brief review of the literature has revealed a dearth of research on the interactions between biology and the entrepreneurial environment or that which fosters or suppresses entrepreneurial behaviors. Examining the moderating influences of environmental variables is crucial because, as we have earlier discussed, the effects of biological factors on entrepreneurship are not deterministic.

We also know very little about the influence of biological factors on the probability that some individuals select *into* environments that positively affect entrepreneurship, a concept known as the biology-environment correlation (Plomin, 1991; Nicolaou and Shane, 2009). This concept suggests that the environment and the opportunities in which people create are endogenously influenced by their biological propensities. To what degree and in what ways remains unanswered questions.

Research on the BPE should also consider the importance of other dependent variables such as the pathways along which individuals engage in entrepreneurship and then leave it. We know that the propensity to undertake entrepreneurship varies along the life course due to, e.g., varying opportunity costs, confidence in one's ability to start a business, and social network support. In this respect, most of the research on the BPE has focused on

opportunity exploitation with little work examining opportunity recognition (Nicolaou et al., 2009) and entrepreneurial performance. We believe this is an area ripe for exploration.

Overall, more research in each of the strands in the BPE is required. The four strands are still emerging, which imply opportunities for more theorizing and the accumulation of empirical evidence. For example, future research on the genetics of entrepreneurship could utilise polygenic risk scores (Dudbridge, 2013; Rietveld et al., 2020). A polygenic risk score involves combining many genetic markers into a single score associated with entrepreneurial behavior (Dudbridge, 2013). The use of genealogical methods to trace the inheritance of genetic variations across entrepreneurial families may provide new insights into the relative strengths of environmental factors such as recessions, wars, and economic boom periods in sustaining entrepreneurship across the generations. The research on family entrepreneurs could use fresh perspectives that go beyond static constructs such as familiness or social emotional wealth. Further work in physiology could examine how different hormones interact with each other to affect how entrepreneurs choose the entrepreneurial career option (Wolfe and Patel, 2017). The work in this strand is more accessible, from the standpoint of technology and finance, than the other strands. For example, we believe that there are good reasons to exploit ambulatory measurements that track physiological markers in real time throughout the day (e.g., heart rate, blood pressure and skin conductivity, Eatough, Shockly & Yu, 2016) providing much needed objective measures of entrepreneurs' stress response and their well-being (Stephan, 2018, Wiklund et al., 2019). We also need additional work that examines interactions between the four biological strands. For example, research could investigate how hormones mediate the genetic predisposition to entrepreneurship (Nofal et al., 2018). Finally, we need more work on the variables that mediate the association between biology and entrepreneurship. In social science, mediators help researchers pry open the

black box that is the mechanism linking independent and dependent variables. Work on the BPE can benefit from similar approaches.

Papers in the Special Issue

Below, we introduce the papers in the special issue. This special issue was conceived by the editorial team, to provide a forum for accelerating research in this domain. The published papers are the result of a rigorous double-blind review process and provide new insights into three of the four strands of the BPE, genetics, physiology, and neurodevelopmental conditions.

Genetics and entrepreneurship. In this paper, Patel, Rietveld, Wolfe and Wiklund (2020) investigate the polygenic risk score (PRS) of subjective well-being – a combination of multiple genetic variants that assess an individual's stable genetic predisposition to experience well-being. This PRS relates to the choice of self-employment and earnings from self-employment in a representative sample of U.S. Americans aged 50 and over. The PRS explains variation in earnings beyond subjective measures of well-being. The study's findings suggest that individuals in the 50+ years age group with a genetic predisposition to experience well-being are particularly attracted to self-employment, and reap more benefits from doing so, in terms of earnings. Another paper in the special issue explores the PRS for ADHD (Patel, Rietveld & Verheul, 2020) and is discussed together with other papers on neurodevelopmental conditions below.

Physiology and entrepreneurship. Five papers speak to the physiology of entrepreneurship. Hatak and Zhou (2020) conceptualize entrepreneurs' health as an important dimension of human capital that drives entrepreneurial success (measured as subsequent annual income and subsequent subjective well-being). They find supporting evidence in their longitudinal study of a representative sample (n>11,000) of German entrepreneurs and their

spouses. The relationships between mental and physical health and entrepreneurial success were stronger from men vs. women entrepreneurs, likely because women's mental health is more fluid. Using Actor-Partner Interdependent Models, the study finds that both the entrepreneurs' health that of their spouses' impact success.

Two papers investigate the role of infectious disease. Lerner et al. 2020 focus on Toxoplasma gondii (TG) infection and link TG infections to subsequent entrepreneurial activity in a representative sample of Danish women (*N*>16,000 entrepreneurs and a control sample of N>58,000 non-entrepreneurs). TG infections are associated with physiological and behavioral changes such as elevated levels of testosterone, dopamine, norepinephrine etc. that are themselves associated with increased novelty seeking and risk-taking behaviors. In their study, TG infected women were 29% more likely to choose entrepreneurship versus women who were not infected. Infected individuals were more likely to create multiple ventures, found ventures on their own, exhibit higher general levels of performance but also greater variation in performance, and were less persistent as entrepreneurs.

Bennett and Nikolaev (2020) examine how the historical prevalence of infectious diseases shape the innovation performance of 83 countries. Their instrumented variable analysis identifies the cultural values of individualism (vs. collectivism) as one critical pathway consistent with Parasite Stress theory. Societies that experience a greater threat of infectious disease evolve a 'psychological immune system' that mitigates the effects of economic and social interaction with out-groups, which is consistent with the cultural values of collectivism. These values are associated with diminished innovation. Consider the 2020 Covid-19 pandemic, which spread like a wildfire around the world and led to more than 900,000 deaths[2]. The variation in individual responses to this public health crisis, at the

[2] https://coronavirus.jhu.edu/map.html, accessed September 12, 2020.

population level of analysis, offers timely insights on how biological factors can alter the psychology and behavior of societies to restrict innovation.

In their research note, Wolfe and Patel (2020) present new evidence on how entrepreneurship relates to biomarkers of stress and health. Across two studies, they relate self-employment to oxidative stress and biomarkers of negative physical health (triglyceride levels). The self-employed are vulnerable to low antioxidant levels, which for them are more strongly associated with an increased risk of negative physical health compared to those who are employed. Intriguingly, diet has been linked to antioxidant levels, implying that diets rich in antioxidants might help entrepreneurs mitigate the negative health consequences of their stressful work.

Neurodevelopmental conditions and entrepreneurship. All four papers that researched the relationship between neurodevelopmental disorders and entrepreneurship focused on ADHD. In part, this is because ADHD is now a condition that has been socially destigmatized with its recognition in early childhood and school programs to handle their effects in the classroom. Gunia, Gish and Mensmann (2020) investigate sleep problems as an antecedent to ADHD-like tendencies. In their paper, they offer a new perspective on ADHD and entrepreneurship research that seeks to understand ‘everyday’ ADHD tendencies and their antecedents. This perspective blends the physiological and neurodevelopmental approaches by highlighting the situational factors, such as insufficient physiological recovery during sleep, that are associated with cognitive and behavioral patterns associated with ADHD-type symptoms. The paper employs a sleep-deprivation experiment, three correlational field studies, and a focused-meta analysis to integrate the findings. Insomnia, and poor sleep quality and quantity are positively related to ADHD-like tendencies and entrepreneurial intentions.

Moore, McIntyre and Lanivich (2020) investigate entrepreneurship-relevant cognitive correlates ('the entrepreneurial mindset') of ADHD including cognitive style (analytic vs. intuition), entrepreneurial alertness, meta-cognition, and resource-oriented coping. They find that individuals who self-report ADHD symptoms are more likely to employ an intuitive cognitive style, report more entrepreneurial alertness, and resource-oriented coping. These findings help scholars better understand why and how ADHD relates to entrepreneurship, and more importantly, at what stage of the entrepreneurial process ADHD symptoms are beneficial or disadvantageous to entrepreneurial action.

The last two studies in this volume attempt to connect ADHD to entrepreneurial outcomes. While past research has linked ADHD and entrepreneurial behaviors, it has not provided evidence whether ADHD helps or hinders individuals to succeed in their entrepreneurial careers. Yu, Wiklund and Pérez-Luño (2020) differentiate the impulsivity/hyperactivity and inattention symptoms of ADHD and link them to firm performance. They find that impulsivity/hyperactivity but not inattention relates positively to firm performance via enhancing entrepreneurial orientation (EO) in two studies in the US and Spain. Differentiating ADHD symptoms and including EO as a mechanism offers new insights into how and why ADHD can be beneficial for entrepreneurial performance.

Patel, Rietveld and Verheul (2020) link ADHD with entrepreneurial outcomes in the form of earnings from self-employment. They use an innovative measure of ADHD drawing on genetics: the polygenic risk score (PRS) for ADHD, which may help overcome the endogeneity concerns embedded in these types of questions. They find a positive link of the PRS for ADHD with self-employment, but a subsequent negative link with earnings in a longitudinal study of nearly 8000 U.S. individuals aged 50–65 years. The PRS for ADHD increased the odds of being self-employed but decreased yearly earnings. While Yu et al. 2020 report performance enhancing effects of ADHD, Patel et al. seem to find the opposite.

This could be due to the level of analysis (firm performance vs. individual earnings), the age characteristics of the sample, and the measure of ADHD (manifest symptoms vs. genetic propensity). The simple message of these studies is that more needs to be done and the studies provide good models for how to do them.

Conclusion

This reflection and the special issue are a summary of the first wave of research on the BPE. The collective contribution of this 'first wave' has established that biology – from genes, physiology, neuroscience to neurodevelopmental disorders – matters for those of us who want to better understand the entrepreneurship phenomenon. They provide a 'proof-of-concept' for future studies in this domain and suggest useful directions for follow-on studies. We urge scholars in the 'second wave' to marry the traditional economic, sociological, and psychological factors with their BPE models, to advance toward true multilevel explanations for entrepreneurship.

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Table 1: Summary of research in genetics, physiology, neuroscience, and neurodevelopmental conditions in entrepreneurship

Authors	Theme	Journal	Question	Typical Methods	Key findings
White et al.2007	Physiology	Organizational Behavior and Human Decision Processes	Does testosterone influence entrepreneurship?	Salivary testosterone	Testosterone levels are associated with entrepreneurship and this is partially mediated by risk propensity
Nicolaou et al. 2008	Genetics	Management Science	Is there a genetic predisposition to entrepreneurship?	Twin study of monozygotic (MZ) and dizygotic (DZ) twins. Comparison of twin concordances for entrepreneurship between MZ and DZ twins	Heritability estimates between 0.37 and 0.48 for entrepreneurship depending on the operationalization of the construct
Zhang et al. 2009	Genetics	Organizational Behavior and Human Decision Processes	Do extraversion and neuroticism partly mediate the genetic predisposition to entrepreneurship?	Multivariate genetic analysis	Neuroticism and extraversion mediate the genetic predisposition to entrepreneurship for women
Logan, 2009	Neurodevelopmental conditions	Dyslexia	Is dyslexia associated with entrepreneurship?	Survey of entrepreneurs and corporate managers	Dyslexics are more likely than corporate managers to engage in entrepreneurship

Shane et al. 2010	Genetics	Journal of Applied Psychology	Do genetic factors account for part of the covariance between the Big Five and entrepreneurship?	Cross-characteristic cross-twin correlations between MZ and DZ twins	Common genetic factors influence the covariation between openness to experience and extraversion and entrepreneurship
Van der Loos et al. 2014	Genetics	Plos One	Molecular genetics of self-employment	Genome-wide association study	55% percent of the variance in self-employment due to additive genetic effects; 25% of variance in self-employment explained by additive effects of common SNPs; no genome-wide SNPs identified.
Lindquist et al. 2015	Genetics	Journal of Labor Economics	Decomposition of the intergenerational transmission of entrepreneurship into pre-birth and post-birth factors	Adoption data with information on both biological and adoptive parents	Both biological and adoptive parents contribute to the likelihood that adopted children become entrepreneurs
Bönte, Procher & Urbig, 2015	Physiology	Entrepreneurship Theory and Practice	Does prenatal testosterone exposure influence entrepreneurship?	2d:4d ratio as a marker of prenatal testosterone	Prenatal testosterone exposure is associated with entrepreneurship
Unger, Rauch, Weis and Frese, 2015	Physiology	Journal of Business Venturing Insights	Do biological factors interact with psychological factors in influencing entrepreneurship?	2d:4d ratio	Need for achievement moderated the effects of prenatal testosterone on entrepreneurial impact

Wiklund, Patzelt and Dimov, 2016	Neurodevelopmental conditions	Journal of Business Venturing Insights	How does ADHD influence the decision to become an entrepreneur and entrepreneurial performance?	Multiple case study	Inattention and hyperfocus significantly influence entrepreneurship
Wolfe and Patel, 2017	Physiology	Journal of Business Venturing Insights	Does cortisol modulate the relationship between epinephrine and self-employment?	Regression analysis – MIDUS 2 data	At lower levels of cortisol, higher epinephrine levels are associated with self-employment
Wiklund et al. (2017)	Neurodevelopmental conditions	Journal of Business Venturing	How does ADHD influence entrepreneurship?	4 rounds of survey data from MBA alumni	Hyperactivity is positively but inattention negatively correlated with entrepreneurship
Wolfe and Patel, 2017	Neurodevelopmental conditions	Journal of Business Venturing Insights	Is obsessive compulsive personality disorder associated with self-employment?	Regressions using National Epidemiologic Survey on Alcohol and Related Conditions	Individuals with obsessive compulsive personality disorder have a higher likelihood of engaging in self-employment
Nicolaou et al., 2018	Physiology	Management Science	Does testosterone increase the likelihood of self-employment?	(i)2SLS regressions using serum testosterone. (ii)2d:4d ratio (iii)Twin testosterone	Serum testosterone levels are positively associated with self-employment for males; lower 2d:4d (higher prenatal testosterone) in left hand associated with self-employment;

				transfer effect: prenatal hormone transfer in opposite-sex and same-sex twins	support for testosterone transfer hypothesis.
Weinberger, Wach, Stephan, Wegge, 2018	Physiology	Journal of Business Venturing	How does recovery from work stress influence entrepreneurs' generation of new ideas?	Diary study with entrepreneurs over twelve days using actigraphic devices to measure sleep	Sleep efficiency and work-related problem solving pondering positively associated with entrepreneurs' creativity.
Lahti, Halko, Karagozoglu and Wincent, 2018	Neuroscience	Journal of Business Venturing	Why and how do founding entrepreneurs bond with their ventures?	Functional magnetic resonance imaging	Entrepreneurs showed similar signs of affective bonding to parents
Shane, Drover, Clingingsmith and Cerf, 2019	Neuroscience	Journal of Business Venturing	How does variation in entrepreneurs' displayed passion influence investor interest?	Functional magnetic resonance imaging	Passionate founders raise investor neural engagement and interest in the start-up