The Biology of Entrepreneurship

Ahmed Maged Nofal[1,2], Nicos Nicolaou[3], and Scott Shane[4]

[1] Emlyon Business School

[2] Department of Business Administration, Cairo University

[3] Warwick Business School

[4] Weatherhead School of Management

Author Note

We are grateful to Michael Frese and Michael Gielnik for their most helpful comments on an earlier version of the paper.

The Biology of Entrepreneurship

Historically, research in entrepreneurship has largely ignored biological factors. However, recently researchers have begun to explore the ways in which human biology affects this phenomenon. This literature has been fragmented, scattered across various outlets, making it difficult for entrepreneurship scholars to aggregate the findings and develop a broad theoretical perspective to describe how biology relates to entrepreneurship (Nofal, Nicolaou, Symeonidou, & Shane, 2018).

In this chapter, we provide a systematic review of the biological perspective in entrepreneurship. Specifically, we systematically review research linking the three biological strands of genetics, physiology, and neuroscience to entrepreneurship. We discuss the findings of this growing literature and how incorporating biology into the study of entrepreneurship can enhance our understanding of various entrepreneurial outcomes. We then discuss the mechanisms through which biology affects entrepreneurship. Finally, we conclude with directions for future research.

Systematic Review

The review strategy is designed to provide a systematic and explicit method for reviewing the research on genetics, physiology, and neuroscience in entrepreneurship. It adopts the same approach that Nofal, et al. (2018) have previously used in their review of the biology of management. First, it uses the same keywords used by Nofal, et al. (2018) that are related to the three biological areas (see Table 1). Second, it follows the protocols of Tranfield, Denyer, and Smart (2003) for undertaking systematic reviews in the field of management.

Using these protocols, we searched the databases of Thomson ISI Web of Knowledge and Google Scholar. We then reviewed all studies published in journals listed in the Chartered Association of Business Schools' list. We included all papers that were written through the end

of July 2019, the stop point for this review. We transferred all the papers to Endnote, and screened all the papers using title and abstract analysis to identify the studies that might be relevant to the review. This process resulted in a total of 200 articles. Of these articles, 151 were then excluded according to the exclusion criteria of Nofal, et al. (2018) (see Table 2), leaving us with a total of 49 articles. We also approached two experts in the area and employed a backward and forward snowballing procedure by manually searching the reference lists of all included studies to make sure that we included all the necessary articles – the approach that yielded 13 more papers on genetics, 8 more papers on physiology, and 11 more papers on neuroscience[i]. After validating the retrieved papers, our overall search shows a total number of 81 papers and 5 books/book chapters (see Table 3).

Table 1

Keywords and Search Terms

	Genetics	Physiology	Neuroscience
Business	✓ Biology and business ✓ Gene and business	✓ Biology and business ✓ Hormone and business ✓ Testosterone and business ✓ Dopamine and business ✓ Cortisol and business ✓ Oxytocin and business ✓ Serotonin and business ✓ Physiology and business	✓ Biology and business, ✓ Neuroscience and business
Management	✓ Biology and management ✓ Gene and management	✓ Biology and management ✓ Hormone and management ✓ Testosterone and management ✓ Dopamine and management ✓ Cortisol and management ✓ Oxytocin and management ✓ Serotonin and management ✓ Physiology and management	✓ Biology and management ✓ Neuroscience and management
Leadership	✓ Biology and leadership ✓ Gene and leadership	✓ Biology and leadership ✓ Hormone and leadership ✓ Testosterone and leadership ✓ Dopamine and leadership ✓ Cortisol and leadership ✓ Oxytocin and leadership ✓ Serotonin and leadership ✓ Physiology and leadership	✓ Biology and leadership ✓ Neuroscience and leadership
Entrepreneurship	✓ Biology and entrepreneurship ✓ Gene and entrepreneurship	✓ Biology and entrepreneurship ✓ Hormone and entrepreneurship ✓ Testosterone and entrepreneurship ✓ Dopamine and entrepreneurship	✓ Biology and entrepreneurship ✓ Neuroscience and entrepreneurship

		✓ Cortisol and entrepreneurship ✓ Oxytocin and entrepreneurship ✓ Serotonin and entrepreneurship ✓ Physiology and leadership	
Organizational Behavior	✓ Biology and Organizational Behavior ✓ Gene and Organizational Behavior	✓ Biology and Organizational Behavior ✓ Hormone and Organizational Behavior ✓ Testosterone and Organizational Behavior ✓ Dopamine and Organizational Behavior ✓ Cortisol and Organizational Behavior ✓ Oxytocin and Organizational Behavior ✓ Serotonin and Organizational Behavior ✓ Physiology and Organizational Behavior	✓ Biology and Organizational Behavior, ✓ Neuroscience and Organizational Behavior
Strategy	✓ Biology and Strategy ✓ Gene and Strategy	✓ Biology and Strategy ✓ Hormone and Strategy ✓ Testosterone and Strategy ✓ Dopamine and Strategy ✓ Cortisol and Strategy ✓ Oxytocin and Strategy ✓ Serotonin and Strategy ✓ Physiology and Strategy	✓ Biology and Strategy, ✓ Neuroscience and Strategy
Occupational Health and Safety	✓ Biology and Occupational Health and Safety ✓ Gene and Occupational Health and Safety	✓ Biology and Occupational Health and Safety ✓ Hormone and Occupational Health and Safety ✓ Testosterone and Occupational Health and Safety ✓ Dopamine and Occupational Health and Safety ✓ Cortisol and Occupational Health and Safety ✓ Oxytocin and Occupational Health and Safety ✓ Serotonin and Occupational Health and Safety ✓ Physiology and Occupational Health and Safety	✓ Biology and Occupational Health and Safety, ✓ Neuroscience and Occupational Health and Safety

Table 2

Exclusion Criteria

N	Criteria	Reason for Exclusion
1	Organizational evolution papers	Examine how organizations evolve but do not look at the relationships between biology and entrepreneurship.
2	Metaphor papers	Compare organizational activities to biology only metaphorically and do not look at the relationships between biology and entrepreneurship.
3	Biological contexts papers	Examine the relationships between different management variables in biology-related contexts such as hospitals, pharmacies, biotech companies but do not look at the relationships between biology and entrepreneurship
4	Proxy papers	Use proxies such as age, gender, and ethnicity for biology.
5	Marketing papers	Do not capture entrepreneurship-related phenotypes
6	Accounting, Economics and Finance papers	Do not capture entrepreneurship-related phenotypes

Source: Nofal, et al. (2018)

The articles that result from the systematic review are listed in Table 3. The journals that make the biggest contribution to the review are: *Journal of Business Venturing*, *Journal of Applied Psychology*, *Organizational Behavior and Human Decision Processes*, and *Applied Psychology*. We next review the papers in each of the three biological strands. Afterwards, we discuss the mechanisms through which biology influences entrepreneurship.

Research on Genetics and Entrepreneurship

Research in the genetics strand has examined the influence of DNA on the propensity to engage in entrepreneurship, the propensity to recognize entrepreneurial opportunities, entrepreneurial intentions and entrepreneurial performance (Nicos Nicolaou & Shane, 2009: 2). Two methods are used to examine whether genetics affects entrepreneurship. The first method is called "quantitative genetics", while the second is called "molecular genetics". The former builds on natural experiments of twins and adoptees to separate the influences of genes from the effects of environmental factors in an entrepreneurial phenotype. The latter attempts to identify the specific genetic variants that influence entrepreneurial propensities, using candidate gene and genome-wide association studies.

To date, quantitative genetics research has received more attention than molecular genetics research, as evidenced by the number of publications. This research shows that genetic factors explain 48% of the variance in self-employment (Nicos Nicolaou, Shane, Cherkas, Hunkin, & Spector, 2008; Zhen Zhang et al., 2009a), 40% of the variance in starting a new business, and 43% of the variance in engaging in the firm start-up process (Lindquist, Sol, & Van Praag, 2015; Nofal, et al., 2018; Zunino, 2016). The majority of those papers used self-employment and business ownership as proxies to measure entrepreneurship, which are less likely to capture the explorative dimensions of entrepreneurship (Henrekson & Sanandaji, 2014). Attempting to address this issue, other studies have examined the influence of genes on

other entrepreneurial outcomes, such as opportunity recognition and entrepreneurial intentions. For instance, there is evidence that genetics contribute to 45% of the variance in opportunity recognition (Scott Shane & Nicos Nicolaou, 2015) and 42% of the variance in entrepreneurial intentions (Nicos Nicolaou & Shane, 2010).

Table 3

Publications included in the Systematic Review (Sorted by Year)

Genetics	Physiology	Neuroscience
1. (Nicos Nicolaou, Shane, Cherkas, Hunkin, et al., 2008) 2. (Nicos Nicolaou, Shane, Cherkas, & Spector, 2008) 3. (Frank, Doll, Oas-Terpstra, & Moreno, 2009) 4. (W. Johnson, 2009) 5. (Nicos Nicolaou & Shane, 2009) 6. (Nicos Nicolaou, Shane, Cherkas, & Spector, 2009) 7. (Shane, 2009) 8. (Zhen Zhang, Ilies, & Arvey, 2009b) 9. (Zhen Zhang, et al., 2009a) 10. (Koellinger et al., 2010) 11. (Nicos Nicolaou & Shane, 2010) 12. (Shane, 2010) 13. (Shane, Nicolaou, Cherkas, & Spector, 2010b) 14. (Shane, Nicolaou, Cherkas, & Spector, 2010a) 15. (van der Loos, Koellinger, Groenen, & Thurik, 2010) 16. (Nicos Nicolaou & Shane, 2011) 17. (Nicos Nicolaou, Shane, Adi, Mangino, & Harris, 2011; van der Loos, et al., 2010) 18. (van der Loos et al., 2011) 19. (R. Arvey & Zhen, 2012) 20. (Quaye, Nicolaou, Shane, & Harris, 2012) 21. (Quaye, Nicolaou, Shane, & Mangino, 2012) 22. (Wernerfelt, Rand, Dreber, Montgomery, & Malhotra, 2012) 23. (Shane & Nicolaou, 2013) 24. (van der Loos, Rietveld, et al., 2013) 25. (R. D. Arvey & Zhang, 2015) 26. (Lindquist, et al., 2015) 27. (S. Shane & N. Nicolaou, 2015) 28. (Schermer, Johnson, Jang, & Vernon, 2015) 29. (Scott Shane & Nicos Nicolaou, 2015)	1. (White, Thornhill, & Hampson, 2006) 2. (Tomasino, 2007) 3. (Weis, Firker, & Hennig, 2007) 4. (White, Thornhill, & Hampson, 2007) 5. (Shane, 2009) 6. (Jens M Unger, Rauch, Narayanan, Weis, & Frese, 2009) 7. (Sundararajan, 2010) 8. (Trahms, Coombs, & Barrick, 2010) 9. (Guiso & Rustichini, 2011b) 10. (Guiso & Rustichini, 2011a) 11. (R. Arvey & Zhen, 2012) 12. (van der Loos, Haring, et al., 2013) 13. (Alrajih & Ward, 2014) 14. (Greene, Han, Martin, Zhang, & Wittert, 2014) 15. (Rietveld, van Kippersluis, & Thurik, 2014) 16. (R. D. Arvey & Zhang, 2015) 17. (Bönte, Procher, & Urbig, 2015) 18. (S. Shane & N. Nicolaou, 2015) 19. (Jens M. Unger, Rauch, Weis, & Frese, 2015) 20. (Nofal, et al., 2017) 21. (Wolfe & Patel, 2017) 22. (Nicos Nicolaou, Patel, & Wolfe, 2017) 23. (Nofal, et al., 2018) 24. (Diallo, 2019) 25. (Patel & Wolfe, In press) 26. (Wolfe & Patel, 2018)	1. (Frank, et al., 2009) 2. (Collins & Karasek, 2010; Shane, 2009) 3. (Laureiro-Martínez, Brusoni, & Zollo, 2010) 4. (R. Arvey & Zhen, 2012) 5. (P. M. de Holan, 2013) 6. (Nejati & Shahidi, 2013) 7. (N. Nicolaou & Shane, 2013) 8. (Tracey & Schluppeck, 2013) 9. (Krueger & Welpe, 2014) 10. (McMullen, Wood, & Palich, 2014) 11. (Laureiro-Martinez et al., 2014) 12. (R. D. Arvey & Zhang, 2015) 13. (Laureiro-Martínez, Brusoni, Canessa, & Zollo, 2015a) 14. (Laureiro-Martínez, Venkatraman, Cappa, Zollo, & Brusoni, 2015) 15. (Massaro, 2015) 16. (S. Shane & N. Nicolaou, 2015) 17. (Pablo Martin De Holan & Couffe, 2017) 18. (Nofal, et al., 2017) 19. (Víctor Pérez-Centeno, 2017) 20. (Nofal, et al., 2018) 21. (S. K. Johnson et al., 2018) 22. (Victor Pérez-Centeno, 2018) 23. (Lahti, Halko, Karagozoglu, & Wincent, 2019) 24. (Nicos Nicolaou, Lockett, Ucbasaran, & Rees, 2019) 25. (Shane, Drover, Clingingsmith, & Cerf, 2019)

30. (R. D. Arvey, Li, & Wang, 2016) 31. (Zunino, 2016) 32. (Nofal, Nicolaou, & Symeonidou, 2017) 33. (Nofal, et al., 2018) 34. (Guedes, Nicolaou, & Patel, 2019) 35. (Kuechle, 2019)		

Note : Some papers span more than one category and accordingly appear in more than one column.

While research shows that genetic factors explain a significant part of the variance in entrepreneurship, research trying to detect the specific genes influencing the tendency to engage in entrepreneurship has been less informative compared to quantitative genetics research. In this regard, Nicos Nicolaou, et al. (2011) found a single nucleotide polymorphism in the dopamine receptor genes to be associated with entrepreneurship using a candidate-gene study.

However, candidate gene studies (in most settings) have suffered from lack of replication (Duncan, Ostacher, & Ballon, 2019; van der Loos, et al., 2011) and have been superseded by genome wide association studies (GWAS). GWAS aims to identify small effect size genes influencing entrepreneurial phenotypes by examining the entire genome without the need for a priori hypotheses.

GWAS suffer from their own limitations. In particular, GWAS require very large samples (Koellinger, et al., 2010; van der Loos, et al., 2010) and genome-wide significance levels of 5×10^{-8}. In other words, due to the large number of statistical tests conducted, a Bonferroni correction is needed to adjust the alpha values from $p<0.05$ to $p<(0.05/\text{number of statistical tests})$. For GWASs, the adjusted Bonferroni correction corresponds to $p<5 \times 10^{-8}$. Meanwhile, the highest significance values achieved for GWAS in entrepreneurship were 6×10^{-7} for the rs10791283 of the OPCML gene (Quaye, Nicolaou, Shane, & Mangino, 2012), and 1.25×10^{-7} for the rs6738407 located in the HECW2 gene (van der Loos, Rietveld, et al., 2013). As a result, the GWAS are largely inconclusive. There might be very large number of genes involved in entrepreneurship, each with such a small individual effect size that the effects are difficult to detect.

Research on Physiology and Entrepreneurship

Physiology is the second strand in the literature on the biology of entrepreneurship. This strand has mainly focused on the influence of hormones. Among the key findings are that testosterone influences the tendency of people to engage in self-employment (White et al., 2006; Greene et al., 2014). Testosterone is suggested to influence risk-taking which in turn affects the tendency to become self-employed (Bönte, et al., 2015; White, et al., 2006). Nicos Nicolaou, Patel, and Wolfe (2018) utilized three different studies using serum testosterone levels, prenatal testosterone exposure using the 2D:4D ratio, and testosterone transfer in opposite-sex and same-sex twins to show that testosterone is associated with a higher propensity of engaging in entrepreneurship. Jens M. Unger, et al. (2015) also found a significant interactive effect between prenatal testosterone and need for achievement on the number of jobs created by an entrepreneur.

Testosterone is not the only hormone examined. Other research shows a significant interactive effect of the stress hormone "cortisol" and epinephrine on the tendency to become an entrepreneur (Wolfe & Patel, 2017). Individuals with elevated epinephrine levels are more likely to engage in risky decision-making when their cortisol levels are low.

Research on Neuroscience and Entrepreneurship

The third strand of the biological theory of entrepreneurship examines the relationship between neuroscience and entrepreneurship (P. M. de Holan, 2013; N. Nicolaou & Shane, 2013). Examining neural activity in the brain can help us better understand how human beings function (Hannah, Balthazard, Waldman, Jennings, & Thatcher, 2013; Lee, Butler, & Senior, 2008). For instance, incorporating neuroscience methods into the study of entrepreneurship has allowed "researchers to obtain more truthful data" about numerous "psychological functions such as brain reward systems and judgement" (Lahti, Halko, Karagozoglu, & Wincent, 2018:

17). Capturing the neural activity has also helped in revealing various neuropsychological antecedents to individuals' strategic decisions, including emotions and cognitions (Laureiro-Martínez, Venkatraman, et al., 2015).

Nicos Nicolaou, et al. (2019) propose four complementary mechanisms through which neuroscience can enhance our understanding of entrepreneurship; 1) capturing hidden mental processes that are unlikely to be revealed using other techniques, 2) confirming discriminant and convergent validity of entrepreneurship constructs, 3) investigating the underlying antecedents and temporal ordering of variables, and 4) refining theoretical perspectives.

Unfortunately, to date most of the work on the neuroscience of entrepreneurship is conceptual (Nicos Nicolaou, et al., 2019). Nevertheless, the few empirical papers in this area have uncovered some patterns for the study of entrepreneurship. For example, Lahti, et al. (2018) argue that entrepreneurs' bonding with their ventures activates the same brain regions as parents' bonding with children, suggesting that entrepreneurs exhibit strong bonding, intimacy, caregiving dispositions, and affective emotions when thinking about their ventures – which resembles the relationship between parents and their children. Laureiro-Martinez, et al. (2014) show that entrepreneurs have greater decision-making efficiency than managers and stronger activation in the in the frontopolar cortex, which has been associated with exploration. In a recent fMRI study Shane, et al. (2019) found that founders with high passion trigger investors' neural engagement by 39% and investors' interest in the venture by 26% compared to founders with low passion.

Mechanisms Explaining the Biological Basis of Entrepreneurship

An understanding of the mechanisms relating biology to entrepreneurship can augment our ability to understand various entrepreneurial outcomes (Colarelli & Arvey, 2015; Nicos Nicolaou & Shane, 2011). As (Shane, et al., 2019, p.6) explain, understanding the mechanisms

relating biology to entrepreneurship is novel, but not easy, and "human beings are too complex biologically for there to be a single mechanism". Research has presented a number of mechanisms to explain how biology impacts the tendency of people to engage in entrepreneurship.

First, biology may impact the tendency of people to engage in entrepreneurship through psychological characteristics. Prior work shows, for instance, that agreeableness, openness to experience and extraversion mediate the relationship between genetic factors and entrepreneurial performance (Shane & Nicolaou, 2013). Extant literature also shows that testosterone affects entrepreneurial intentions through risk-taking (Bönte, et al., 2015).

Second, biology may moderate the relationship between environmental factors and the tendency to engage in entrepreneurship. Empirical evidence, for example, indicates that genetics and social environments play an interactive role in influencing the propensity towards entrepreneurship (Z. Zhang, Ilies, & Arvey, 2010; Zhen Zhang, et al., 2009a). Further work proposes an interactive influence of genetic factors and education on the likelihood of self-employment (Quaye, Nicolaou, Shane, & Harris, 2012).

Third, biology may influence the propensity towards entrepreneurship by affecting the likelihood of people to select certain environments that in turn affect their likelihood of engaging in entrepreneurship. For instance, the genetic makeup of individuals may enable them to self-select environments that give them better access to business angels and venture capitalists which in turn increases the likelihood that they engage in entrepreneurship (S. Shane & N. Nicolaou, 2015).

Fourth, interactions between biological factors may affect the tendency of people to become entrepreneurs. Research shows, for instance, that cortisol and epinephrine have an interactive effect on the probability of becoming self-employed (Wolfe & Patel, 2017). Cortisol has been commonly labelled as the stress hormone, and epinephrine is widely known as

adrenaline – which triggers the decision to fight rather than withdraw. Bringing these arguments to entrepreneurship, Wolfe and Patel (2017) propose that individuals who have high levels of epinephrine (i.e. adrenaline) are more likely to fight and engage in entrepreneurship provided that they possess low levels of stress as expressed by their decreased levels of cortisol.

In the same line, studies show that the anterior cingulate cortex interacts with the orbitofrontal cortex and the locus coeruleus to affect exploration and exploitation (Aston-Jones & Cohen, 2005; Laureiro-Martínez, et al., 2010; Nofal, et al., 2018). This evidence shows that exploration and exploitation are associated with interactions between the two brain regions that are responsible for reward seeking and attentional control (Laureiro-Martínez, Brusoni, Canessa, & Zollo, 2015b). While showing the complexity of entrepreneurial behavior, those interactive influences of biological factors on entrepreneurship could also partly explain why prior studies have failed to detect the specific genetic variants influencing the tendency to engage in entrepreneurship. For example, there could be interactions between genetic factors contributing to the variance of who engages in entrepreneurship.

Future Research

There are a number of research gaps that future studies need to address. For instance, further entrepreneurship variables need to be examined, such as the influence of biology on entrepreneurial biases, entrepreneurs' thinking styles and fear of failure. Researchers are also urged to provide further empirical evidence on how biology and environmental factors interact to influence the tendency of people to engage in entrepreneurship (Quaye, Nicolaou, Shane, & Harris, 2012). More empirical work is also needed on how people's biological make up can drive them to self-select into certain environments to engage in entrepreneurship (Nicos Nicolaou & Shane, 2009).

Research pertaining to the specific biological strands is also needed. For example, extant work trying to identify specific genes influencing entrepreneurship has been less

successful, with detected genes explaining a very low percentage of the variance of entrepreneurship (Quaye, Nicolaou, Shane, & Mangino, 2012; van der Loos, Rietveld, et al., 2013). These unsuccessful attempts are believed to be due to a number of reasons. First, genes can influence entrepreneurship by interacting with other biological and environmental factors (Nicos Nicolaou & Shane, 2009). Second, the effect of genes on complex variables, such as entrepreneurial outcomes, is characterized by being polygenic in nature (Plomin, DeFries, Knopik, & Neiderhiser, 2012). It is unlikely that a single gene would have a large effect on entrepreneurial outcomes, but rather a combination of genes each of a small effect size combine to affect the tendency of people to engage in entrepreneurial outcomes (Quaye, Nicolaou, Shane, & Massimo, 2012). Research on polygenic risk scores may be a useful avenue in this endeavor (e.g. Belsky et al., 2016)).

In addition, empirical studies on hormones and entrepreneurship have only focused on a few hormones, such as testosterone, cortisol and epinephrine (Nofal, et al., 2018; Wolfe & Patel, 2017). Researchers are encouraged to examine the influence of serotonin, dopamine, and oxytocin on entrepreneurship. Serotonin and dopamine contribute to the formation of various personality traits and psychological attitudes, which have been previously related to entrepreneurship, such as sensation seeking, risk-taking, novelty-seeking, and job satisfaction (Song, Li, & Arvey, 2011). Oxytocin is commonly known as the social bonding and/or the trust hormone as it promotes social networking abilities, with people high in oxytocin more likely to establish trusted social networks and bonds (Algoe, Kurtz, & Grewen, 2017), and therefore more likely to engage in entrepreneurship (S. Shane & N. Nicolaou, 2015). Oxytocin is also famous for its impact on stress regulation (Olff et al., 2013).

Additional research on the neural correlates of entrepreneurship is also required. For instance, although studies have reported that entrepreneurs exhibit distinctive activity in certain regions of the brain relative to their counterparts, we need to know more about the implications

of this neural activity for entrepreneurship (Laureiro-Martinez, et al., 2014; Nofal, et al., 2018; Shane, et al., 2019).

Discussion

The goal of this chapter is to bring together research examining the role of genetics, physiology and neuroscience in entrepreneurship. This literature has been highly fragmented, limiting our ability to comprehensively understand the mechanisms governing the relationship between biology and entrepreneurship (Nofal, et al., 2018). Our systematic review shows that the past decade has witnessed a significant rise in work examining the influence of biology on entrepreneurship as well as calls for research in this area. For instance, our review shows that six journals in the past 10 years have called for special issues on the role of biology and/or mental conditions in management; *Academy of Management Perspectives* (Phan & Wright, 2018), *Applied Psychology* (R. Arvey & Zhen, 2012; R. D. Arvey & Zhang, 2015), *Journal of Business Venturing* (Wiklund, Nikolaev, Shir, Foo, & Bradley, 2019), *Entrepreneurship Theory & Practice* (Nicos Nicolaou, Phan, & Stephan, In press), *Leadership Quarterly* (Lee, Senior, & Butler, 2012), and *Organizational Behavior and Human Decision Process* (Shane, 2009). There have also been some special issues calls in non-management journals, such as *Frontiers in Human Neuroscience* (Waldman, 2013).

Studies on the biology of entrepreneurship demonstrate that entrepreneurship is a function not only of environmental factors but also of biological factors. In fact, as researchers argue, “we are all biological creatures and our biology affects all aspects of our behavior, including our work” (Nofal, et al., 2018: 23). Entrepreneurial outcomes, such as opportunity recognition (Shane, et al., 2010a), entrepreneurial intentions, entrepreneurial performance (Patel & Wolfe, In press; Shane & Nicolaou, 2013; Wolfe, Patel, & Drover, 2018), crowdfunding performance (Anglin, Wolfe, Short, McKenny, & Pidduck, 2018), business ownership (Nicos Nicolaou, Shane, Cherkas, Hunkin, et al., 2008), self-employment and the

tendency to engage in entrepreneurship (Scott Shane & Nicos Nicolaou, 2015; Wolfe & Patel, 2017), have all been shown to be influenced by both biological and environmental factors. These biological factors often play a role in affecting people's psychological traits and attitudes, which in turn affect their tendencies to engage in entrepreneurship. These traits include, sensation-seeking, openness to experience, creativity, and extraversion.

Moreover, our systematic review shows that different biological strands can jointly play a role in entrepreneurship, such as evidence of gene-gene interactions, gene-hormone interactions (Frank, et al., 2009; Quaye, Nicolaou, Shane, & Harris, 2012), and hormone-psychological variables interactions (Jens M. Unger, et al., 2015). Furthermore, evidence of the influence of biology on entrepreneurship suggests that the effect of biology on entrepreneurship is less likely to be direct, but likely to partially manifest through other psychological factors and attitudes, such as risk-taking, openness to experience, and sensation seeking (Bönte, et al., 2015; Nicos Nicolaou, Shane, Cherkas, & Spector, 2008; Shane, et al., 2010a; White, et al., 2006).

Conclusion

The biological theory of entrepreneurship is becoming an increasingly important area in the field. This chapter has examined how genetics, physiology, and neuroscience influence the tendency of people of become entrepreneurs. This growth is parallel to the growth in the biological perspective in management, where more than 133 journals world-wide have published at least one article on the biological perspective in management during the past few years (Nofal, et al., 2018). Yet, many gaps still exist and further research is required to boost our understanding of the biological underpinnings of entrepreneurship.

References

Algoe, S. B., Kurtz, L. E., & Grewen, K. (2017). Oxytocin and social bonds: the role of oxytocin in perceptions of romantic partners' bonding behavior. *Psychological science, 28*(12), 1763-1772.

Alrajih, S., & Ward, J. (2014). Increased facial width-to-height ratio and perceived dominance in the faces of the UK's leading business leaders. *British Journal of Psychology, 105*(2), 153-161. doi: 10.1111/bjop.12035

Anglin, A. H., Wolfe, M. T., Short, J. C., McKenny, A. F., & Pidduck, R. J. (2018). Narcissistic rhetoric and crowdfunding performance: A social role theory perspective. *Journal of Business Venturing, 33*(6), 780-812. doi: https://doi.org/10.1016/j.jbusvent.2018.04.004

Arvey, R., & Zhen, Z. (2012). Applied Psychology: An International Review Special Issue; Biological Factors in Organizational Behavior and I/O Psychology. *Applied Psychology, 61*(1), 174-176. doi: 10.1111/j.1464-0597.2011.00466.x

Arvey, R. D., Li, W.-D., & Wang, N. (2016). Genetics and Organizational Behavior. *Annual Review of Organizational Psychology and Organizational Behavior, 3*(1), 167-190. doi: 10.1146/annurev-orgpsych-032414-111251

Arvey, R. D., & Zhang, Z. (2015). Biological Factors in Organizational Behavior and I/O Psychology: An Introduction to the Special Section. *Applied Psychology, 64*(2), 281-285. doi: 10.1111/apps.12044

Aston-Jones, G., & Cohen, J. D. (2005). An integrative theory of locus coeruleus-norepinephrine function: adaptive gain and optimal performance. *Annu. Rev. Neurosci., 28*, 403-450.

Belsky, D. W., Moffitt, T. E., Corcoran, D. L., Domingue, B., Harrington, H., Hogan, S., . . . Williams, B. S. (2016). The genetics of success: How single-nucleotide polymorphisms

associated with educational attainment relate to life-course development. *Psychological science, 27*(7), 957-972.

Bönte, W., Procher, V. D., & Urbig, D. (2015). Biology and Selection Into Entrepreneurship-The Relevance of Prenatal Testosterone Exposure. *Entrepreneurship Theory and Practice, 40*(5), 1121-1148. doi: 10.1111/etap.12165

Colarelli, S. M., & Arvey, R. D. (2015). *The Biological Foundations of Organizational Behavior*: University of Chicago Press.

Collins, S., & Karasek, R. (2010). Reduced vagal cardiac control variance in exhausted and high strain job subjects. *International Journal of Occupational Medicine and Environmental Health, 23*(3), 267-278. doi: 10.2478/v10001-010-0023-6

de Holan, P. M. (2013). It's All in Your Head: Why We Need Neuroentrepreneurship. *Journal of Management Inquiry, 23*(1), 93-97. doi: 10.1177/1056492613485913

De Holan, P. M., & Couffe, C. (2017). Unpacking neuroentrepreneurship: conducting entrepreneurship research with EEG technologies *Handbook of Research Methodologies and Design in Neuroentrepreneurship*: Edward Elgar Publishing.

Diallo, B. (2019). Entrepreneurship and genetics: New Evidence. *Journal of Business Venturing Insights, 11*, e00123. doi: https://doi.org/10.1016/j.jbvi.2019.e00123

Duncan, L. E., Ostacher, M., & Ballon, J. (2019). How genome-wide association studies (GWAS) made traditional candidate gene studies obsolete. *Neuropsychopharmacology: official publication of the American College of Neuropsychopharmacology*.

Frank, M. J., Doll, B. B., Oas-Terpstra, J., & Moreno, F. (2009). Prefrontal and striatal dopaminergic genes predict individual differences in exploration and exploitation. *Nature Neuroscience, 12*(8), 1062-1068. doi: 10.1038/nn.2342

Greene, F. J., Han, L., Martin, S., Zhang, S., & Wittert, G. (2014). Testosterone is associated with self-employment among Australian men. *Economics and Human Biology, 13*, 76-84. doi: 10.1016/j.ehb.2013.02.003

Guedes, M. J., Nicolaou, N., & Patel, P. C. (2019). Genetic distance and the difference in new firm entry between countries. [journal article]. *Journal of Evolutionary Economics*. doi: 10.1007/s00191-019-00613-2

Guiso, L., & Rustichini, A. (2011a). Understanding the Size and Profitability of Firms: The Role of a Biological Factor. *CEPR Discussion Paper*, (DP8205). Retrieved from Available at SSRN: https://ssrn.com/abstract=1749846

Guiso, L., & Rustichini, A. (2011b). *What Drives Women Out of Entrepreneurship? The Joint Role of Testosterone and Culture.* Paper presented at the CEPR Discussion Paper

Hannah, S. T., Balthazard, P. A., Waldman, D. A., Jennings, P. L., & Thatcher, R. W. (2013). The psychological and neurological bases of leader self-complexity and effects on adaptive decision-making. *Journal of Applied Psychology, 98*(3), 393-411. doi: 10.1037/a0032257

Henrekson, M., & Sanandaji, T. (2014). Small business activity does not measure entrepreneurship. *Proceedings of the National Academy of Sciences, 111*(5), 1760-1765.

Johnson, S. K., Fitza, M. A., Lerner, D. A., Calhoun, D. M., Beldon, M. A., Chan, E. T., & Johnson, P. T. (2018). Risky business: linking Toxoplasma gondii infection and entrepreneurship behaviours across individuals and countries. *Proceedings of the Royal Society B: Biological Sciences, 285*(1883), 20180822.

Johnson, W. (2009). So what or so everything? Bringing behavior genetics to entrepreneurship research. *Journal of Business Venturing, 24*(1), 23-26. doi: 10.1016/j.jbusvent.2007.11.002

Koellinger, P. D., van der Loos, M. J. H. M., Groenen, P. J. F., Thurik, A. R., Rivadeneira, F., van Rooij, F. J. A., . . . Hofman, A. (2010). Genome-wide association studies in economics and entrepreneurship research: promises and limitations. *Small Business Economics, 35*(1), 1-18. doi: 10.1007/s11187-010-9286-3

Krueger, N., & Welpe, I. (2014). Neuroentrepreneurship: what can entrepreneurship learn from neuroscience? *Annals of Entrepreneurship Education and Pedagogy*.

Kuechle, G. (2019). The contribution of behavior genetics to entrepreneurship: An evolutionary perspective. *Journal of Evolutionary Economics*, 1-22.

Lahti, T., Halko, M.-L., Karagozoglu, N., & Wincent, J. (2018). Why and how do founding entrepreneurs bond with their ventures? Neural correlates of entrepreneurial and parental bonding. *Journal of Business Venturing*. doi: https://doi.org/10.1016/j.jbusvent.2018.05.001

Lahti, T., Halko, M.-L., Karagozoglu, N., & Wincent, J. (2019). Why and how do founding entrepreneurs bond with their ventures? Neural correlates of entrepreneurial and parental bonding. *Journal of Business Venturing, 34*(2), 368-388. doi: https://doi.org/10.1016/j.jbusvent.2018.05.001

Laureiro-Martínez, D., Brusoni, S., Canessa, N., & Zollo, M. (2015a). Understanding the exploration-exploitation dilemma: An fMRI study of attention control and decision-making performance. *Strategic Management Journal, 36*(3), 319-338. doi: 10.1002/smj.2221

Laureiro-Martínez, D., Brusoni, S., Canessa, N., & Zollo, M. (2015b). Understanding the exploration–exploitation dilemma: An fMRI study of attention control and decision-making performance. *Strategic Management Journal, 36*(3), 319-338. doi: 10.1002/smj.2221

Laureiro-Martínez, D., Brusoni, S., & Zollo, M. (2010). The neuroscientific foundations of the exploration−exploitation dilemma. *Journal of Neuroscience, Psychology, and Economics, 3*(2), 95-115. doi: 10.1037/a0018495

Laureiro-Martinez, D., Canessa, N., Brusoni, S., Zollo, M., Hare, T., Alemanno, F., & Cappa, S. F. (2014). Frontopolar cortex and decision-making efficiency: comparing brain activity of experts with different professional background during an exploration-exploitation task. *Frontiers in Human Neuroscience, 7*, 927. doi: 10.3389/fnhum.2013.00927

Laureiro-Martínez, D., Venkatraman, V., Cappa, S., Zollo, M., & Brusoni, S. (2015). Cognitive Neurosciences and Strategic Management: Challenges and Opportunities in Tying the Knot *Cognition and Strategy* (Vol. 32, pp. 351-370): Emerald Group Publishing Limited.

Lee, N., Butler, M. J., & Senior, C. (2008). The brain in business: the case for organizational cognitive neuroscience? *Nature Precedings*.

Lee, N., Senior, C., & Butler, M. (2012). Leadership research and cognitive neuroscience: The state of this union. *The Leadership Quarterly, 23*(2), 213-218. doi: http://dx.doi.org/10.1016/j.leaqua.2011.08.001

Lindquist, M. J., Sol, J., & Van Praag, M. (2015). Why Do Entrepreneurial Parents Have Entrepreneurial Children? *Journal of Labor Economics, 33*(2), 269-296. doi: 10.1086/678493

Massaro, S. (2015). Neuroscientific methods for strategic management. *Research Methods for Strategic Management*, 253.

McMullen, J. S., Wood, M. S., & Palich, L. E. (2014). Entrepreneurial cognition and social cognitive neuroscience. *Handbook of entrepreneurial cognition, 29*, 723-740.

Nejati, V., & Shahidi, S. (2013). Does the Ability to Make a New Business Need More Risky Choices during Decisions? Evidences for the Neurocognitive Basis of Entrepreneurship. *Basic and Clinical Neuroscience, 4*(4), 287-290.

Nicolaou, N., Lockett, A., Ucbasaran, D., & Rees, G. (2019). Exploring the potential and limits of a neuroscientific approach to entrepreneurship. *International Small Business Journal, 37*(6), 557-580. doi: 10.1177/0266242619843234

Nicolaou, N., Patel, P. C., & Wolfe, M. T. (2017). Testosterone and Tendency to Engage in Self-Employment. *Management Science, 64*(4).

Nicolaou, N., Patel, P. C., & Wolfe, M. T. (2018). Testosterone and Tendency to Engage in Self-Employment. *Management Science, 64*(4), 1825-1841. doi: 10.1287/mnsc.2016.2664

Nicolaou, N., Phan, P., & Stephan, U. (In press). Entrepreneurship and Biology. *Entrepreneurship Theory and Practice*.

Nicolaou, N., & Shane, S. (2009). Can genetic factors influence the likelihood of engaging in entrepreneurial activity? *Journal of Business Venturing, 24*(1), 1-22. doi: 10.1016/j.jbusvent.2007.11.003

Nicolaou, N., & Shane, S. (2010). Entrepreneurship and occupational choice: Genetic and environmental influences. *Journal of Economic Behavior & Organization, 76*(1), 3-14. doi: 10.1016/j.jebo.2010.02.009

Nicolaou, N., & Shane, S. (2011). The Genetics of Entrepreneurship *Handbook of Research on Innovation and Entrepreneurship*. Cheltenham, UK: 'Edward Elgar Publishing, Inc.'.

Nicolaou, N., & Shane, S. (2013). Biology, Neuroscience, and Entrepreneurship. *Journal of Management Inquiry, 23*(1), 98-100. doi: 10.1177/1056492613485914

Nicolaou, N., Shane, S., Adi, G., Mangino, M., & Harris, J. (2011). A polymorphism associated with entrepreneurship: evidence from dopamine receptor candidate genes. *Small Business Economics, 36*(2), 151-155. doi: 10.1007/s11187-010-9308-1

Nicolaou, N., Shane, S., Cherkas, L., Hunkin, J., & Spector, T. D. (2008). Is the Tendency to Engage in Entrepreneurship Genetic? *Management Science, 54*(1), 167-179. doi: 10.1287/mnsc.1070.0761

Nicolaou, N., Shane, S., Cherkas, L., & Spector, T. D. (2008). The influence of sensation seeking in the heritability of entrepreneurship. *Strategic Entrepreneurship Journal, 2*(1), 7-21. doi: 10.1002/sej.37

Nicolaou, N., Shane, S., Cherkas, L., & Spector, T. D. (2009). Opportunity recognition and the tendency to be an entrepreneur: A bivariate genetics perspective. *Organizational Behavior and Human Decision Processes, 110*(2), 108-117. doi: 10.1016/j.obhdp.2009.08.005

Nofal, A. M., Nicolaou, N., & Symeonidou, N. (2017). Biology and Entrepreneurship. In G. Ahmetoglu, T. Chamorro-Premuzic, B. Klinger & T. Karcisky (Eds.), *The Wiley Handbook of Entrepreneurship*: Wiley.

Nofal, A. M., Nicolaou, N., Symeonidou, N., & Shane, S. (2018). Biology and Management: A Review, Critique, and Research Agenda. *Journal of Management, 44*(1), 7-31. doi: 10.1177/0149206317720723

Olff, M., Frijling, J. L., Kubzansky, L. D., Bradley, B., Ellenbogen, M. A., Cardoso, C., . . . van Zuiden, M. (2013). The role of oxytocin in social bonding, stress regulation and mental health: An update on the moderating effects of context and interindividual differences. *Psychoneuroendocrinology, 38*(9), 1883-1894. doi: https://doi.org/10.1016/j.psyneuen.2013.06.019

Patel, P. C., & Wolfe, M. T. (In press). In the eye of the beholder? The returns to beauty and IQ for the self-employed. *Strategic Entrepreneurship Journal, 0*(0). doi: 10.1002/sej.1323

Pérez-Centeno, V. (2017). Brain-driven entrepreneurship research: a review and research agenda *Handbook of Research Methodologies and Design in Neuroentrepreneurship*: Edward Elgar Publishing.

Pérez-Centeno, V. (2018). Brain-driven entrepreneurship research: Expanded review and research agenda towards entrepreneurial enhancement: Working Paper.

Phan, P., & Wright, M. (2018). Advancing the Science of Human Cognition and Behavior. *Academy of Management Perspectives, 32*(3), 287-289. doi: 10.5465/amp.2018.0058

Plomin, R., DeFries, J. C., Knopik, V. S., & Neiderhiser, J. M. (2012). *Behavioral Genetics*: Worth Publishers.

Quaye, L., Nicolaou, N., Shane, S., & Harris, J. (2012). A Study of Gene-Environment Interactions In Entrepreneurship. *Entrepreneurship Research Journal, 2*(2). doi: 10.1515/2157-5665.1053

Quaye, L., Nicolaou, N., Shane, S., & Mangino, M. (2012). A Discovery Genome-Wide Association Study of Entrepreneurship. *International Journal of Developmental Science, 6*, 127–135.

Quaye, L., Nicolaou, N., Shane, S., & Massimo, M. (2012). A Discovery Genome-Wide Association Study of Entrepreneurship. *International Journal of Developmental Science, 6*, 127-135.

Rietveld, C. A., van Kippersluis, H., & Thurik, A. R. (2014). Self-Employment and Health: Barriers or Benefits? *Health Economics*. doi: 10.1002/hec.3087

Schermer, J. A., Johnson, A. M., Jang, K. L., & Vernon, P. A. (2015). Phenotypic, genetic, and environmental relationships between self-reported talents and measured intelligence. *Twin Research and Human Genetics, 18*(1), 36-42. doi: 10.1017/thg.2014.80

Shane, S. (2009). Introduction to the focused issue on the biological basis of business. *Organizational Behavior and Human Decision Processes, 110*(2), 67-69. doi: 10.1016/j.obhdp.2009.10.001

Shane, S. (2010). *Born Entrepreneurs, Born Leaders: How Your Genes Affect Your Work Life*: Oxford University Press.

Shane, S., Drover, W., Clingingsmith, D., & Cerf, M. (2019). Founder passion, neural engagement and informal investor interest in startup pitches: An fMRI study. *Journal of Business Venturing*, 105949.

Shane, S., & Nicolaou, N. (2013). The genetics of entrepreneurial performance. *International Small Business Journal, 31*(5), 473-495. doi: 10.1177/0266242613485767

Shane, S., & Nicolaou, N. (2015). The Biological Basis of Entrepreneurship. In S. M. Colarelli & R. D. Arvey (Eds.), *The Biological Foundations of Organizational Behavior*: University of Chicago Press.

Shane, S., & Nicolaou, N. (2015). Creative personality, opportunity recognition and the tendency to start businesses: A study of their genetic predispositions. *Journal of Business Venturing, 30*(3), 407-419. doi: 10.1016/j.jbusvent.2014.04.001

Shane, S., Nicolaou, N., Cherkas, L., & Spector, T. D. (2010a). Do openness to experience and recognizing opportunities have the same genetic source? *Human Resource Management, 49*(2), 291-303. doi: 10.1002/hrm.20343

Shane, S., Nicolaou, N., Cherkas, L., & Spector, T. D. (2010b). Genetics, the Big Five, and the tendency to be self-employed. *Journal of Applied Psychology, 95*(6), 1154-1162. doi: 10.1037/a0020294

Song, Z., Li, W., & Arvey, R. D. (2011). Associations between dopamine and serotonin genes and job satisfaction: Preliminary evidence from the Add Health Study. *Journal of Applied Psychology, 96*(6), 1223-1233. doi: http://dx.doi.org/10.1037/a0024577

Sundararajan, M. (2010). Physiological Emotions and Entrepreneurial Decisions. *Global Business and Management Research: An International Journal, 2*(4), 310-322.

Tomasino, D. (2007). The psychophysiological basis of creativity and intuition: accessing 'the zone' of entrepreneurship. *International Journal of Entrepreneurship and Small Business, 4*(5), 528-542. doi: 10.1504/ijesb.2007.014388

Tracey, P., & Schluppeck, D. (2013). Neuroentreprenuership: "Brain Pornography" or New Frontier in Entrepreneurship Research? *Journal of Management Inquiry, 23*(1), 101-103. doi: 10.1177/1056492613485915

Trahms, C. A., Coombs, J. E., & Barrick, M. (2010). Does biology matter? : how prenatal testosterone, entrepreneur risk propensity, and entrepreneur risk perceptions influence venture performance. [Aufsatz im Buch, Article in book]. *Frontiers of entrepreneurship research 2010 : proceedings of the thirtieth annual Entrepreneurship Research Conference*, 217-229.

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management, 14*(3), 207-222. doi: 10.1111/1467-8551.00375

Unger, J. M., Rauch, A., Narayanan, J., Weis, S., & Frese, M. (2009). Does prenatal testosterone predict entrepreneurial success? Relationships of 2D: 4D and business success (summary). *Frontiers of Entrepreneurship Research, 29*(5), 15.

Unger, J. M., Rauch, A., Weis, S. E., & Frese, M. (2015). Biology (prenatal testosterone), psychology (achievement need) and entrepreneurial impact. *Journal of Business Venturing Insights, 4*, 1-5. doi: http://dx.doi.org/10.1016/j.jbvi.2015.05.001

van der Loos, M. J. H. M., Haring, R., Rietveld, C. A., Baumeister, S. E., Groenen, P. J. F., Hofman, A., . . . Thurik, A. R. (2013). Serum testosterone levels in males are not associated with entrepreneurial behavior in two independent observational studies. *Physiology and Behavior, 119*, 110-114. doi: 10.1016/j.physbeh.2013.06.003

van der Loos, M. J. H. M., Koellinger, P. D., Groenen, P. J. F., Rietveld, C. A., Rivadeneira, F., van Rooij, F. J. A., . . . Thurik, A. R. (2011). Candidate gene studies and the quest for the entrepreneurial gene. *Small Business Economics, 37*(3), 269-275. doi: 10.1007/s11187-011-9339-2

van der Loos, M. J. H. M., Koellinger, P. D., Groenen, P. J. F., & Thurik, A. R. (2010). Genome-Wide Association Studies and the Genetics of Entrepreneurship. *European Journal of Epidemiology, 25*(1), 1-3.

van der Loos, M. J. H. M., Rietveld, C. A., Eklund, N., Koellinger, P. D., Rivadeneira, F., Abecasis, G. R., . . . Thurik, A. R. (2013). The molecular genetic architecture of self-employment. *PLoS One, 8*(4), e60542. doi: 10.1371/journal.pone.0060542

Waldman, D. A. (2013). Interdisciplinary research is the key. *Frontiers in Human Neuroscience, 7*, 562. doi: 10.3389/fnhum.2013.00562

Weis, S. E., Firker, A., & Hennig, J. (2007). Associations between the second to fourth digit ratio and career interests. *Personality and Individual Differences, 43*(3), 485-493. doi: 10.1016/j.paid.2006.12.017

Wernerfelt, N., Rand, D. G., Dreber, A., Montgomery, C., & Malhotra, D. K. (2012). Arginine Vasopressin 1a Receptor (AVPR1a) RS3 Repeat Polymorphism Associated with Entrepreneurship Retrieved from Available at SSRN: https://ssrn.com/abstract=2141598 or http://dx.doi.org/10.2139/ssrn.2141598 website:

White, R. E., Thornhill, S., & Hampson, E. (2006). Entrepreneurs and evolutionary biology: The relationship between testosterone and new venture creation. *Organizational*

Behavior and Human Decision Processes, 100(1), 21-34. doi: 10.1016/j.obhdp.2005.11.001

White, R. E., Thornhill, S., & Hampson, E. (2007). A biosocial model of entrepreneurship: the combined effects of nurture and nature. *Journal of Organizational Behavior, 28*(4), 451-466. doi: 10.1002/job.432

Wiklund, J., Nikolaev, B., Shir, N., Foo, M.-D., & Bradley, S. (2019). Entrepreneurship and well-being: Past, present, and future. *Journal of Business Venturing*, *34*(4), 579-588. doi: https://doi.org/10.1016/j.jbusvent.2019.01.002

Wolfe, M. T., & Patel, P. C. (2017). Two are better than one: Cortisol as a contingency in the association between epinephrine and self-employment. *Journal of Business Venturing Insights*, *8*, 78-86. doi: https://doi.org/10.1016/j.jbvi.2017.07.002

Wolfe, M. T., & Patel, P. C. (2018). Racing to get self-employed? Life history models and self-employment. *Journal of Business Venturing Insights, 10*, e00093. doi: https://doi.org/10.1016/j.jbvi.2018.e00093

Wolfe, M. T., Patel, P. C., & Drover, W. (2018). The Influence of Hypomania Symptoms on Income in Self-Employment. *Entrepreneurship Theory and Practice*, 1042258718807175. doi: 10.1177/1042258718807175

Zhang, Z., Ilies, R., & Arvey, R. D. (2009b). Beyond genetic explanations for leadership: The moderating role of the social environment. *Organizational Behavior and Human Decision Processes, 110*(2), 118-128. doi: http://dx.doi.org/10.1016/j.obhdp.2009.06.004

Zhang, Z., Ilies, R., & Arvey, R. D. (2010). Moderating effects of earlier family environment on genetic influences on entrepreneurship. *Behavior Genetics*, *40*(6), 821-821.

Zhang, Z., Zyphur, M. J., Narayanan, J., Arvey, R. D., Chaturvedi, S., Avolio, B. J., . . . Larsson, G. (2009a). The genetic basis of entrepreneurship: Effects of gender and

personality. *Organizational Behavior and Human Decision Processes, 110*(2), 93-107. doi: http://dx.doi.org/10.1016/j.obhdp.2009.07.002

Zunino, D. (2016). Are Genetics and Environment Substitutes or Complements in Affecting Entrepreneurial Choice? *Academy of Management Proceedings, 2016*(1), 12173. doi: 10.5465/ambpp.2016.12173abstract

[i] Some articles and book chapters are included in more than one biological strand because they examine more than one biological factor.