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The Biological Perspective in Entrepreneurship

by

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A Thesis Submitted in Partial Fulfilment of the Requirements for the
Degree of Doctor of Philosophy in Business and Management

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DECLARATION AND DISCLAIMER

This thesis is my own original piece of work and is based on secondary data I accessed and analyzed. All extracts and non-original work have been acknowledged and cited. No part of this thesis has been published as yet unless acknowledged or submitted for a degree elsewhere, except the second chapter which I published last year as the lead article of the January 2018 issue of the Journal of Management. In addition, chapters 3 and 4 have been previously presented at high quality conferences.

LIST OF PEER-REVIEWED PUBLICATIONS

Parts of this thesis have been peer-reviewed and/or presented at high quality conferences.

- Nofal, A. M., Nicolaou, N., & Symeonidou, N. 2017. Biology and entrepreneurship. In G. Ahmetoglu, T. Chamorro-Premuzic, B. Klinger and 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.
- Nofal, A. M., Nicolaou, N., & Symeonidou, N. 2018. Birth weight and Self-employment. *Entrepreneurship Theory & Practice workshop on the special issue titled "Entrepreneurship and Biology"*. Warwick Business School, Coventry: Entrepreneurship Theory & Practice.
- Nofal, A. M., Nicolaou, N., & Symeonidou, N. 2019. Anxiety and Entrepreneurship. *The future of Conducting and Publishing Research in Entrepreneurship, Innovation Management and Strategy Workshop*. Bologna Business School, Bologna.
- Nofal, A. M., Nicolaou, N., & Symeonidou, N. 2019. Anxiety and Entrepreneurship. *Academy of Management Proceedings*, (Vol. 2019, No. 1, p. 17802). Briarcliff Manor, NY 10510: Academy of Management.

LIST OF ABBREVIATIONS

ABS	Association of Business Schools
GWA	Genome-wide Association
SNPs	Single Nucleotide Polymorphisms
GWASs	Genome-wide Association Studies
BMI	Body Mass Index
ADHD	Attention Deficit Hyperactivity Disorder
qEEG	quantitative Electroencephalography
fMRI	functional Magnetic Resonance Imaging
OCPD	Obsessive-compulsive Personality Disorder
NFBC	Northern Finland Birth Cohort
NCDS	National Child Development Study
MIDUS	Midlife Development in the United States
BSAG	Bristol Social Adjustment Guide
BAS	Behavioral Activation System
BIS	Behavioral Inhibition System
RST	Reinforcement Sensitivity Theory
BCS	British Cohort Study BCS

ABSTRACT

In this thesis, we adopt a four-paper framework to examine how biology relates to entrepreneurship. In the first paper, we conduct a systematic review of the literature on the biological perspective in management and investigate research spanning the areas of genetics, physiology and neuroscience. We present an organizing framework of the area, explain the mechanisms through which biological factors relate to management, and discuss the implications of the biological perspective. Finally, we present an agenda highlighting avenues for future research. In the second paper, we explore the association between birth weight and self-employment using three samples - two longitudinal datasets and a sample of twins - from Finland, the UK and the USA. After accounting for endogeneity with the use of longitudinal designs, two-stage least squares instrumental variable regressions and a twin study design, we find evidence for a curvilinear relationship between birth weight and the tendency to become self-employed. We propose a mediating psychological mechanism – anxiety – to explain this association and find support for this. In the third paper, we contribute to the literature linking mental conditions to entrepreneurship by exploring the relationship between anxiety and entrepreneurship using five samples – one cross sectional, three longitudinal and a sample of twins. We find a negative relationship between anxiety and the tendency to engage in entrepreneurship. Our findings also suggest that improving individuals' financial conditions can attenuate the negative influence of anxiety on entrepreneurship. The fourth paper explores the relationship between breastfeeding duration and the likelihood of engaging in entrepreneurship using two longitudinal datasets from the UK. After partly mitigating endogeneity concerns using the Mundlak-Chamberlain estimator and two-stage least squares instrumental variable regression, we find a positive relationship between breastfeeding duration and the tendency to become an entrepreneur. We propose a mediating psychological mechanism – openness to experience – to explain this relationship.

Chapter 1: Introduction

Research in entrepreneurship has assumed for some time that “nurture dominates over nature” (White, Thornhill & Hampson, 2007). While this can be partly true, this assumption has been recently challenged with emerging literature showing that there are various biological predispositions to entrepreneurial outcomes. As a result, recent work explains how biology in interaction with environmental factors can shape entrepreneurial outcomes (Nicolaou, Shane, Cherkas, Hunkin & Spector, 2008a; Shane & Nicolaou, 2013; Shane, Nicolaou, Cherkas & Spector, 2010a). Yet, this literature “presents an intriguing challenge to organizational scholars” (Colarelli & Arvey, 2015, p. 338). For instance, organizational scholars know little about this research since the literature is scattered and fragmented across a wide range of journals, with many papers published in non-management journals that researchers do not usually follow (Shane, 2009). Furthermore, extant research has been unclear about the mechanisms relating biology to entrepreneurship (Lindebaum & Jordan, 2014; Nicolaou & Shane, 2009). Moreover, while few, most empirical studies on the biological basis of entrepreneurship focuses on the role of genetics, with much less number of papers relating physiology and neuroscience to entrepreneurship (Arvey, Li & Wang, 2016; Heaphy & Dutton, 2008; Nicolaou, Patel & Wolfe, 2017).

1.1. OVERVIEW OF THE THESIS CHAPTERS

This thesis aims to fill some of these gaps by systematically reviewing extant research linking biology to management, laying down the mechanisms relating biology to management outcomes, examining the relationship between birth weight and the tendency of people to become self-employed, the association between anxiety and the likelihood of entrepreneurship as well as investigating the relationship between breastfeeding and the tendency to engage in entrepreneurship. Each chapter reports on a separate study and was written such that it can be read independently from the other chapters. Therefore, some overlap exists across the chapters in the theory and method descriptions.

In chapter 2, we conduct a systematic review of the emerging literature on the biological perspective in management and investigate research spanning the areas of genetics, physiology, and neuroscience. We examine 291 papers published in 133

journals over an 85-year period as well as 10 conference/working papers and six books. On the basis of this analysis, we present an organizing framework of the area, explain the mechanisms through which biological factors relate to management, and discuss the implications of the biological perspective for the theory and the practice of management. Finally, we present an agenda highlighting avenues for future research in this field.

In chapter 3, the focus is on examining the influence of birth weight on the tendency of people to engage in self-employment. Despite the emerging evidence on the biological underpinnings (i.e. genetic, physiological and neurological) of self-employment, and the large number of studies showing that birth weight has several short- and long-run influences on adult outcomes, there are no studies that examine the potential effect of birth weight on the likelihood of self-employment. We explore for the first time the association between birth weight and the likelihood of self-employment using three samples - two longitudinal datasets and a sample of twins - from Finland, the UK and the USA. After accounting for potential endogeneity with the use of longitudinal designs, two-stage least squares instrumental variable regressions and a twin study design, we find evidence for a curvilinear relationship between birth weight and the tendency to become self-employed. We also propose a mediating psychological mechanism – anxiety – to explain this association and find support for this.

Chapter 4 investigates the relationship between anxiety and the likelihood of engaging in entrepreneurship. Although there is increasing evidence of the role of mental conditions in the tendency to engage in entrepreneurship, extant literature is unclear about the role of the most prevalent mental condition worldwide, anxiety, in entrepreneurship. In this chapter, we contribute to this literature by exploring the relationship between anxiety and the likelihood of engaging in entrepreneurial activities using five samples – one cross sectional, three longitudinal and a sample of twins. We find a negative relationship between anxiety and the tendency to engage in entrepreneurship. Our findings also suggest that improving individuals' financial conditions can attenuate the negative influence of anxiety on the propensity to engage in entrepreneurship.

In chapter 5, we contribute to this literature by exploring for the first time the relationship between breastfeeding duration and the likelihood of engaging in entrepreneurship using two longitudinal datasets from the UK. After partly mitigating endogeneity concerns using the Mundlak-Chamberlain estimator and two-stage least squares instrumental variable regression, we find a positive relationship between breastfeeding duration and the tendency to become an entrepreneur. We also propose a mediating psychological mechanism – openness to experience – to explain this relationship. Finally, chapter 6 provides an overall conclusion, and some future research suggestions.

**Chapter 2: Biology and Management: A Review, Critique, and Research
Agenda**

2.1. ABSTRACT

In this article, we conduct a systematic review of the emerging literature on the biological perspective in management and investigate research spanning the areas of genetics, physiology and neuroscience. We examine 291 papers published in 133 journals over an 85-year period, as well as ten conference/working papers and six books. Based on this analysis, we present an organizing framework of the area, explain the mechanisms through which biological factors relate to management, and discuss the implications of the biological perspective for the theory and the practice of management. Finally, we present an agenda highlighting avenues for future research in this field.

*An appendix is attached below.

2.2. INTRODUCTION

What do we know about the role of biology in management? The past decade has witnessed a significant increase in the number of papers that address the ways that genetics, physiology, and neuroscience affect different aspects of management. As a result, we know far more than we once did.

However, our new knowledge is fragmented. “Much of this research has been published in journals that management scholars do not routinely follow, and the different studies themselves have been isolated from one another making it difficult to see the cumulative set of findings” (Shane, 2009, p. 67). Moreover, empirical work on the topic can be found across a large number of journals and in numerous subfields of management, which makes it difficult for management scholars to see how the same theoretical patterns are present in different subfields. Most importantly, the field of management also lacks a systematic discussion of how these individual findings relate to a broader theoretical perspective on how biology influences management, the different mechanisms governing each of these biological influences, and the links between them.

In response to this gap in the literature, we have systematically reviewed 291 papers published in 133 journals, four conference papers, six working papers, and six books/book chapters published over the past 85 years to review and synthesize the biological perspective in management. On the basis of this analysis, we present an organizing framework of this area (see figure 1) and explain the mechanisms through which biological factors relate to management.

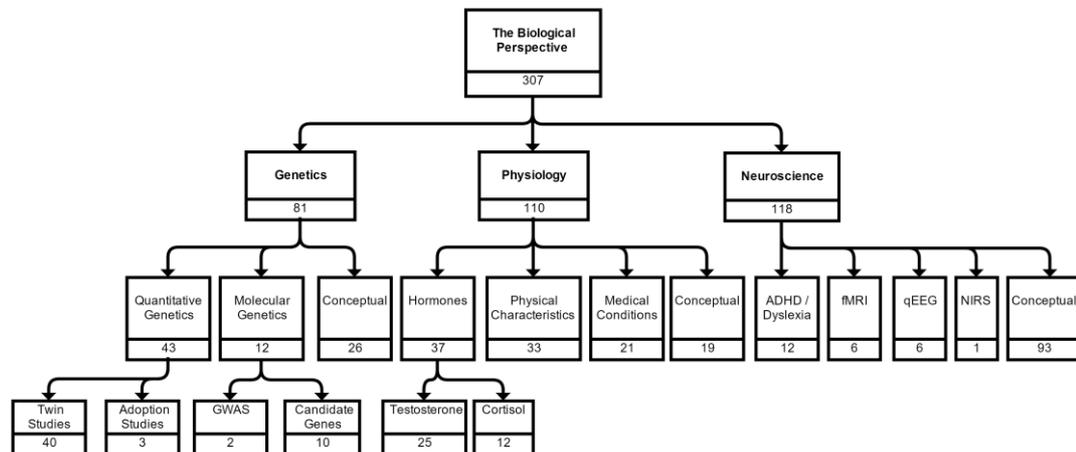
Our review indicates that there has been a substantial amount of research on biological aspects of business. However, there has been little research that connects the three main biological strands to each other and no organizing framework for this biological perspective. Moreover, extant research does not take into account how environment and biology jointly interact to influence management. Previous work has also neglected dynamic considerations, as evidenced by the lack of longitudinal studies. Furthermore, our review shows that research on the implications of the biological perspective for the practice of management is strikingly limited.

We begin our review by providing a detailed description of our methodology and review strategy. Then, we systematically synthesize the findings of previous studies on the biological perspective and describe the mechanisms through which

biology relates to management. Finally, we identify avenues for future research and discuss the implications of the biological perspective for the practice of management.

Figure 1

Organizing Framework¹



2.3. THE BIOLOGICAL PERSPECTIVE

We define the biological perspective on management as the set of studies that examine: a) genetic influences (Arvey et al., 2016; Lindquist, Sol & Van Praag, 2015), b) physiology (Heaphy & Dutton, 2008; White, Thornhill & Hampson, 2006), and c) neuroscience (Becker, Cropanzano & Sanfey, 2011; Waldman, Wang & Fenters, 2016a). Taken together, these studies form the basis for a new school of thought that incorporates human biology into explanations of management behavior (Shane, 2009).

Although the past few years have witnessed the emergence of efforts to synthesize and review studies on each of the three subsets of biological factors, no reviews have sought to bring those different subsets together into a broader biological perspective. Because genetics, physiology and neuroscience jointly affect human behavior, it is important to consider how these factors collectively influence management (Shane, 2009). By offering a *systematic* review of these three areas, considering the mechanisms that govern each, and by highlighting their effects together, we can begin to develop a comprehensive understanding of how biology influences management.

¹ Note: Some studies are included in more than one category. For example, the paper by Mehta and Josephs (2010) is included in both the testosterone and cortisol sections as it examines both.

2.4. METHODOLOGY

Our review strategy is designed to provide a systematic and explicit method for reviewing all three biological aspects in management research. First, we identified keywords (search terms) related to the three biological factors, which we then constructed into search strings (see table S-1 in the appendix below). Second, we followed the protocols outlined by Tranfield, Denyer and Smart (2003) for undertaking reviews in the field of management. Using these protocols, we searched the databases ProQuest, Thomson ISI Web of Knowledge and Scopus to ensure that we uncovered all relevant work. We then reviewed all studies published in journals listed in the Chartered Association of Business Schools' list to identify every possible article that might be relevant to a review of the biological perspective in management.²

While we began our effort to find articles written since 1900, the first article we found was that of Carter (1932) on the possible influences of genes on occupational choices. We included all articles written through the end of March 2017, the stop point for our study. We exported all the papers to Endnote, where the studies were screened using title and abstract analysis to identify every paper that might be relevant to our topic. This effort yielded a total of 335 articles and one book chapter. Of these articles, 164 were then excluded according to our exclusion criteria (see table S-2 in the appendix below), leaving us with a total of 171 articles and one book chapter.

We then employed a backward and forward snowballing procedure by manually searching the reference lists of all included studies. This additional procedure increased the number of articles by 51 journal papers, two books, two conference papers, and one working paper. These journal articles were also screened according to the inclusion and exclusion criteria using a title and abstract analysis. By following this approach, our review was not limited to specific journals or authors who publish in this area, but included all articles cited by or that cited work in this area. This procedure is a precondition for a complete and exhaustive summary of the literature (Tranfield et al., 2003).

Finally, to ensure that we did not miss any articles, we included several papers based on experts' opinions. We showed our list of articles to three experts in the field and asked them to identify any papers that our procedure had failed to identify. This

² The Association of Business School's Academic Journal Guide (ABS, 2015) provides a list of 1401 journals in different business areas.

additional step yielded five more papers on genetics, 41 on physiology, and 23 on neuroscience. It also provided two conference papers, five additional working papers, and three book chapters/books. After validating the search criteria against the retrieved papers, our overall search yielded a total number of 291 published journal articles, four conference papers, six working papers, and six books/book chapters (see table 1).

Table 1³

Articles included in the Systematic Review (sorted by year)

Genetics	Physiology	Neuroscience
(Carter, 1932)	(Chase, 1967)	(Hines, 1987)
(Vandenberg & Kelly, 1964)	(Ramey, 1973)	(Mannuzza, Klein, Bessler, Malloy & LaPadula, 1993)
(Vandenberg & Stafford, 1967)	(Matteson & Ivancevich, 1979)	(Carroll & Ponterotto, 1998)
(Novit, 1981)	(Purifoy & Koopmans, 1979)	(Cooper, 2000)
(Kefalas & Suojanen, 1974)	(Cann, Siegfried & Pearce, 1981)	(Kussrow, 2001)
(Arvey, Bouchard, Segal & Abraham, 1989)	(Ivancevich, Matteson & Preston, 1982)	(Taylor & Walter, 2003)
(Tambs, Sundet, Magnus & Berg, 1989)	(Rose, Jenkins, Hurst, Herd & Hall, 1982)	(Reynolds, 2006)
(Cropanzano & James, 1990)	(Balick & Herd, 1987)	(Rock & Schwartz, 2006)
(Moloney, Bouchard & Segal, 1991)	(Chung & Leung, 1988)	(Bailey, 2007)
(Lykken, McGue, Tellegen & Bouchard, 1992)	(Steffy & Jones, 1988)	(Butler & Senior, 2007a)
(Bouchard, Arvey, Keller & Segal, 1992)	(Dabbs, de La Rue & Williams, 1990)	(Butler & Senior, 2007b)
(Keller, Bouchard, Arvey, Segal & Dawis, 1992)	(Dabbs, 1992)	(Dvorak & Badal, 2007)
(Lichtenstein, Pedersen & McClearn, 1992)	(Fox, Dwyer & Ganster, 1993)	(Klein & D'Esposito, 2007)
(Kupfer, 1993)	(Schaubroeck, Ganster & Kemmerer, 1994)	(Lee & Chamberlain, 2007)
(Lykken, Bouchard, McGue & Tellegen, 1993)	(Schaubroeck & Merritt, 1997)	(Goleman & Boyatzis, 2008)
(Arvey & Bouchard, 1994)	(Dabbs, Alford & Fielden, 1998)	(Gordon, 2008)
(Arvey, McCall, Bouchard, Taubman & Cavanaugh, 1994)	(Lundberg & Frankenhaeuser, 1999)	(Lee, Butler & Senior, 2008)
(Betsworth et al., 1994)	(Melin, Lundberg, Soderlund & Granqvist, 1999)	(Painter, Prevatt & Welles, 2008)
	(Evans & Steptoe, 2001)	(Peterson, Balthazard, Waldman & Thatcher, 2008)
	(Ganster, Fox & Dwyer, 2001)	(Ringleb & Rock, 2008)
	(Rau, Georgiades, Fredrikson, Lemne & de Faire, 2001)	(Senior, Lee & Butler, 2008b)
	(Chiu & Babcock, 2002)	(Senior, Lee & Butler, 2008a)
	(Lundberg & Hellström, 2002)	(Beugré, 2009)
	(Roehling, 2002)	(Halmøy, Fasmer, Gillberg & Haavik, 2009)
	(Barling, Kelloway & Iverson, 2003)	(Kleinman, Durkin, Melkonian & Markosyan, 2009)
	(Fannin & Dabbs, 2003)	(Logan, 2009)
		(Salvador & Folger, 2009)
		(Becker & Cropanzano, 2010)
		(Lafferty & Alford, 2010)

³ Note: Complete references for the papers listed in Table 1 appear in the appendix below.

-
- (Hershberger, Lichtenstein & Knox, 1994)
 (Scarr & Weinberg, 1994)
 (Strudler, 1994)
 (McCall, Cavanaugh, Arvey & Taubman, 1997)
 (Johnson, Vernon, McCarthy, Molson, Harris & Jang, 1998)
 (Murry, Wimbush & Dalton, 2001)
 (Ilies & Judge, 2003)
 (Roberts, 2003)
 (Ilies, Gerhardt & Le, 2004)
 (Johnson, Vernon, Harris & Jang, 2004)
 (Arvey, Rotundo, Johnson, Zhang & McGue, 2006)
 (Ilies, Arvey & Bouchard, 2006)
 (Arvey, Zhang, Avolio & Krueger, 2007)
 (Barclay & Markel, 2007)
 (Nicolaou et al., 2008a)
 (Nicolaou, Shane, Cherkas & Spector, 2008b)
 (Salter, 2008)
 (Frank, Doll, Oas-Terpstra & Moreno, 2009)
 (Johnson, 2009)
 (Nicolaou & Shane, 2009)
 (Nicolaou, Shane, Cherkas & Spector, 2009)
 (Zhang, Ilies & Arvey, 2009a)
 (Zhang et al., 2009b)
 (Koellinger et al., 2010)
 (Nicolaou & Shane, 2010)
 (Shane, 2010)
 (Shane, Nicolaou, Cherkas & Spector, 2010b)
 (Shane et al., 2010a)
- (Hosoda, Stone-Romero & Coats, 2003)
 (Cawley, 2004)
 (Judge & Cable, 2004)
 (Kunz-Ebrecht, Kirschbaum, Marmot & Steptoe, 2004)
 (Schlotz, Hellhammer, Schulz & Stone, 2004)
 (Ferris, Sinclair & Kline, 2005)
 (Tunceli, Bradley, Nerenz, Williams, Pladevall & Elston Lafata, 2005)
 (Baron, Markman & Bollinger, 2006)
 (Byrne & Hochwarter, 2006)
 (White et al., 2006)
 (Little, Burriss, Jones & Roberts, 2007)
 (Lovelace, Manz & Alves, 2007)
 (Tomasino, 2007)
 (White et al., 2007)
 (Heaphy & Dutton, 2008)
 (Rystedt, Cropley, Devereux & Michalianou, 2008)
 (Wirtz, Siegrist, Rimmele & Ehlert, 2008)
 (Bass & Bass, 2009)
 (Han, Norton & Stearns, 2009)
 (Hansen, Larsen, Rugulies, Garde & Knudsen, 2009)
 (Heraclides, Chandola, Witte & Brunner, 2009)
 (Judge, Hurst & Simon, 2009)
 (Shane, 2009)
 (Sapienza, Zingales & Maestripieri, 2009)
 (Unger, Rauch, Narayanan, Weis & Frese, 2009)
 (Wright, Cropanzano, Bonett & Diamond, 2009)
 (Zyphur, Narayanan, Koh & Koh, 2009)
 (Akinola, 2010)
 (Ilies, Dimotakis & Watson, 2010b)
 (Ilies, Dimotakis & De Pater, 2010a)
 (Mehta & Josephs, 2010)
 (Sundararajan, 2010)
- (Laureiro-Martínez, Brusoni & Zollo, 2010)
 (Lee, Butler & Senior, 2010)
 (Rock, 2010)
 (Senior, 2010)
 (Becker et al., 2011)
 (Boyatzis, 2011)
 (Powell, 2011)
 (Senior, Lee & Butler, 2011)
 (Waldman, Balthazard & Peterson, 2011b)
 (Waldman, Balthazard & Peterson, 2011a)
 (Balthazard, Waldman, Thatcher & Hannah, 2012)
 (Boyatzis et al., 2012)
 (Hills, 2012)
 (Lee, Senior & Butler, 2012a)
 (Lee, Senior & Butler, 2012b)
 (Lindebaum, 2012)
 (Powell & Puccinelli, 2012)
 (Seni, 2012)
 (Volk & Kohler, 2012)
 (Ashkanasy, 2013)
 (Becker & Menges, 2013)
 (Bozionelos & Bozionelos, 2013)
 (Butler, 2013)
 (Cropanzano & Becker, 2013)
 (de Holan, 2013)
 (Halbesleben, Wheeler & Shanine, 2013)
 (Hannah, Balthazard, Waldman, Jennings & Thatcher, 2013)
 (Jack, Boyatzis, Khawaja, Passarelli & Leckie, 2013)
 (Laureiro-Martinez et al., 2014)
 (Lindebaum, 2013a)
 (Lindebaum, 2013b)
 (Lindebaum & Zundel, 2013; Scherbaum & Meade, 2013)
 (Nicolaou & Shane, 2013)
 (Senior & Lee, 2013)
 (Tracey & Schlupeck, 2013)
 (Waldman, 2013)
 (Waldman et al., 2013)
 (Waytz & Mason, 2013)
-

(van der Loos, Koellinger, Groenen & Thurik, 2010)	(Trahms, Coombs & Barrick, 2010)	(Ashkanasy, Becker & Waldman, 2014)
(Zhang & Ilies, 2010)	(Voracek & Schicker, 2010)	(Boyatzis, 2014)
(Chaturvedi, Arvey, Zhang & Christoforou, 2011)	(Agerstrom & Rooth, 2011)	(Boyatzis, Rochford & Jack, 2014)
(Li, 2011)	(Guiso & Rustichini, 2011b)	(Cikara & Van Bavel, 2014)
(Nicolaou, Shane, Adi, Mangino & Harris, 2011)	(Guiso & Rustichini, 2011a)	(Foxall, 2014)
(Song, Li & Arvey, 2011)	(Jackson, Madewell & Kennison, 2011)	(Healey & Hodgkinson, 2014)
(van der Loos et al., 2011)	(Karlson, Eek, Hansen, Garde & Ørbaek, 2011)	(Krueger & Welpe, 2014)
(Cesarini, Johannesson, Magnusson & Wallace, 2012)	(Saphire-Bernstein, Way, Kim, Sherman & Taylor, 2011)	(Lindebaum & Jordan, 2014)
(Chaturvedi, Zyphur, Arvey, Avolio & Larsson, 2012)	(Arvey & Zhen, 2012)	(Lindebaum & Raftopoulou, 2014)
(Judge, Ilies & Zhang, 2012)	(Klofstad, Anderson & Peters, 2012)	(McDermott & Hatemi, 2014)
(Li, Arvey, Zhang & Song, 2012)	(Little & Roberts, 2012)	(McDonald & Tang, 2014)
(Quaye, Nicolaou, Shane & Harris, 2012a)	(Livingston, Rosette & Washington, 2012)	(Spector, 2014)
(Quaye, Nicolaou, Shane & Mangino, 2012b)	(Re, Dzhelyova, Holzleitner, Tigue, Feinberg & Perrett, 2012)	(Volk & Becker, 2014)
(Wernerfelt, Rand, Dreber, Montgomery & Malhotra, 2012)	(Sherman et al., 2012)	(Volk, Köhler & Pudelko, 2014)
(De Neve, Mikhaylov, Dawes, Christakis & Fowler, 2013; Meyers, van Woerkom & Dries, 2013)	(Spisak, Homan, Grabo & Van Vugt, 2012)	(Balthazard & Thatcher, 2015)
(Shane & Nicolaou, 2013)	(Spisak, Dekker, Kruger & van Vugt, 2012)	(Basnakova, van Berkum, Weber & Hagoort, 2015)
(van der Loos et al., 2013b)	(Spisak, 2012)	(Becker, Volk & Ward, 2015)
(Zyphur, Zhang, Barsky & Li, 2013)	(Ganster & Rosen, 2013)	(Boyatzis, Rochford & Taylor, 2015)
(Kong, 2014)	(Li & Xie, 2013)	(Case & Oetama-Paul, 2015)
(Spain & Harms, 2014)	(Re, DeBruine, Jones & Perrett, 2013)	(Coetzer, 2015)
(Colarelli & Arvey, 2015)	(Ronay & Carney, 2013)	(Friedman, Jack, Rochford & Boyatzis, 2015)
(Dimotakis & Schatten, 2015)	(Scherbaum & Meade, 2013)	(Jackie, 2015)
(Li, Wang, Arvey, Soong, Saw & Song, 2015)	(van der Loos et al., 2013a)	(Jiang et al., 2015)
(Lindquist et al., 2015)	(White, Kenrick & Neuberg, 2013)	(Kawasaki et al., 2015)
(Schermer, Johnson, Jang & Vernon, 2015)	(Alrajih & Ward, 2014)	(Laureiro-Martínez, Brusoni, Canessa & Zollo, 2015a)
	(Arvey, Wang, Song & Li, 2014)	(Laureiro-Martínez, Venkatraman, Cappa, Zollo & Brusoni, 2015b)
	(Christian, Eisenkraft & Kapadia, 2014)	(Massaro, 2015)
	(Doll et al., 2014)	(Molenberghs, Prochilo, Steffens, Zacher & Haslam, 2015)
	(Greene, Han, Martin, Zhang & Wittert, 2014)	(Senior, Lee & Braeutigam, 2015)
	(Gundemir, Homan, de Dreu & van Vugt, 2014)	(Verheul, Block, Burmeister-Lamp, Thurik, Tiemeier & Turturea, 2015)
	(Little, 2014)	(Waldman & Balthazard, 2015b)
	(Olivola, Eubanks & Lovelace, 2014)	
	(Re & Perrett, 2014)	

(Shane & Nicolaou, 2015b)	(Arvey & Zhang, 2015)	(Waldman & Balthazard, 2015a)
(Zyphur, Li, Zhang, Arvey & Barsky, 2015)	(Bendahan, Zehnder, Pralong & Antonakis, 2015)	(Butler, O'Broin, Lee & Senior, 2016)
(Arvey et al., 2016)	(Vongas & Al Hajj, 2015)	(Cropanzano, Massaro & Becker, 2016)
(Belsky et al., 2016)	(Schipper, 2015)	(Dulebohn, Davison, Lee, Conlon, McNamara & Sarinopoulos, 2016)
(Chi, Li, Wang & Song, 2016)	(Unger, Rauch, Weis & Frese, 2015)	(Healey, Hodgkinson & Massaro, 2016)
(Clark, Barney & Reddington, 2015)	(Klofstad, Anderson & Nowicki, 2015)	(Hoffman, 2016)
(Hahn, Gottschling, König & Spinath, 2016)	(Bönte, Procher & Urbig, 2015)	(Lindebaum, 2016)
(Li, Stanek, Zhang, Ones & McGue, 2016b)	(Diebig, Bormann & Rowold, 2016)	(Niven & Boorman, 2016)
(Li, Zhang, Song & Arvey, 2016a)	(Gielen, Holmes & Myers, 2016)	(Robertson, Voegtlin & Maak, 2016)
	(Klofstad, Nowicki & Anderson, 2016)	(Rochford, Jack, Boyatzis & French, 2016)
	(Manville, Akremi, Niezborala & Mignonac, 2016)	(Thurik, Khedhaouria, Torrès & Verheul, 2016)
	(Nickson, Timming, Re & Perrett, 2016)	(Verheul, Rietdijk, Block, Franken, Larsson & Thurik, 2016)
	(Overskeid, 2016)	(Waldman et al., 2016a)
	(Re & Rule, 2016a)	(Wiklund, Patzelt & Dimov, 2016)
	(Re & Rule, 2016b)	(Waldman, Ward & Becker, 2016b)
	(Re & Rule, 2016c)	(Butler, Lee & Senior, 2018)
	(Sherman, Lerner, Josephs, Renshon & Gross, 2016)	(Braeutigam, Lee & Senior, 2017)
	(van der Meij, Schaveling & van Vugt, 2016)	(Waldman, Wang, Hannah & Balthazard, 2017)
	(Zak & Winn, 2016)	
	(Nicolaou et al., 2017)	
	(Silberzahn & Menges, 2016)	

2.5. RESULTS

The results of our review show that the biological perspective has been studied in a number of subfields of management (see table S-3 in the appendix below). We show key journals contributing to the review in terms of their coverage of this area in figure S-1 in the appendix below. The review shows that 56% of the studies are empirical and 44% are conceptual. The majority of retrieved articles focused on neuroscience (115 papers), followed by physiology (109 papers), and genetics (77 papers). There are also two book chapters focusing on neuroscience, two book chapters as well as a full book investigating the role of genetics in management, and one book examining the different biological predispositions to organizational behavior.

2.5.1. Findings of Genetics

A large number of the studies on the biological perspective focused on the role of genetics in management. In this review, we define research on genetics as the set of studies that examine the influence of factors that “are encoded in DNA and transmitted biologically” (Nicolaou & Shane, 2009, p. 2) on management behavior. Management scholars have sought to examine the genetic predispositions to management through two methods: a quantitative genetics approach and a molecular genetics approach. Our review shows that 77% of the genetics studies in management took a quantitative genetics approach, while 23% adopted a molecular genetics approach.

Quantitative genetics. The quantitative genetics approach identifies the relative proportion of the variance in a variable and the covariance between multiple variables that can be attributed to genetic and environmental differences (Plomin, DeFries, Knopik & Neiderhiser, 2012). With this approach, researchers have been able to disentangle the contributions of genes and environment across a wide variety of organizational phenotypes using experiments of nature, specifically, studies of twins, and experiments of nurture, particularly, studies of adoptees (Shane & Nicolaou, 2015a). In addition, this approach has recently started to examine how the relative contributions of genetic and environmental factors can change over time (Arvey et al., 2016; Li et al., 2016b).

The classical twin design compares the phenotypic resemblance between pairs of monozygotic and dizygotic twins to examine whether the phenotype is heritable (Polderman et al., 2015). A failure to detect differences between monozygotic and dizygotic twin pairs' resemblance in a phenotype would indicate that genetic factors do not play any role in explaining the variance of this phenotype. But if the resemblance between monozygotic twins is higher than the resemblance between dizygotic twins, then genetic factors influence this phenotype (Nicolaou et al., 2008a). This natural experiment draws on the fact that monozygotic twins are developed from one ovum fertilized by one sperm, unlike dizygotic twins who are developed from two ova fertilized by two different sperms. As a result, monozygotic twins are genetically identical and dizygotic twins share, on average, 50% of their segregating genetic makeup (Plomin et al., 2012).

Studies of adopted children also enable researchers to examine the heritability of organizational phenotypes. Adopted children carry the genes of their biological parents and are exposed to the environment of their adoptive parents. The phenotypic resemblance between children and their two sets of parents indicates the extent to which this phenotype is inherited. If there is a phenotypic resemblance between children and their biological parents, then genetic factors influence this phenotype. Meanwhile, if there is a phenotypic resemblance between the children and their adoptive parents, then environmental factors affect this phenotype. By comparing both correlations, researchers can examine the extent to which genetic and environmental factors influence management phenotypes.

Twin studies have demonstrated that there are genetic predispositions to numerous management phenotypes, such as the tendency to engage in entrepreneurship (Nicolaou et al., 2008a; Nicolaou et al., 2009; Shane et al., 2010b; Zhang et al., 2009b), opportunity recognition (Nicolaou et al., 2009; Shane et al., 2010a), leadership role occupancy (Arvey et al., 2006; Arvey et al., 2007; Johnson et al., 1998; Li et al., 2012), leadership emergence (Chaturvedi et al., 2012; Ilies et al., 2004), transformational leadership (Chaturvedi et al., 2011), job demands, job control, social support at work, job complexity (Li et al., 2016a), behavioral anomalies (Cesarini et al., 2012), income (Zyphur et al., 2015) and job satisfaction (Arvey et al., 1989; Hahn et al., 2016; Ilies & Judge, 2003; Judge et al., 2012) (see figure S-2 in the appendix below). Three studies used samples of adoptees to show the heritability of an organizational phenotype, respectively, vocational interests (Betsworth et al., 1994), occupational status (Scarr & Weinberg, 1994), and entrepreneurial tendencies (Lindquist et al., 2015).

The findings of the quantitative genetics research have shown that genetic factors can explain, on average, the variances of organizational phenotypes in a range from 20% to 60%. In addition, most of the work suggests that shared environmental factors (environmental influences that twins in the same family have in common) account for negligible amounts of variances in organizational phenotypes, unlike unique environmental factors (environmental effects that differ from one twin to another) which were found consistently to be very influential. Simply put, the most important factor affecting the organizational phenotypes that people display is the non-shared environment, followed by their genetics.

Although studies of twins and adoptees have been successful in revealing the genetic influences on organizational phenotypes, these methods do not detect the specific genetic variants that contribute to the variations in these phenotypes. For that, researchers must conduct molecular genetics studies.

Molecular genetics. The molecular genetics approach provides two powerful methods for identifying the specific genetic variants that influence organizational phenotypes: candidate-gene and genome-wide association (GWA) methods. The candidate gene approach is a hypothesis-driven design in which certain genes are, a priori, hypothesized to influence the variable under examination. Candidate-gene studies propose that a particular gene influences management based on its function. For instance, if genes influence certain physiological patterns associated with management phenotypes, researchers can hypothesize that these predictor genes can affect their associated management phenotypes (Munafò, 2006).

Studies using the candidate-gene method have shown that the dopamine receptor genes are associated with entrepreneurship (Nicolaou et al., 2011), leadership (Li et al., 2015), job changes (Chi et al., 2016), job satisfaction (Song et al., 2011), and exploration and exploitation (Frank et al., 2009). Further evidence has also shown that the serotonin transporter genes are associated with corporate corruption (Kong, 2014) and job satisfaction (Song et al., 2011). The long-repeat polymorphism of the AVPR1a RS3 microsatellite was also associated with entrepreneurship (Wernerfelt et al., 2012).

On the other hand, the genome-wide approach is a hypothesis-free design that involves investigating the entire genome (Koellinger et al., 2010; Yeo, 2011). It uses microarrays to genotype millions of single nucleotide polymorphisms (SNPs) on small chips in order to locate the genetic variants influencing organizational phenotypes (Plomin et al., 2012; Shane & Nicolaou, 2015a).

Increasingly, researchers are turning to genome-wide association studies (GWASs) to identify the genetic variants affecting management (Koellinger et al., 2010; Quaye et al., 2012b; van der Loos et al., 2010; van der Loos et al., 2013b) because genetic research has shown that (a) GWASs are better than candidate gene studies in detecting very-small-effect-size genes expected for complex phenotypes in management without pre-hypotheses, and (b) they perform better in dealing with the polygenic nature of management phenotypes, where most phenotypes are influenced

by a large number of genes rather than by a single gene. For example, in a GWAS, researchers have found an association between the rs10791283 of the OPCML gene on chromosome 11q25 and entrepreneurship at the 6×10^{-7} genome-wide significance level, which did not reach the 10^{-8} level of significance required for a GWAS (Quaye et al., 2012b).

The molecular genetic studies show that organizational phenotypes are both polygenic and pleiotropic (Song, Li & Wang, 2015). Polygenic means that a very large number of genes are required to influence an organizational phenotype. For example, Belsky et al. (2016) found that polygenic scores derived from a GWAS predicted economic outcomes. Pleiotropic means that the same gene that influences one variable may also influence another; for example, serotonin transporter genes have been associated with both job satisfaction (Song et al., 2011) and corporate corruption (Kong, 2014).

2.5.2. Findings of Physiology

The second strand of the biological perspective has examined the role of physiology in management. Physiology is “the study of the normal functioning of a living organism and its component parts, including all its chemical and physical processes” (Silverthorn, 2001, p. 2)⁴. In this review, we define research on physiology as the set of studies that examine the relationship between hormones, physical characteristics, medical conditions, and dimensions of management. The systematic review has retrieved a total of 109 papers on physiology and three books/book chapters.

Hormones. The first stream of research in the physiology strand has examined the influence of hormones in management. The most common hormones investigated in the social sciences include: (a) testosterone, (b) dopamine, (c) oxytocin, (d) serotonin and (e) cortisol (Narayanan & Prasad, 2015). However, within the field of management, empirical studies have only looked at two of these five hormones: 25 studies examined testosterone, while 12 studies looked at cortisol⁵. This research has found significant associations between testosterone and numerous organizational

⁴ Although ‘biology’ and ‘physiology’ are sometimes used interchangeably, biology is the study of living organisms, divided into various sub-disciplines, such as anatomy, immunology, microbiology, physiology and neurology (Avila, 1995; Raven, Johnson, Mason, Losos & Singer, 2013).

⁵ Sherman et al (2016) examined the association of both testosterone and cortisol with attained status in male executives.

phenotypes, such as entrepreneurial intention (Bönte et al., 2015), self-employment (Greene et al., 2014; Nicolaou et al., 2017; White et al., 2006), earnings (Gielen et al., 2016), leaders' corruption (Bendahan et al., 2015), entrepreneurial performance (Unger et al., 2009; Unger et al., 2015), perceived empathic accuracy (Ronay & Carney, 2013), and firm performance (Trahms et al., 2010) (see figure S-3 in the appendix below). These findings reveal that testosterone is an important, but often overlooked, factor in explaining power and status in organizations, by driving people's need to acquire additional resources and by stimulating competitive and retaliatory behaviors (Narayanan & Prasad, 2015).

Prior studies have also found a positive relationship between cortisol and work stress (Karlson et al., 2011), and a negative relationship between cortisol and leader's position (Sherman et al., 2012) as well as attained status in male executives (Sherman et al., 2016). The influence of cortisol is "a double-edged sword" in the sense that cortisol may impair people's ability to perform and attenuate overall organizational effectiveness but at the same time increase the likelihood that people attain leadership positions (Diebig et al., 2016, p. 684). Indeed, cortisol research has been rich in providing explanations about how managers handle stress in organizations and why some leaders perform better than others (Diebig et al., 2016; Mehta & Josephs, 2010).

While no research in management has examined the association between management and oxytocin, dopamine or serotonin, some studies have suggested potential relationships. For instance, oxytocin has been associated with self-esteem (Saphire-Bernstein et al., 2011), which is a key predictor of several management phenotypes (Arora, Haynie & Laurence, 2013; Judge & Bono, 2001), including entrepreneurship and job satisfaction. In another example, dopamine has been associated with sensation seeking (Nicolaou et al., 2011), which is associated with entrepreneurship (Nicolaou et al., 2008b).

Physical characteristics. The second stream of research in the physiology strand has examined the role of physical characteristics in management. Physical characteristics include "height, weight, physique, athletic, prowess, energy and energy level" (Arvey et al., 2014, p. 12). The systematic review has retrieved 33 empirical papers and 10 conceptual papers linking physical characteristics to management.

Empirical evidence has shown that physical characteristics, including physical attractiveness and facial cues, influence management phenotypes, such as entrepreneurial performance (Baron et al., 2006) and leadership (Alrajih & Ward,

2014; Doll et al., 2014; Little, 2014; Little et al., 2007; Re et al., 2013; Re & Perrett, 2014). Researchers have also found a relationship between body weight (Agerstrom & Rooth, 2011; Cawley, 2004; Re et al., 2012) and voice (Klofstad et al., 2015; Klofstad et al., 2012; Klofstad et al., 2016) and various organizational phenotypes. For instance, Re et al. (2012) found that there is a negative relationship between leadership and body weight, explaining that a higher body mass index (BMI) raises negative perceptions about leaders' abilities, which in turn influences their leadership. Klofstad et al. (2015) found that individuals with lower-pitched voices are perceived as strong, competent, and having high physical prowess and thus more likely to be selected as leaders than their counterparts.

The most studied physical characteristics were facial cues (19 studies), followed by body weight (seven studies). Facial cues and attractiveness were frequently related to leadership (Alrajih & Ward, 2014; Little, 2014; Little et al., 2007; Olivola et al., 2014), while body weight was related to hiring, earnings, and leadership. Other work has linked management-related phenotypes, including employment, leadership, and job satisfaction to mouth width (one study), body image (one study), skin color (two studies), voice pitch (two studies), and height (three studies).

Medical conditions. The third stream of research in the physiology strand has examined the role of medical conditions in management, including cardiovascular factors, diabetes and musculoskeletal conditions. The systematic review has retrieved 20 empirical and nine conceptual papers. For instance, blood pressure (Ganster & Rosen, 2013; Ilies et al., 2010b; Lundberg & Frankenhaeuser, 1999; Melin et al., 1999), cardiovascular problems (Ganster et al., 2001; Ganster & Rosen, 2013; Matteson & Ivancevich, 1979; Schaubroeck et al., 1994; Schaubroeck & Merritt, 1997; Steffy & Jones, 1988), pain fluctuations (Christian et al., 2014), and musculoskeletal disorders (Manville et al., 2016) were associated with workload, work stress and other occupational outcomes.

The most studied medical conditions were heart problems (20 studies), which were mostly associated with occupational and workplace factors. Other work has linked management-related phenotypes to diabetes (two studies), occupational injuries (one study), and musculoskeletal disorders (one study). In combination, these findings reveal the role of medical conditions in influencing several work outcomes, including career choices, workload, job satisfaction, and income.

2.5.3. Findings of Neuroscience

The third strand of the biological perspective focuses on the relationship between neuroscience and management (Hannah et al., 2013; Waldman et al., 2011a). This strand examines “how neuroscience can broaden our understanding of people at work and organizing processes” (Waldman et al., 2016b, p. 9.2). “It involves the study of processes within the brain that underlie or influence human decisions, behaviors, and interactions either (a) within organizations or (b) in response to organizational manifestations or institutions.” (Butler & Senior, 2007b; Ward, Volk & Becker, 2015, p. 19). This is the most prominent area of the biological perspective as evidenced by the number of studies identified in our review (115 papers).

Although scholars in entrepreneurship (de Holan, 2013; Nicolaou & Shane, 2013), leadership (Hannah et al., 2013), human resource management (Becker et al., 2015) and other management areas (Becker et al., 2011; Butler et al., 2016) have started to recognize the value of neuroscientific methods to organizational disciplines, it is surprising that we know very little about the role of neuroscience in management, as the literature is mainly conceptual: out of the 115 retrieved studies, we found 25 empirical articles incorporating neuroscience into management research.

Nevertheless, the empirical papers do show some patterns. Researchers have found that people with attention deficit hyperactivity disorder (ADHD) (Thurik et al., 2016; Verheul et al., 2015; Verheul et al., 2016; Wiklund et al., 2016) and dyslexia (Logan, 2009) have a higher tendency to engage in entrepreneurial activities⁶.

Other empirical studies have shown several associations between neurological activations in the brain and management. For instance, Dulebohn et al. (2016) found that the activations of the insula, ventral striatum, ventromedial prefrontal cortex and anterior cingulate cortex regions of the brain are associated with procedural justice, while the activations of the dorsal medial prefrontal cortex and the precuneus/posterior cingulate regions are related to distributive justice, with these findings varying from males to females.

In leadership, Waldman et al. (2011a) found that the right frontal coherence is associated with the formation of a socialized visionary communication, which in turn builds followers’ perceptions of the leader’s inspirational capabilities. In another

⁶ ADHD is a “neurodevelopmental disorder characterized by attention-deficit and hyperactivity” (Verheul., 2016: 793).

leadership study, Boyatzis et al. (2012) found that recalling experiences with resonant leaders was associated with the activation of regions such as the bilateral insula, right inferior parietal lobe, and left superior temporal gyrus, while recalling experiences with dissonant leaders limited the activations of the right anterior cingulate cortex and positively activated the right inferior frontal gyrus, bilateral posterior region of the inferior frontal gyrus, and bilateral inferior frontal gyrus/insula. Other quantitative electroencephalography (qEEG) findings have shown that being exposed to an inspirational leader activates the bilateral rostral inferior parietal lobule, pars opercularis, and posterior midcingulate cortex, while being exposed to a non-inspirational leader activates the medial prefrontal cortex (Molenberghs et al., 2015).

Researchers have also demonstrated that the lateral occipital cortex, superior temporal cortex, medial parietal, subgenual cingulate, nucleus accumbens, and left lateral prefrontal cortex are activated by affect that may be provided by inspirational coaching and mentoring (Jack et al., 2013). Hannah et al. (2013) also found that a lower level of EEG coherence in the alpha frequency range in the frontal lobes is associated with greater adaptive decision-making, suggesting that both the frontal lobes in the brain and the adaptive decision making are related to leader self-complexity. Other evidence has shown a significant correlation between job demand and oxygenated hemoglobin changes in the left dorsolateral prefrontal cortex in females, while greater changes in the right temporal cortex were observed among males (Kawasaki et al., 2015). Moreover, Waldman et al. (2017) found that the interaction of leader relativism and idealism partially mediates the influence of the brains' default mode network on ethical leadership.

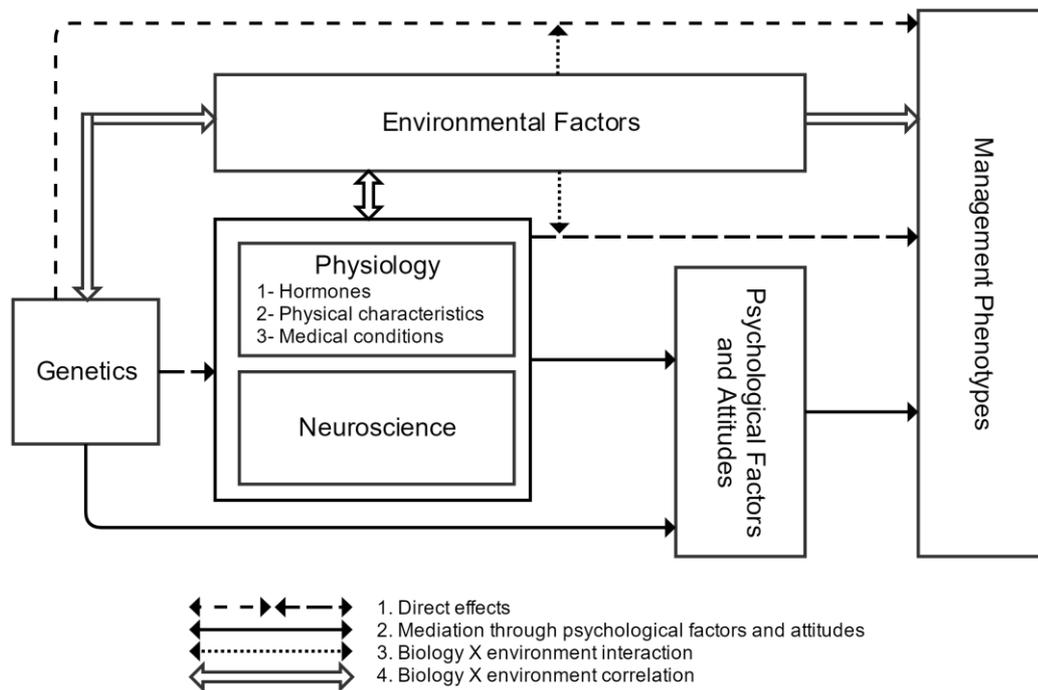
In entrepreneurship, using functional magnetic resonance imaging (fMRI), researchers found that entrepreneurs showed higher decision-making efficiency, and a stronger activation in regions of frontopolar cortex than managers (Laureiro-Martinez et al., 2014). Activations of the ventral tegmental area, substantia nigra, ventral striatum, nucleus accumbens, and ventro medial prefrontal cortex brain regions were associated with exploration. On the other hand, activations of the dorsolateral prefrontal cortex, locus coeruleus-norepinephrine circuit, frontopolar cortex and inferior parietal lobule were associated with exploitation (Laureiro-Martínez et al., 2015a).

2.6. MECHANISMS

In this section, we explain the mechanisms through which biological factors may affect management: direct effects, mediation through psychological factors and attitudes, biology X environment interactions, biology X environment correlations, interactions within biological strands and interactions between biological strands. The overall pattern is presented in Figure 2.

Figure 2

Theoretical Framework⁷



2.6.1. Direct Effects

Biology may directly influence management. For instance, blood pressure problems, increased heart rate, immune system disorders and coronary heart diseases may result in poor productivity and high job turnover rates (Ganster & Rosen, 2013; Zhang & Zyphur, 2015). Evidence also indicates that genetic factors may act as antecedents to other biological factors that influence management. Nicolaou and Shane (2009) argued that genetic factors may affect hormones, brain functions, and appearance, which in turn influence management. For instance, researchers have

⁷ The figure draws from Arvey and Bouchard (1994) and Arvey et al. (2014) and focuses only on biological influences on management. There are also interactions between biological factors such as gene X gene interactions and hormone X hormone interactions that are not described in the diagram

suggested that genetically influenced testosterone may influence the tendency of people to engage in entrepreneurship (Shane & Nicolaou, 2015a; White et al., 2006; Zhang & Zyphur, 2015). In physiology, Zhang and Zyphur (2015) have indicated that variations in hormone levels are related to cardiovascular processes and changes in the functioning of the immune system which may affect work outcomes, such as burnout and productivity.

2.6.2. Mediation through Psychological factors and attitudes

Biology may influence management through psychological factors and attitudes. In genetics, research has shown that genes may influence entrepreneurship, leadership, vocational interests, work values, job switching, and job satisfaction by affecting individual attributes, such as psychological traits, attitudes, and preferences (Arvey et al., 2016; Shane & Nicolaou, 2015a). Numerous studies have shown that neuroticism, extraversion, conscientiousness, openness to experience, agreeableness (Shane et al., 2010a, b; Zhang et al., 2009b), proactivity (Li, 2011), rule breaking (Li et al., 2015) and cognitive abilities (Arvey et al., 2006; Chaturvedi et al., 2011; Schermer et al., 2015; Shane & Nicolaou, 2015b) mediated the relationships between genes and organizational phenotypes.

In physiology, researchers have suggested, for instance, that hormones may influence people's attitudes toward competition, fairness, and trust which in turn affect organizational decision making (Narayanan & Prasad, 2015). There is also some evidence that hormones affect people's choice to become entrepreneurs. White et al. (2006) found that testosterone influences the tendency of individuals to become self-employed through risk taking. In line with this evidence, Bönnte et al. (2015) indicated that the relationship between prenatal testosterone exposure and entrepreneurial intention is mediated by both general risk taking and domain-specific risk taking (e.g., professional career and financial investment).

Consistently, researchers have shown that positive affect mediates the effect of entrepreneurs' physical attractiveness on the evaluation of their ideas (Baron et al., 2006). Similarly, several scholars have found that facial cues influence people's beliefs which in turn affect leadership choice, and occupational success. For instance, Little (2014) suggested that leaders are partly chosen based on their faces as people believe that certain facial cues reflect specific abilities that are well suited for particular leading positions.

In neuroscience, Hannah et al. (2013) have suggested that the influence of the frontal lobes of the brain on leadership adaptability may be mediated by leaders' psychological self-complexity. In another recent qEEG study, Waldman et al. (2017) found that the role of brains' default mode network in predicting ethical leadership may be mediated by the interaction of leader relativism and idealism.

2.6.3. Biology X Environment interactions

The biological influence on management may be contingent on the presence of environmental factors. In genetics, research has labeled this pathway as gene X environment interaction (Rowe, 2003). Researchers, for instance, have found that genetic factors interact with social environment to influence the tendency of people to occupy leadership roles (Zhang et al., 2009a) and that unfavorable family environment in childhood lowers the genetic influence on entrepreneurship in adulthood (Zhang & Ilies, 2010). Chi et al. (2016) have also demonstrated that early life environments and dopamine genes interact to influence later job changes. Findings indicate that in gene X environment interaction studies, education, family and social environment as well as socioeconomic status interacted with genetic factors to influence various management-related phenotypes, including entrepreneurship (Quaye et al., 2012a), job changes (Chi et al., 2016), and leadership (Zhang & Ilies, 2010; Zhang et al., 2009a).

In physiology, research has indicated, for instance, that the interaction between chronic pain and perceived organizational support influences citizenship behavior, work intensity and effectiveness as well as task performance (Byrne & Hochwarter, 2006). Specifically, higher levels of perceived organizational support decreased the adverse influences of chronic pain on occupational performance.

2.6.4. Biology X Environment correlations

Researchers have suggested that biology may play a role in people selecting particular environments that in turn influence their behavior. This implies that the environment that people face is partly endogenously influenced by their biology. In genetics, this mechanism is called gene X environment correlation (Nicolaou & Shane, 2009). There are three main types of gene X environment correlations: passive, evocative and active (Plomin et al., 2012; Shane & Nicolaou, 2015a). A passive gene X environment correlation occurs when people are exposed to inherited environments

that are compatible with their genetic makeup. This correlation may lead to an association between genetic and environmental factors which in turn influence various organizational phenotypes. For example, a person with “leadership genes” would be more likely to have parents who would provide both the genes and an environment that is supportive of leadership.

An evocative gene X environment correlation suggests that people may evoke reactions from other people on the basis of their genetic tendencies. For instance, people with genes that predispose them to leadership may evoke more positive reactions from people looking for others to lead various projects and organizations.

An active gene X environment correlation demonstrates that people may select or create environments that are compatible with their genetic makeup. For example, a person with genes that predispose them to leadership may engage in situations where leadership is required and develop leadership capabilities through acting as a leader.

Although researchers have explained that genetic and environmental factors may correlate to influence management (Arvey et al., 2016; Lykken et al., 1993; Nicolaou & Shane, 2009; Shane & Nicolaou, 2015a), only one study has found evidence for this mechanism (see table S-4 in appendix below). Specifically, Li et al. (2016a) have suggested that, over time, individuals are gravitated to jobs with specific environmental conditions to satisfy their genetic makeup.

In physiology, current evidence suggests that environmental factors, particularly job demands and job controls, play a mediating role in the association between individuals’ physiological well-being (i.e. cortisol and cortisone hormone levels as well as cardiovascular problems) and leadership role occupancy (Li & Xie, 2013).

2.6.5. Interactions within Biological strands

The existing literature has also revealed evidence for interactions within biological strands, such as interactions between genes - a mechanism that researchers have labeled gene X gene interactions (Polderman et al., 2015), interactions between hormones – a mechanism labeled hormone X hormone interactions, and interactions between different brain regions. Research, for instance, has suggested that genes may jointly interact to influence management outcomes such as job satisfaction (Song et al., 2011). Researchers have also shown that cortisol and testosterone jointly interact to influence attained status in male executives (Sherman et al., 2016). In another study,

Mehta and Josephs (2010) indicated that high levels of cortisol diminish the influence of testosterone on dominance. Moreover, neuroscience studies have also found that the interactions between the orbitofrontal cortex, the anterior cingulate cortex, and the locus coeruleus may modulate attention, which influences exploration and exploitation decisions (Aston-Jones & Cohen, 2005; Laureiro-Martínez et al., 2010).

2.6.6. Interactions between Biological strands

Different biological strands may also interact to influence management. Epigenetics demonstrates that biological and environmental stimuli may modify genes transcription. Studies have suggested that biological factors, such as hormones and neuroscience, may play a key interactive role in the modification of such genes (Caspi & Moffitt, 2006; Zhang & Meaney, 2010). However, we did not find any studies examining epigenetics in management.

Frank et al. (2009) have also suggested that the dopaminergic genes interact with the prefrontal cortex region of the brain to influence individuals' exploration and exploitation decisions. This relationship is mediated in two steps, first, by the interaction between the striatum region of the brain and reinforcement learning environments and, then, the dopamine hormone which influences exploration and exploitation. Thus, different mechanisms can jointly shape managerial behavior.

2.7. DISCUSSION AND IMPLICATIONS

Our organizing framework (figure 1) highlights the three strands of the biological perspective, shows the constituents of each, and maps the distribution of studies across them. Importantly, this review uncovers several mechanisms (figure 2) through which biology influences management. However, we argue that, to fulfill the potential of this perspective, all aspects must be integrated, something that has not happened to date. As we mentioned, the mechanisms explaining these relationships suggest that biological factors are not mutually exclusive and the mechanisms that govern the influence of one biological factor on management involve other biological factors.

Our review reveals that genetic factors explain more than one-third of the variance in many phenotypes, such as work values (Arvey et al., 1994), creativity (Shane & Nicolaou, 2015b), job switching (McCall et al., 1997), transactional

leadership (Johnson et al., 1998) and the propensity to engage in entrepreneurship (Nicolaou et al., 2008a). The genetic influences are both polygenic and pleiotropic, and the influence of a single genetic polymorphism is very small, reflecting the complex architecture of management phenotypes.

To date, physiological variables have played a peripheral role in the study of management (Zhang & Zyphur, 2015) but as Heaphy and Dutton (2008) argue, management research that does not take into account the role of physiology is incomplete. However, relatively few physiological characteristics and relatively few outcomes have been explored. In addition, the majority of studies in the hormones stream of research have focused on the effects of just one hormone, testosterone, with relatively fewer studies examining the effects of cortisol. Furthermore, there have been no studies examining the effects of oxytocin, serotonin, or dopamine.

A small literature now shows that brain function is associated with managerial behavior, as demonstrated by neuroscience studies in leadership, decision-making, entrepreneurship, and work stress. Studies have also examined the influence of ADHD and dyslexia on managerial outcomes. While relatively few aspects of management have been explored empirically, with leadership being the most prevalent, this literature has provided a “theoretical basis as to the choice of neurological variables that one might incorporate” in the study of neuroscience and management (Waldman et al., 2016b, p. 9.13).

The lack of research in this area is puzzling. We are all biological creatures and our biology affects all aspects of our behavior, including our work. By ignoring our biology, management researchers are missing an important part of the explanation for managerial behavior.

The biological perspective has several theoretical implications. It improves our understanding of how biological factors moderate the influence of environmental factors in influencing work outcomes. It extends existing theories in organizational behavior by identifying how psychological traits and attitudes mediate the influence of biology. It also enhances our understanding of the antecedents of environmental factors, by showing that these are often biologically influenced, a finding called nature of nurture (Arvey et al., 2016; Plomin & Bergeman, 1991).

The biological perspective has some important implications for the practice of management. The biological perspective may affect career coaching and may help organizations provide individualized practices suited to the different distinctive

abilities of their personnel (Arvey et al., 2016; Lawler, 1974; Rousseau, 2005). For instance, drawing on the finding that ADHD has a positive influence on entrepreneurial activities, organizations may encourage people with ADHD to pursue such careers.

The biological perspective may also deliver insights to policy makers by revealing the environmental factors moderating the biological influences on management. Understanding those factors would allow policy makers to know how to reinforce positive interactions and minimize negative ones.

In addition, by knowing the architecture of physiological conditions, organizations may change various job features to diminish any negative influences at work. For instance, because high workloads increase cardiovascular risks in employees, it might be valuable to identify the job features that attenuate the negative influences of high workloads (Ilies et al., 2010a). This line of research would also have the potential to answer various enquiries in the occupational health and safety literature, such as “the links between occupational health and safety and human resource strategies” (Zanko & Dawson, 2012, p. 340).

The biological perspective may also provide organizations with strategies to maximize corporate venturing activities. For example, researchers found that genetic factors account for 82 percent of the covariance between creativity and the tendency towards entrepreneurship (Shane & Nicolaou, 2015b) and 46% of the covariance between sensation seeking and the tendency to engage in entrepreneurship (Nicolaou et al., 2008b). As environmental factors account for a greater part of the covariance between sensation seeking and entrepreneurship than between creativity and entrepreneurship (e.g. 54% and 18% respectively), efforts to influence sensation seeking would be more effective than efforts to influence creativity in affecting entrepreneurship.

However, several challenges face this area of research. These include (1) the challenges of conducting interdisciplinary research (Bromham, Dinnage & Hua, 2016), (2) the difficulties of generating heritability estimates in the presence of gene-environment interactions and correlations (Arvey et al., 2016), (3) small effect sizes, (4) endogeneity issues, (5) experimental conditions in neuroscientific experiments, and (6) issues of reverse inference in fMRI studies (Poldrack, 2006). Scholars will need to address these issues in their study designs to move our collective understanding of the biological influences on management forward.

2.8. FUTURE RESEARCH DIRECTIONS

Our review suggests several areas for future research. First, more explanatory factors and more outcome variables should be examined empirically. The review shows that research in this area is characterized by being highly conceptual with limited empirical evidence. It is time to further this area of research by conducting more empirical studies.

Second, it is unlikely that much managerial behavior is explained solely by human biology. Because most managerial behavior is likely accounted for by the interaction of human biology and environmental factors, additional research should empirically investigate how environment and biology interplay to influence management. Although research has suggested plausible mechanisms through which these factors jointly influence management, we have little empirical evidence of those interactions.

Third, biological factors are not mutually exclusive and may jointly interact to influence management behavior. Future research should explore those interactions. For example, future research should consider how hormones mediate genetic predispositions and in turn trigger physiological effects to influence management. Similarly, studies should explore how genes interact with environmental factors, such as occupational threat, stimulating the hypothalamic pituitary adrenal axis to trigger the stress hormone “cortisol,” which, in turn, may affect managerial outcomes, such as leadership. Finally, future genetics work should draw from neuroscience research for the formulation of gene-environment interaction hypotheses (Caspi & Moffitt, 2006).

Fourth, additional research on the psychological factors and attitudes that mediate the relationship between biology (genetics, physiology and neuroscience) and management is encouraged. Additional mediators can advance our understanding of the theoretical mechanisms through which the influence of biological factors on management is manifested.

Fifth, researchers should incorporate epigenetics into the study of the biological perspective. Numerous epigenetics mechanisms have been uncovered over the past decade, such as DNA methylation, DNA hydroxymethylation, and histone modifications like acetylation, phosphorylation, and sumoylation (Zhang & Meaney,

2010). These mechanisms reveal that environmental factors may alter people's genetic, physiological and neurological factors.

Sixth, researchers should think about the effects of biological factors more dynamically. In this domain, few longitudinal studies have been conducted. Longitudinal studies would reveal how biological influences can change over time. For instance, genetic influences on leadership could change with age, given evidence of age-related changes in the heritability of job satisfaction (Li et al., 2016b) and other behavioral measures in the sciences (Bergen, Gardner & Kendler, 2007).

Additional research pertaining to each area is also needed. For example, in genetics, we encourage further research using bivariate and multivariate genetic techniques that explore shared genetic influences between management-related phenotypes. Genome-wide association studies using very large samples are also needed to advance molecular genetic research in management. Nuclear twin family models, which are an improvement over the classical twin model as they incorporate more family information about twins, their parents, and siblings, are also encouraged, as they can provide more accurate parameters for the decomposition of genetic and environmental influences (Zyphur et al., 2013). Studies identifying gene-environment correlations in organizational settings are also needed.

In physiology, research is needed to empirically examine the influence of oxytocin, dopamine, serotonin, and melatonin, as studies in management have only examined empirically the role of testosterone and cortisol. Additional work is also needed to examine how hormones interact with each other, such as the dual hormone hypothesis that emphasized the combined effects of testosterone and cortisol in regulating dominance (Mehta and Josephs, 2010). Future work could also examine physiological responses at the group level, while additional research is required to examine how organizational interventions can moderate the influence of physiological processes on managerial outcomes.

In neuroscience, future research should also incorporate neuroscience techniques into the study of teams. As management outcomes are highly dependent on interactions between individuals, researchers are encouraged to use neuroscience techniques, such as qEEG, to examine interactions between employees, such as interpersonal conflicts and negative/positive affect (Waldman et al., 2016b).

Further research pertaining to each management area including entrepreneurship and organizational behavior is also urged. For instance, in entrepreneurship, work employing a biological perspective is needed to examine topics such as entrepreneurial biases (Zhang & Cueto, 2017, p. 2), fear of failure (Cacciotti, Hayton, Mitchell & Giazitzoglu, 2016), and entrepreneurs' thinking styles, skills and goal commitment (Bönte et al., 2015). In organizational behavior, additional research is needed on the biological underpinnings of human resource management and work design (Arvey et al., 2016) including GWA and fMRI studies.

2.9. CONCLUSION

Much progress has been made in research on the biological perspective over the past years that has enriched our understanding of various organizational phenomena. Yet, many gaps about the underpinnings linking biology to management remain. This review has systematically provided a summary of what has been achieved in this area of research and has offered a number of directions to take the field forward. We hope that this work may inspire additional research in this area to further our understanding of management.

Chapter 3: Birth weight and Self-employment

3.1. ABSTRACT

Does birth weight influence the tendency of people to engage in self-employment? Despite the emerging evidence on the biological underpinnings (i.e. genetic, physiological and neurological) of self-employment, and the large number of studies showing that birth weight has several short- and long-run influences on adult outcomes, there are no studies that examine the potential effect of birth weight on the likelihood of self-employment. We explore for the first time the association between birth weight and the likelihood of self-employment using three samples - two longitudinal datasets and a sample of twins - from Finland, the UK and the USA. After accounting for potential endogeneity with the use of longitudinal designs, two-stage least squares instrumental variable regressions and a twin study design, we find evidence for a curvilinear relationship between birth weight and the tendency to become self-employed. We also propose a mediating psychological mechanism – anxiety – to explain this association and find support for this.

3.2. INTRODUCTION

Self-employment is at the core of countries' initiatives to stimulate economic growth, job creation and employment (Shane, 2003). Many studies have shown that biological factors, such as testosterone (Bendahan et al., 2015; Nicolaou et al., 2017; Unger et al., 2009; Unger et al., 2015; White et al., 2006), cortisol (Wolfe & Patel, 2017b), dyslexia (Logan, 2009), attention-deficit hyperactivity disorder (Wiklund, Yu, Tucker & Marino, 2017b), and obsessive-compulsive personality disorder (Wolfe & Patel, 2017a), influence the tendency of people to become self-employed. Yet, little is known about the influence of early biological factors on self-employment (Nofal, Nicolaou, Symeonidou & Shane, 2018). This study attempts to fill this gap by providing evidence of the impact of birth weight on the likelihood of self-employment.

Birth weight encompasses numerous "biological, genetic and environmental endowments at both family and individual levels" (Conley, Strully & Bennett, 2006, p. 152). It can evoke "a wide spectrum of neurosensory impairments, learning difficulties, behavioral and emotional problems" creating "subtle difficulties in psychosocial functioning" which can in turn influence various behaviors and attitudes (Conley, Strully, Bennett & Bennett, 2003; Schmidt, Miskovic, Boyle & Saigal, 2008, p. e181). Its influence has been examined in a number of literatures. For instance, extant studies in economics suggest that birth weight affects occupational earnings (Behrman & Rosenzweig, 2004; Black, Devereux & Salvanes, 2007; Conley et al., 2006), and human capital accumulation (Figlio, Guryan, Karbownik & Roth, 2014; Iyigun & Owen, 1998). Research in psychology shows that birth weight influences various mental conditions such as attention-deficit hyperactivity disorder (ADHD) (van Mil et al., 2015), dyslexia (Samuelsson et al., 1999), depression (Levine, 2014) and obsessive-compulsive personality disorder (OCPD) (Brander et al., 2016).

In this paper, we argue that birth weight influences the tendency of people to engage in self-employment and that this is mediated through anxiety. We base our argument on research linking birth weight to anxiety and research examining the relationship between anxiety and entrepreneurship. We investigate our hypotheses using two longitudinal cohort studies and a study of twins; the 1966 Northern Finland Birth Cohort (NFBC), the 1958 National Child Development Study (NCDS) and the

National Survey of Midlife Development in the United States (MIDUS). We find a curvilinear relationship between birth weight and the likelihood of self-employment. We also find that anxiety mediates this association.

This paper makes a number of contributions to the literature. First, we contribute to the biological theory of entrepreneurship by highlighting for the first time the effect of birth weight on self-employment. Specifically, our study contributes to the growing body of research on physiology in entrepreneurship and provides another “tie between human physiology and organizational research” (Addoum, Korniotis & Kumar, 2016; Heaphy & Dutton, 2008, p. 137). While existing studies linking organizational research to physiological factors have focused on the effects of hormones and medical characteristics (Nofal et al., 2018), there are no studies examining the role of birth weight in management. Given the central role of birth weight in affecting individuals’ life chances (Conley et al., 2006; Petersen & Aarøe, 2015), we attempt to offer an additional insight into the role of physiology in organizational research by uncovering, for the first time, a significant relationship between birth weight and the likelihood of becoming self-employed. Moreover, in so doing, we respond to the call for more work employing a physiological perspective in entrepreneurship (Shane, 2009) and fill an empirical void recently raised by Nofal et al. (2018, p. 17), who argue that “research in this area is characterized by being highly conceptual with limited empirical evidence”. We also address recent calls in the birth weight literature to examine the influence of birth weight on additional adult outcomes (Figlio et al., 2014).

Second, by studying the mediating role of anxiety in the relationship between birth weight and self-employment, we attempt to explicate the theoretical foundation of the relationship between anxiety and self-employment. Specifically, we show that some people are physiologically more prone to anxiety because of their birth weight and accordingly are less likely to engage in self-employment.

Third, we address various methodological biases and the problem of endogenous findings in the birth weight literature that Conley et al. (2006) raised through the use of instrumental variables (Delis, Gaganis, Hasan & Pasiouras, 2017; Nicolaou et al., 2017), panel (Arvey et al., 2016; Li et al., 2016b) and twin designs (Black et al., 2007; Figlio et al., 2014; Petersen & Aarøe, 2015). Moreover, by

analyzing three samples from three different locations, we respond to research that has inquired whether the effect of birth weight differs heterogeneously across different demographic groups (Behrman & Rosenzweig, 2004; Figlio et al., 2014). Furthermore, in response to Xie, Ho, Liu and Hui (2014) who argue that modeling the effect of birth weight linearly underestimates its influence, we provide evidence for a curvilinear association between birth weight and the likelihood of engaging in self-employment.

3.3. THEORY DEVELOPMENT

A small but growing literature attempts to incorporate biological theory and tools to increase our understanding of entrepreneurship (e.g. Antshel, 2017; Houdek, 2017; Waldman et al., 2017; Wiklund, Yu & Patzelt, 2017a). This literature shows that various biological factors, such as genetics, hormones, and mental conditions, affect the tendency of people to engage in entrepreneurship (Nofal et al., 2018). However, there is no research investigating the role of early life biological factors in entrepreneurship. While this is surprising because of the numerous reported long-term effects of early life biological factors (Sutin, Stephan & Terracciano, 2016), there exist various studies showing that early life biological factors, such as prenatal testosterone, birth weight, and breastfeeding, can have large impact on adult outcomes. In this study, we attempt to expand this literature to the field of entrepreneurship and examine for the first time the relationship between birth weight and the likelihood of self-employment.

A long stream of research has examined the influence of birth weight on short-term and long-term outcomes (Behrman & Rosenzweig, 2004; Black et al., 2007; Nakamuro, Uzuki & Inui, 2013). This evidence is rooted mainly in three domains; psychology, economics, and biology. In psychology, research associates birth weight with various psychological factors, such as ADHD (van Mil et al., 2015), dyslexia (Samuelsson et al., 1999), depression (Levine, 2014) and obsessive-compulsive personality disorder (OCPD) (Brander et al., 2016). In economics, the most investigated factors are occupational earnings, and educational attainment. For example, Figlio et al. (2014) suggest a positive relationship between birth weight and human capital accumulation. Additionally, researchers found evidence of a direct positive effect of birth weight on earnings and wages (Figlio et al., 2014; Miller,

Mulvey & Martin, 2005; Nakamuro et al., 2013). Moreover, several studies found that birth weight is positively associated with educational attainment (Aarnoudse-Moens, Weisglas-Kuperus, van Goudoever & Oosterlaan, 2009; Conley & Bennett, 2000; Grunau, Whitfield & Fay, 2004; Hack, Flannery, Schluchter, Cartar, Borawski & Klein 2002; Nakamuro et al., 2013). In addition, there is evidence that birth weight favorably affects schooling attainment at the majority of birth weight ranges (Behrman & Rosenzweig, 2004). In a study using a sibling and twin design, scholars found that birth weight predicts high school completion and labor force outcomes (Philip, Mark, Randy & Leslie, 2008).

In biology, researchers associate birth weight with various neurological and physiological factors, including hormones and medical characteristics. Endocrinology studies, for instance, suggest that birth weight is inversely linked to the stress hormone “cortisol” (Cho, Su, Phillips & Holditch-Davis, 2015; Phillips et al., 2000; Reynolds et al., 2001). Evidence shows that low birth weight positively influences stress by increasing the activity of the hypothalamic pituitary adrenal axis in the brain to activate the stress hormone cortisol (Narayanan & Prasad, 2015; Reynolds et al., 2001). There is also evidence that birth weight is positively associated with individuals’ testosterone levels (Scaramuzzo, Boldrini, Bertelloni, Parrini, Serino & Ghirri, 2010). Moreover, there is a significant positive relationship between birth weight, hypertension and blood pressure (Lackland, Egan & Ferguson, 2003). However, other evidence suggests that birth weight is inversely associated with blood pressure (Davies, Smith, May & Ben-Shlomo, 2006; Gamborg et al., 2007). Furthermore, neuroscientists report a positive relationship between birth weight and the activation of the parietal lobule in the brain (Narberhaus et al., 2009). Nosarti et al. (2006) also found that birth weight is associated with increased activity in certain regions located in the frontopolar and the dorsolateral prefrontal cortices of the brain.

Existing work shows that many aspects that have been linked to birth weight in the three domains of psychology, economics, and biology contribute to our understanding of who becomes self-employed. For instance, most studies report a significant positive relationship between birth weight and educational attainment (Aarnoudse-Moens et al., 2009; Conley & Bennett, 2000; Grunau et al., 2004; Hack et al., 2002), which may also suggest a positive association between birth weight and the likelihood of becoming self-employed, as educational attainment positively

influences the likelihood of self-employment (Kim, 2007). In addition, research shows that birth weight is positively associated with testosterone (Scaramuzzo et al., 2010), which is positively related to self-employment (Bönte et al., 2015; Greene et al., 2014; Nicolaou et al., 2017; White et al., 2006). Evidence also indicates that both low birth weight people and entrepreneurs might exhibit high levels of ADHD (van Mil et al., 2015; Wiklund et al., 2017b), dyslexia (Logan, 2009; Samuelsson et al., 1999), depression (Hessels, Rietveld, Thurik & van der Zwan, 2018; Levine, 2014) and obsessive-compulsive personality disorder (OCPD) (Brander et al., 2016; Wolfe & Patel, 2017a).

A key concern in the majority of the birth weight literature is the dependence on linear models to examine the influence of birth weight (Xie et al., 2014). Accordingly, researchers have sought to examine the curvilinear influence of birth weight on various outcomes. For instance, van Mil et al. (2015) found that birth weight is curvilinearly correlated with attention and impulsivity problems. In addition, Figlio et al. (2014) found that birth weight is positively related to full-time earnings for people weighing less than 4,000 grams, but this influence tends to decline for people who weighed more.

Therefore, we hypothesize:

Hypothesis 1. There is a curvilinear relationship between birth weight and the tendency to become self-employed.

3.3.1. Birth Weight, Anxiety, and Self-employment

To date, researchers have proposed six main mechanisms through which biological factors may influence the likelihood of self-employment, particularly 1) biological direct effects, 2) mediation through psychological factors and attitudes, 3) biology-environment interactions, 4) biology-environment correlations, 5) interactions within biological strands, and 6) interactions between biological strands (Nicolaou & Shane, 2009; Nofal et al., 2018).

Our theory focuses on the second of these mechanisms. We argue that birth weight may influence the tendency to become self-employed through anxiety. Anxiety is believed to influence all humans' attitudes (Kramer, 1994). Theories of anxiety are categorized as follows: 1) psychoanalytic, 2) learning/behavioral, 3) physiological, 4)

phenomenological/existential, 5) cognitive, and 6) uncertainty-related theories. To our knowledge, in entrepreneurship, researchers have only applied the uncertainty-related theory of anxiety into the study of entrepreneurial outcomes. Research argues that scholars should study anxiety from a physio-cognitive perspective to be more broadly conceived (Strongman, 1995). The physiological theory of anxiety suggests that biological factors, such as the activation of septal-hippocampal system in the brain, underpins anxiety (Gray, 1987; Gray & McNaughton, 2003). The cognitive theory of anxiety demonstrates that the structure and processes of cognitive systems, including short-term and long-term memory systems, differentiate between people who are low and high in anxiety (Eysenck, 2013). Both theories attribute anxiety to our biology; however, the latter assumes that the influence of biological factors on anxiety is dynamic and varies from one time to another.

Because anxiety is at least partially a physiological and cognitive process (Strongman, 1995) and birth weight encompasses individuals' cognitive systems in childhood and adulthood (Pearce, Mann, Singh & Sayers, 2014; Shenkin, Starr & Deary, 2004), we argue that the influence of birth weight on the likelihood of self-employment is mediated by anxiety. In the next section, we review research linking birth weight to anxiety and studies examining the relationship between anxiety and entrepreneurship.

Birth weight and anxiety. Research demonstrates that anxiety, fear, and worry are commonly used interchangeably to describe the same emotional state (Cacciotti & Hayton, 2015). Birth weight scholars demonstrate that people who weighed less at the time they were born are more likely to become anxious and depressed in stressful environments (Ian, Anushka, Kiyuri & Ryan, 2012; Schetter & Tanner, 2012). Studies also indicate that low birth weight people are more likely to have higher cortisol levels (Phillips et al., 2000), and are thus more prone to stress and anxiety about the future (Ian et al., 2012). Further research also shows a U-shaped relationship between birth weight and perceived stress reactivity, with increased levels of stress reactivity present at the lower and upper extremes of birth weight (Schlotz & Phillips, 2013). Schmidt et al. (2008) also found evidence of a significant association between low birth weight and anxiety, which in turn may negatively affect the likelihood of self-employment.

Anxiety and self-employment. On the other hand, in entrepreneurship, anxiety is commonly investigated as a psychological factor inhibiting engagement in entrepreneurial outcomes (Wiklund et al., 2017b). For instance, researchers suggest that anxiety negatively influences the tendency of people to engage in entrepreneurial activities (Welppe, Spörrle, Grichnik, Michl & Audretsch, 2012). Recent literature argues that anxiety triggers feelings of uncertainty, which in turn causes procrastination and therefore decreases the tendency to engage in entrepreneurship (Frese & Gielnik, 2014; Wiklund et al., 2017b). Studies also show that the stress hormone cortisol negatively influences the tendency to become self-employed (Wolfe & Patel, 2017b). Based on this evidence, we propose a relationship between birth weight and the tendency to engage in self-employment that is mediated by anxiety. Hence, we hypothesize that:

Hypothesis 2. Anxiety mediates the relationship between birth weight and the tendency to become self-employed.

3.4. METHODS

To test our hypotheses, we use three studies, two longitudinal ones and a study of twins, drawn from three different locations; Finland, the UK, and USA. We use the NFBC, the UK NCDS, and the National Survey of MIDUS 1. In the first two studies, we track individuals longitudinally; while in the second study we also adopt a two-stage least squares instrumental variable regression which allows us to overcome potential endogeneity issues that may distort results. To further alleviate concerns about endogeneity, in the third study we adopt a study of twins that acts like a quasi-experiment by employing “within-twin” and “correlated random effect” estimators. We present our three studies in turn.

3.4.1. Study 1

The first study examines the influence of birth weight on the tendency to become self-employed using the NFBC dataset. The NFBC is an epidemiological and longitudinal program that was initiated to examine the risk factors involved in preterm births and intrauterine growth retardation and the consequences of such adverse outcomes on consequent morbidity. The program has witnessed a broader shift in the past decade, where scholars have used the NFBC to examine various genetic and physiological influences on broader outcomes, such as scholastic performance, stress,

investments, and others. The NFBC1966 is one of two longitudinal studies provided by the NFBC, comprising 12,231 individuals born in 1966 in two provinces in Finland namely Oulu and Lapland, with few people born towards the end of 1965 and early in 1967. Both individuals and their parents were followed at certain time intervals across a period of over 40 years through medical tests, parental surveys and observations as well as self-reported surveys, to assess individuals' welfare, health, behavior, work and social background. The details are available at <https://www.oulu.fi/nfbc/node/18080>.

Measures

Self-employment: Employment status was surveyed by asking about “which of the following alternatives describes best your current work situation?” The alternatives included different occupational categories, such as entrepreneur, full-time work, and part-time work (Lankila, Näyhä, Rautio, Koironen, Rusanen & Taanila, 2013). The dataset includes this information from 1982 to 2011. We constructed our binary outcome by coding those who identified themselves as entrepreneurs as one and those who were affiliated with other occupational categories as zero.

Birth weight: Birth weight is measured in grams at the time of birth. For consistency across our studies, we convert the grams into kilograms by dividing the values by 1000.

Anxiety: Following Ekelund, Johansson, Järvelin and Lichtermann (2005), we measure anxiety using the psychobiological model of temperament and character, specifically the temperament dimension of “harm avoidance”. This dimension consists of 4 subscales; 1) anticipatory worry and pessimism, 2) fear of uncertainty, 3) shyness with strangers and 4) fatigability (Cloninger, Svrakic & Przybeck, 1993). At the age of 31, individuals answered 35 binary items in Finnish. To ensure the equivalence of the Finnish scale to the original English scale, we asked a Finnish translator to typically match the Finnish items to their corresponding items in English. Only 34 items were matched, and accordingly, we drop 1 item. A value of 1 is allocated to responses that reflect harm avoidance and a value of zero is given to other responses. We calculate the total scores for harm avoidance by adding the outcome scores of all items (Cloninger, Przybeck & Svrakic, 1994).

Controls: Socioeconomic conditions may influence the tendency to become self-employed (Nicolaou et al., 2017) and previous research has found a negative relationship between birth weight and socioeconomic status (Jefferis, Power & Hertzman, 2002). Moreover, parents' education can be used as a proxy to measure the socioeconomic status of the family (Erola, Jalonen & Lehti, 2016). Therefore, we use maternal education as a proxy for socioeconomic status. Because extant studies argue that education may influence the tendency of people to engage in self-employment (Robinson & Sexton, 1994), we also control for the level of education (scale ranging from 1 to 10). In addition, we control for mental and neurological problems assessed by diagnostic reports of any mental disease (a scale from 1 to 4). Furthermore, we control for the potential influence of gender (1= male and 2= female). Finally, because twins can be born smaller than singletons, we control for whether individuals are twins or singletons.

Inclusion and exclusion criteria

Extant empirical evidence shows that researchers have examined different ranges of birth weights. For instance, Broekman et al. (2009) focused on birth weights ranging from 2.5 to 4 kilograms, while Xie et al. (2014) expanded this range by examining birth weights from 1.4 to 5.4 kilograms. Other studies, however, have focused only on low birth weights (e.g. Almond, Chay & Lee, 2005; Behrman & Rosenzweig, 2004). For comprehensiveness, in our study we include low, normal and high ranges of birth weights. However, we exclude very low (<1.5 kg) and very high birth weights (>5.5 kg) to make sure that the respondents in our sample do not suffer from any mental or physical health problems that may prevent them from engaging in self-employment. We determined the cutoff point of very low and very high birth weight by following Sherry, Mei, Grummer-Strawn and Dietz (2003) and Donahue, Kleinman, Gillman and Oken (2010) respectively.

We also follow Gaydosch, Schorpp, Chen, Miller and Harris (2018) and analyze the data using list-wise deletion of missing values, in which cases with incomplete data are excluded. List-wise deletion provides accurate estimations because it deletes cases only from statistical estimations that require the missing information (Roth & Switzer, 1995). This results in a final sample of 6,648 individuals in the curvilinear analysis and 5,111 individuals in the mediation analysis.

Statistical analyses and results

Table 1 presents the correlations. We estimate Pearson, polychoric, and polyserial correlations to capture the continuous and categorical nature of the variables. Table 2 presents the regressions. We employ a logit function because of the binary nature of the outcome. We also use random effect estimation because fixed effect estimation does not apply here as the predictor does not change across time, which means that subtracting the average of birth weight from the reported values of birth weight would have removed the whole variable from the model and subsequently its coefficient would not have been estimated (Stock & Watson, 2014).

Figure 1

Birth weight and Likelihood of Self-employment in Study One

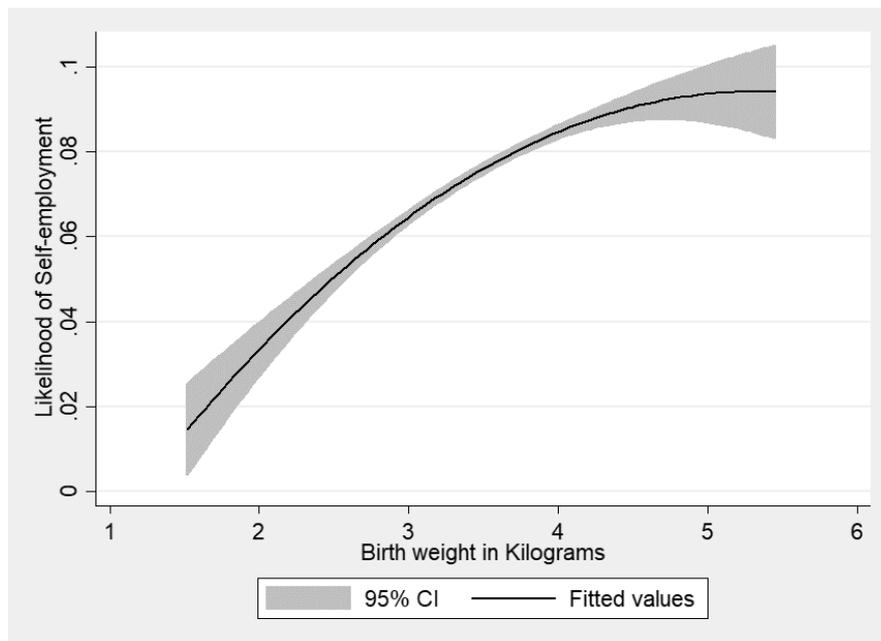


Table 1
Study 1 Correlation Table

	1	2	3	4	5	6	7	8
1- Self-employment	1.00							
2- Birth weight	0.10	1.00						
3- Gender	-0.27	-0.19	1.00					
4- Mental illness	0.03	-0.02	-0.03	1.00				
5- Socioeconomic status	-0.04	0.02	-0.05	0.06	1.00			
6- Educational degree	0.10	-0.00	0.00	-0.02	-0.11	1.00		
7- Anxiety	-0.10	-0.02	0.18	-0.02	0.03	-0.08	1.00	
8- Twin	-0.04	-0.63	-0.10	-0.04	-0.07	0.02	-0.03	1.00

Note: All correlations at or above $|0.01|$ are significant at $p < 0.05$ or below.

We estimate 4 models. In model 1, we run the analysis with the control variables; gender, education, mental illness and socioeconomic status. In model 2, we include birth weight, while in model 3 we add the quadratic function of birth weight to account for the non-linearity expected for the association between birth weight and self-employment. We find a significant curvilinear relationship between birth weight and the tendency to become self-employed (see figure 1). Given that birth weight varies according to gender (Nieves et al., 2005), we also examine the interactive influence of birth weight and gender on self-employment (Schmidt et al., 2008). We find that gender does not play any moderating role in the relationship between birth weight and the tendency to become self-employed.

To examine the mediating role of anxiety, we also estimate a multilevel generalized structural equation model to examine the mediating role of anxiety. Multilevel structural equation models are used to test for mediation and model longitudinal data (Wieseke, Lee, Broderick, Dawson & Van Dick, 2008). We find that anxiety mediates the association between birth weight and the likelihood of self-employment (see table 3).

3.4.2. Study 2

To examine the robustness of our findings, in study 2, we use another longitudinal sample of UK citizens followed over 46 years. We also adopt an instrumental variable approach to rule out any biases that may result from the presence of unobservables. We use the UK NCDS dataset, which monitors the lives of over 17,000 individuals born in 1958 in England, Scotland, and Wales. Initially, this dataset was designed to examine the social and obstetric factors related to stillbirth and infant mortality. Sample units were followed up in 1965 (when individuals were aged 7 years), 1969 (age 11), 1974 (age 16), 1981 (age 23), 1991 (age 33), 1999-2000 (age 41-42), 2004-2005 (age 46-47), 2008-2009 (age 50) and 2013-2014 (age 55) to monitor their health, education, social, economic and biomedical information using paper, electronic and self-reported questionnaires, clinical records, medical examinations, ability tests, physical measurements, educational assessments and diaries. Data is available separately for each wave and we have a total of nine waves. The details are available at: <https://cls.ucl.ac.uk/cls-studies/1958-national-child-development-study/>. We cross-link the last six waves that include self-employment information and wave one which includes the birth weight data (in the first three waves individuals were below 18 years of age).

Table 2
Study 1 Regressions

Outcome: Self-employment	Model 1	Model 2	Model 3
Birth weight		0.32** (4.41)	1.64** (2.45)
Birth weight ²			-0.19** (-1.99)
Gender	-1.31** (-17.68)	-1.26** (-16.89)	-1.27** (-17.05)
Mental illness	0.30* (1.70)	0.31* (1.74)	0.31* (1.74)
Socioeconomic status	-0.05** (-2.62)	-0.05** (-2.64)	0.05** (-2.66)
Educational Degree	0.07** (4.33)	0.07** (4.36)	0.07** (4.40)
Twin	-0.38 (-1.45)	-0.12 (-0.42)	-0.00 (-0.00)
Sample Size	6,648	6,648	6,648

Note: z-statistics in parentheses ** p<0.05, * p<0.1

Table 3**Indirect Effect of Birth weight on the Likelihood of Self-employment in Study 1**

	Path a	Path b	Path c	Path Significance	Overall Indirect Significance
Birth weight →Anxiety	-1.81** (-7.55)			Sig. at p<0.05	
Birth weight ² →Anxiety	0.25** (7.22)			Sig. at p<0.05	
Anxiety → Self- employment		-0.03** (-2.07)		Sig. at p<0.05	
Birth Weight → Self-employment			1.56 (1.16)	Not sig. at p<0.05	Sig. at p<0.05
Birth weight ² → Self-employment			-0.17 (-0.90)	Not sig. at p<0.05	

Note: N= 5,111 individuals. z-statistics in parentheses.

Measures

Self-employment: Self-employed individuals are coded as one and all others as zero.

Birth weight: The weight of individuals at birth is coded on cards and on computers by giving each newborn a serial number and the corresponding birth weight in ounces. We convert the ounces to kilograms by dividing all birth weights by 35.274 to be consistent with the previous study.

Anxiety: We measure anxiety using the teacher-rated Bristol Social Adjustment Guide (BSAG) (Chin, Cumberland, Pujar, Peckham, Ross & Scott, 2011). The BSAG contains 12 items that describe children's psychological distress; these are anxiety, depression, anxiety for acceptance by other children, unforthcomingness, writing off of adults and adult standards, withdrawal, restlessness, inconsequential behavior, miscellaneous nervous symptoms, miscellaneous symptoms, hostility towards adults, and hostility towards other children. Contrary to study 1, our measure captures childhood anxiety. Specifically, at the age of 7, teachers were given 4-page booklets, each containing 250 descriptive statements and were asked to underline statements that best describe each child. The UK NCDS summed the items to form an overall scale of children's psychological anxiety (i.e. the variable used in our study). Extant studies show that the BSAG is a reliable and valid measure of anxiety (Jæger

& Holm, 2012; McDermott, 1980; Montgomery, Cook, Bartley & Wadsworth, 1999; Stansfeld, Clark, Rodgers, Caldwell & Power, 2011).

Controls: We control for individuals' socioeconomic status by asking individuals about their financial status [1: Living comfortably, 2: Doing all right, 3: Just about getting by, 4: Finding it quite difficult, and 5: Finding it very difficult]. We also control for gender [1: male and 2: female], and ethnicity [1: European, Caucasian, 2: African, Negroid, 3: Indian, Pakistani, 4: Other Asian and 5: Other].

Inclusion and exclusion criteria

Consistent with study 1, we limit our analyses to birth weights ranging from 1.5 to 5.5 kilograms. We also use list-wise deletion of missing cases in each analysis. Accordingly, because of the presence of some missing cases, 8,166 individuals contribute to our final non-instrumented quadratic analysis, 3,044 individuals contribute to our two-stage least squares analysis, and 8,166 individuals contribute to our mediation analysis.

Statistical analyses and results

Table 4 lists the Pearson, polychoric, and polyserial correlations to capture the continuous and categorical nature of the different variables. Table 5 presents the regressions - we employ a logit function because of the binary nature of the outcome. We do not use fixed effect estimation because the predictor does not change over time (Wooldridge, 2010). Instead, we use a random effect estimator. In model 1, we run the analysis with the control variables; gender, financial status and whether individuals are twins or singletons. In model 2, we include birth weight, while in model 3 we add the quadratic function of birth weight to account for non-linearity. We find a significant curvilinear relationship between birth weight and the tendency to become self-employed (see Figure 2). We also investigate the interactive influence of birth weight and gender on the tendency to become self-employed. We find that gender does not play any role in the direction nor the shape of the relationship between birth weight and the likelihood of self-employment.

Figure 2
Birth weight and Likelihood of Self-employment in Study Two

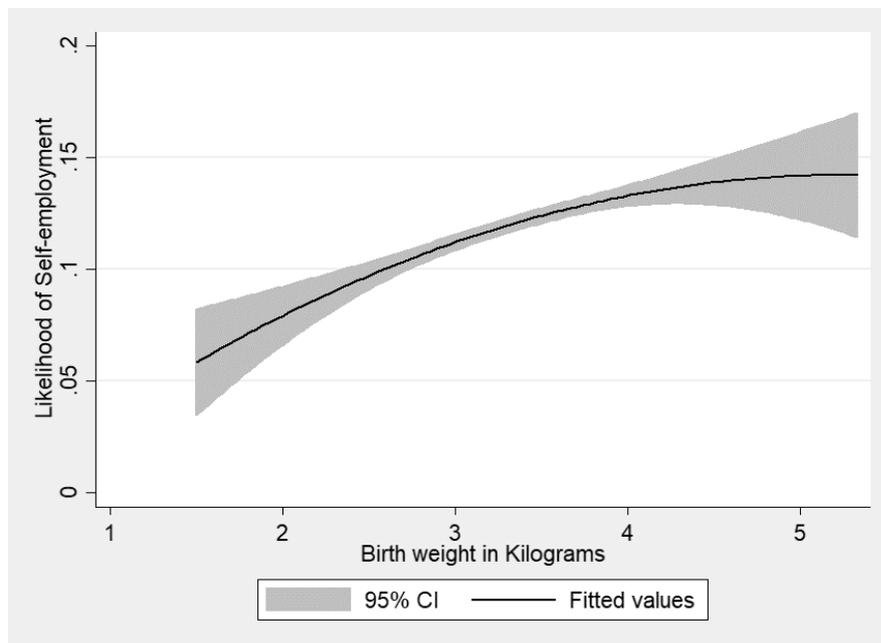


Table 4
Study 2 Correlation Table

	1	2	3	4	5	6	7	8
1- Self-employment	1.00							
2- Birth weight	0.09	1.00						
3- Twin status	0.05	-0.60	1.00					
4- Interval between marriage and birth	-0.04	-0.02	0.03	1.00				
5- Financial status	-0.03	-0.02	0.01	0.05	1.00			
6- Gender	-0.37	-0.18	-0.06	0.03	-0.01	1.00		
7- Ethnicity	0.04	-0.10	0.19	0.28	0.07	-0.07	1.00	
8- Anxiety	-0.02	-0.05	0.11	0.08	0.10	-0.18	0.04	1.00

Note: All correlations at or above |0.02| are significant $p < 0.05$ or below.

To minimize further concerns about endogeneity, we employ a two-stage least squares approach, using two exogenous instruments, the interval between mother's marriage and first birth and twin status. Ideally, our instruments should be i) correlated with birth weight and ii) uncorrelated with the error term. The interval between mother's marriage and first birth has been found to be associated with the use of contraceptives (Beckman, 1978), which have been shown to influence the birth weight of the offspring (Hatch et al., 2015) but not economic outcomes (Ranehill et al., In press), such as self-employment. Evidence suggests that the interval between mother's marriage and first birth shapes mothers' prenatal health by providing family stability which in turn influences the birth weight of the offspring (Kane, 2016). Furthermore, research shows that twins can be born smaller than singletons (Luke & Keith, 1992). However, there is no evidence showing that twin status influences the tendency of people to engage in self-employment. To obtain a meaningful and a valid measure of the interval between mother's marriage and first birth, we follow MacQuarrie (2016) and exclude premarital births from our analyses (i.e. 196 individuals).

Moreover, existing literature suggests that twin status is a credible instrument to examine the influence of birth weight on adult outcomes such as academic performance (Lin, Leung & Schooling, 2017). In addition, research shows that family background variables such as the interval between mother's marriage and first birth can be credible instruments to examine the factors affecting the tendency of people to engage in self-employment (Hoogerheide, Block & Thurik, 2012).

Statistically, we examine the validity of our instruments by checking the Hansen's J-test of over identifying restrictions which tests whether the instruments are correlated with the error term and we found that the two instruments are exogenous (Chi-squared p-value is 0.3483 and J-statistic = 0.880). We also conduct the Cragg-Donald Wald F-test for weak instruments. This test rejects the null of weak identification with F-statistic value equal to 358.48 (>10) (Stock & Watson, 2014) and shows that these instruments are credible instrumental variables for examining the effect of birth weight. Moreover, birth weight is significantly correlated with the two instruments. Thus, we have strong statistical support for our instrumental-variable specification.

Pooled correlated random effects probit regression and two-stage instrumental estimation are two ways to estimate non-linear two-stage least squares models with binary

longitudinal outcomes (Wooldridge, 2010). Because two-stage estimation yields biased standard errors, we use the pooled correlation random effects probit regression in model 4 (Semykina & Wooldridge, 2010). In applying this estimator, it is important to adjust the standard errors to allow for serial correlation across time (Petersen & Aarøe, 2015). To address this issue, we use the cluster-robust standard error option by clustering observations within each cross-sectional identifier (Petersen & Aarøe, 2015; Stock & Watson, 2014). As presented in table 5 in model 4, we find that there is a significant curvilinear relationship between birth weight and the likelihood of self-employment.

In addition, we investigate whether anxiety mediates this relationship using a multilevel generalized structural equation model. We do not use the instruments in the mediation analysis because our instruments can be associated with both birth weight and anxiety. Our findings indicate that anxiety mediates the association between birth weight and the tendency to engage in self-employment (see table 6).

Table 5
Study 2 Regressions

Outcome: Self-employment	Model 1	Model 2	Model 3	Model 4
Birth weight		0.41** (3.85)	2.51** (2.37)	
Birth weight ²			-0.31** (-2.00)	
Instrumented Birth weight				11.40** (8.12)
Instrumented Birth weight ²				-1.88** (-8.49)
Financial status	-0.04 (-0.94)	-0.04 (-0.89)	-0.04 (-0.87)	-0.014 (-1.03)
Gender	-2.52** (-24.26)	-2.47** (-23.48)	-2.47** (-23.38)	-0.39** (-3.25)
Ethnicity	0.20 (0.83)	0.22 (0.91)	0.21 (0.89)	-0.07* (-1.68)
Twin	0.07 (0.20)	0.12 (1.01)	0.52 (1.35)	
Sample Size	8,166	8,166	8,166	7,970

Note: z-statistics in parentheses ** p<0.05, * p<0.1

The number of observations in model 4 are less than the number of observations in the other models because of the missing values in our instruments as well as excluding premarital births.

Table 6**Indirect Effect of Birth weight on the Likelihood of Self-employment in Study 2**

	Path a	Path b	Path c	Path Significance	Overall Indirect Significance
Birth weight →Anxiety	-4.11** (-4.31)			Sig. at p<0.05	
Birth weight ² →Anxiety	0.46** (3.29)			Sig. at p<0.05	
Anxiety → Self- employment		-0.02** (-2.43)		Sig. at p<0.05	
Birth Weight → Self-employment			1.79 (1.37)	Not sig. at p<0.05	Sig. at p<0.05
Birth weight ² → Self-employment			-0.22 (-1.15)	Not sig. at p<0.05	

Note: N= 8,166 individuals. z-statistics in parentheses.

3.4.3. Study 3

Although studies 1 and 2 estimate two panel regressions using two different datasets, omitted variables may still affect the relationship between birth weight and self-employment (Nicolaou et al., 2017). A robust way to address this issue is to investigate the influence of birth weight on the likelihood of self-employment using a twin design. Twin studies control for the effects of all genetic and shared environmental factors, such as family environments, cohort effects, neighborhood effects, enabling us to more accurately test the relationship between birth weight and self-employment (Black et al., 2007; Figlio et al., 2014). Thus, in study 3, we analyze a sample of US twins drawn from MIDUS 1 to examine the influence of birth weight on the likelihood of self-employment. We also investigate the interactive effect of birth weight and age on the tendency to engage in self-employment.

MIDUS is a collaborative, interdisciplinary investigation of the predictors and outcomes of midlife development in different areas, including physical health, psychological well-being, and social responsibility. One part of this dataset provides the first national sample of twin pairs in the USA. A sample of 50,000 individuals was initially screened for the presence of a twin, of which a total of 1,996 twins were

recruited to participate in the study. The details are available at: <http://midus.wisc.edu/>.

Measures

Self-employment: The outcome is measured by asking respondents if they are currently self-employed [1: Yes, 2: No].

Birth weight: Respondents were asked to enter their birth weight in pounds which we convert to kilograms as in the previous two studies.

Anxiety: Interviewers used the International Diagnostic and Statistical Manual of Mental Disorders for the diagnosis of a number of mental conditions such as depression, and generalized anxiety disorder (Keyes, Dhingra & Simoes, 2010). To assess anxiety, we use the derived generalized anxiety disorder score with responses ranging from 0 for the lowest anxiety score to 10 which corresponds to the highest anxiety score.

Controls: We control for financial situation by asking respondents “how would you rate your financial situation these days”. Education levels are assessed by asking about the highest educational degree that individuals had attained. We also control for physical, mental health and self-evaluated health [1: Poor, 2: Fair, 3: Good, 4: Very good, 5: Excellent]. Since monozygotic twins share 100% of their genetic makeup and are born at the same time, we do not control for the potential effect of gender, ethnicity, zygosity, and age in the analyses of monozygotic twins. As the influence of birth weight on adult outcomes may vary across time (Goisis, Özcan & Myrskylä, 2017), we also control for the interactive effect of birth weight and age on the likelihood of self-employment.

Inclusion and exclusion criteria

Consistent with the previous 2 studies, we limit our sample to birth weights ranging from 1.5 to 5.5 kilograms. We also use list-wise deletion of missing cases. Because many people did not report their birth weight, only 240 twins contribute to our final curvilinear model and 225 twins contribute to our mediation analysis. The classification of twins in terms of zygosity in the 240 sample is as follows: 122 monozygotic and 118 dizygotic twins, while the 225 sample comes from 116 monozygotic and 109 dizygotic twins.

Statistical analyses and results

As in the previous 2 studies, table 7 presents the pearson, polychoric, and polyserial correlations to capture the continuous and categorical nature of the different variables. In tables 8 and 9, we employ a logit function using two estimators; the within-twin estimator and the correlated random effect estimator.

Table 7
Study 3 Correlation Table

	1	2	3	4	5	6	7	8	9	10	11	12	13
1- Self-employment	1.00												
2- Birth weight	0.10	1.00											
3- Financial situation	0.01	0.08	1.00										
4- Educational level	0.02	-0.07	0.08	1.00									
5- Gender	-0.25	-0.21	-0.05	-0.15	1.00								
6- Physical health	-0.09	-0.03	0.19	0.30	-0.03	1.00							
7- Mental health	0.08	-0.01	0.27	0.28	-0.17	0.62	1.00						
8- Zygosity	0.02	0.13	-0.02	-0.03	0.15	-0.12	-0.10	1.00					
9- Age	-0.10	0.18	0.14	-0.07	0.07	0.06	-0.07	-0.10	1.00				
10- Number of siblings	-0.02	0.04	-0.01	-0.11	0.01	-0.02	0.01	0.34	-0.06	1.00			
11- Race	-0.09	0.14	-0.14	-0.31	0.20	-0.09	-0.08	-0.01	-0.18	0.29	1.00		
12- Anxiety	-0.23	0.08	-0.07	-0.13	0.63	-0.23	-0.20	-0.05	0.03	-0.05	-0.27	1.00	
13- Self-evaluated health	-0.15	0.05	-0.15	-0.14	0.07	-0.47	-0.33	0.11	-0.08	-0.03	0.06	0.24	1.00

Note: All correlations at or above |0.1| are significant $p < 0.05$ or below.

Within-twin estimation. The within-twin estimator follows the logic of fixed effects. It uses monozygotic twins who share 100% of their genetic makeup and shared environmental influences, including a common familial environment, to subtract the within-twin means for each variable (i.e. self-employment, birth weight and control variables) from their observed values for all twins. This procedure removes all the person-specific error terms that respondents and their twin siblings have in common (Ashenfelter & Rouse, 1998). It controls for all genetic and shared environmental factors between the twins and therefore sex, age, race, number of siblings and zygosity automatically drop out of our estimations. To analyze the dataset using within-twin estimation, twins need to show variations within their self-employment status to be included in the analysis, such that one twin should be self-employed and the co-twin should not. Otherwise, there is no within-twin variation. In other words, if both twins are either self-employed or not self-employed, they are dropped out of the model, resulting in fewer number of observations (i.e. 10 pairs of monozygotic twins). For this reason, only 20 twins contributed to our analysis in models 1, 2 and 3. Controlling for twins' financial situation, level of education, and physical, mental and self-evaluated health, we find a significant relationship between birth weight and the likelihood of self-employment. We increase the sample size by adding dizygotic twins in models 4, 5 and 6 and find similar findings using 39 monozygotic and dizygotic twins (see table 8).

Correlated random effect estimation. To overcome the limitation of the previous approach which drops all the observations that lack within-twins variation in the dependent variable, we employ a correlated random effect estimator that can account for the lack of within-twin variation in the outcome. Extant research demonstrates that the correlated random effect estimator “encompasses the popular fixed effects approach” and “provides useful tests of the validity of strategies using within-family variation” (Elzinga & Gasperini, 2015: 23). However, the assumption of the random effect estimator of no correlation between the error term and birth weight is questionable. We thus follow the methodology adopted by Ashenfelter and Rouse (1998) that replaces the person-specific error terms by the within-twin average of birth weight calculated for each pair of monozygotic and dizygotic twins. This procedure controls for self-selection effects, removes selection biases, and provides less confounded

coefficients (Ashenfelter & Rouse, 1998)⁸. If any of the factors shared between twins confound the influence of birth weight on the tendency to become self-employed, the average of birth weight variable should be able to capture at least 50% of the influences of these unobservables on self-employment (Petersen & Aarøe, 2015).

In models 1, 2 and 3, we use only monozygotic twins. In model 1, we run the analysis with the control variables; mental health, physical health, financial situation, and education. In model 2, we include birth weight, while in model 3 we added the quadratic function of birth weight to account for the expected curvilinear association⁹. We find an insignificant curvilinear relationship between birth weight and the tendency to become self-employed. In models 4, 5 and 6, we re-estimate the 3 models using both monozygotic and dizygotic twins. We also add further controls such as, age, number of siblings, race, gender and zygosity. We replicate the finding of the within twin estimator models and the previous two studies and find a significant curvilinear relationship between birth weight and the tendency to become self-employed (see figure 3). As previously mentioned, because males may have heavier birth weights than females (Nieves et al., 2005), we also examine the interactive influence of birth weight and gender on the tendency to become self-employed. We find that gender does not play any role in the direction nor the shape of the detected association between birth weight and the likelihood of self-employment.

⁸ We also estimated the other model adopted by Petersen and Aarøe (2015) by replacing the average birth weight with birth weight of the co-twin sibling to account for the shared person-specific error terms and we obtained the same results.

² Unlike the within twin estimator models, the correlated random effects models do not control for self-evaluated health because of the many missing cases.

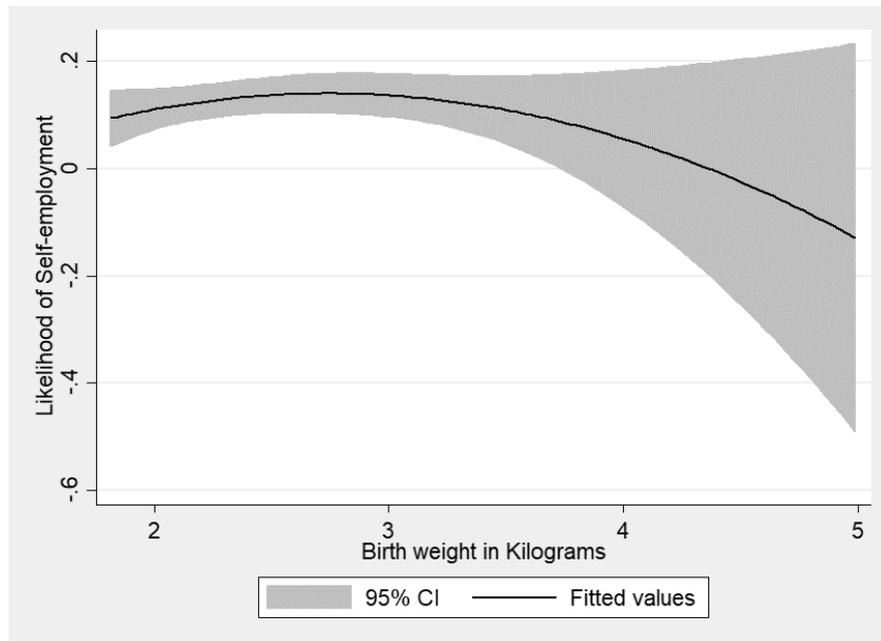
Table 8
Study 3a Regressions

Outcome: Self-employment	(1)	(2)	(3)	(4)	(5)	(6)
Birth weight		-41.69** (-17.94)	505.51** (7.05)		-96.60** (-2.28)	556.5** (26.22)
Birth weight ²			-134.1** (-7.58)			-167.0** (-28.54)
Financial Situation	-0.420 (-0.50)	-0.420 (-0.50)	-0.420 (-0.50)	-1.435* (-1.68)	-1.224 (-1.04)	-0.419 (-0.52)
Educational level	-8.281** (-17.30)	-10.24** (-20.98)	9.423** (4.16)	-4.13* (-1.73)	-11.51** (-18.06)	-10.410** (-15.66)
Physical Health	-2.092** (-2.96)	-18.66** (-16.72)	-57.02** (-9.67)	-10.76* (-1.68)	-67.00** (-3.61)	-156.53** (-11.33)
Mental Health	14.25** (8.01)	39.72** (17.38)	72.39** (12.20)	12.05* (1.67)	73.92** (3.87)	166.17** (11.61)
Self-evaluated health	-17.04** (-24.23)	-24.48** (-32.18)	-16.59** (-37.01)	-12.13* (-1.71)	-48.32** (-5.99)	-100.71** (-18.04)
Sample Size	20	20	20	39	39	39

Note: z-statistics in parentheses ** p<0.05, * p<0.1

Figure 3

Birth weight and Likelihood of Self-employment in Study Three



In model 7, we estimate the interactive effect of birth weight and age on self-employment. Including the interactive effect of birth weight and age on the tendency to engage in self-employment, we find that age plays a counter interacting role such that the negative influence of low and high birth weights on the likelihood of self-employment decreases as people age (see table 9). Moreover, we estimate a generalized structural equation model to investigate the mediation hypothesis. Our findings also support the hypothesis that anxiety mediates the interactive influence of birth weight and age on the propensity to engage in self-employment (see table 10).

Table 9
Study 3b Regressions

Outcome: Self-employment	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Birth weight		-0.18 (-0.11)	3.94 (0.17)		0.27 (0.44)	9.27** (2.07)	31.21** (2.13)
Birth weight ²			-0.85 (-0.16)			-1.75** (-2.15)	-5.57** (-2.13)
Birth weight * Age							-0.51* (-1.73)
Birth weight ² * Age							0.09* (1.67)
Average birth weight	0.02 (0.01)	0.07 (0.11)	0.11 (0.09)	-0.04 (-0.28)	-0.12 (-0.48)	-0.03 (-0.10)	-0.004 (-0.01)
Financial situation	0.11 (0.06)	0.11 (0.69)	0.12 (0.23)	-0.15 (-1.28)	-0.16 (-1.30)	-0.15 (-1.73)	-0.18 (-1.55)
Educational level	0.04 (0.01)	0.04 (0.27)	0.04 (0.06)	-0.08 (0.65)	-0.08 (-0.67)	-0.08 (-0.61)	-0.10 (-0.76)
Physical health	-0.07 (-0.03)	-0.08 (-0.15)	-0.09 (0.18)	-0.01 (-0.02)	0.01 (0.02)	0.04 (0.11)	0.11 (0.30)
Mental health	0.14 (0.34)	0.13 (0.33)	0.12 (0.30)	0.28 (0.86)	0.28 (0.85)	0.20 (0.67)	0.21 (0.70)
Zygoty				0.50 (1.49)	0.49 (1.47)	0.50 (1.56)	0.53 (1.61)
Gender	-1.29 (-0.12)	-1.31** (-2.32)	-1.31 (-0.53)	-0.40 (-0.85)	-0.37 (-0.78)	-0.39 (-0.82)	-0.33 (-0.67)
Age	0.01 (0.04)	0.00 (0.03)	0.00 (0.13)	-0.003 (-0.21)	-0.004 (-0.25)	-0.002 (-0.14)	0.70* (1.75)
Number of Siblings	-0.08 (-0.05)	-0.07 (-0.60)	-0.08 (-0.22)	-0.07 (-0.75)	-0.07 (-0.78)	-0.09 (-0.93)	-0.09 (-1.02)
Sample Size	122	122	122	240	240	240	240

Note: z-statistics in parentheses ** p<0.05, * p<0.1

Table 10**Indirect Effect of Birth weight on the Likelihood of Self-employment in Study 3**

	Path a	Path b	Path c	Path Significance	Overall Indirect Significance
Birth weight	4.48			Marginally sig. at p<0.1	
→Anxiety	(1.60)				
Birth weight ²	-0.94			Marginally sig. at p<0.1	
→Anxiety	(-1.60)				
Birth weight *	-0.12			Marginally sig. at p<0.1	
Age →Anxiety	(-1.63)				
Birth weight ² *	0.02			Marginally sig. at p<0.1	Marginally sig. at p<0.05
Age →Anxiety	(1.62)				
Anxiety → Self-employment		-4.97** (-13.08)		Sig. at p<0.05	
Birth Weight → Self-employment			8.78** (2.05)	Sig. at p<0.05	
Birth weight ² → Self-employment			-1.68** (-2.13)	Sig. at p<0.05	

Note: N= 225 individuals. z-statistics in parentheses.

All standard errors are clustered within families.

Using default standard errors, both direct and indirect relationships are significant at p<0.1.

3.5. DISCUSSION

In this paper, we examine for the first time the relationship between birth weight and self-employment. We find evidence of a significant curvilinear relationship between birth weight and the tendency to become self-employed across the three studies. Our regressions show that the effect size of birth weight on the tendency of people to engage in self-employment is larger than the effect sizes of other important factors including education, socioeconomic status and financial situation. We also show evidence of the mediating role of anxiety in the relationship between birth weight and the likelihood of self-employment. In doing so, we complement existing research that suggests that some people are physiologically more prone to

certain psychological factors and attitudes which in turn affect their tendencies to engage in self-employment (Nofal et al., 2018). Previous research suggests that public policies, including health and social policies, can moderate the negative influences of low birth weight on individual propensities (Figlio et al., 2014). Accordingly, since our analyses show that people with certain birth weights are more likely than others to become self-employed, public policies governing health conditions, such as maternal care (Goisis et al., 2017), childhood obesity screening policies (Yang, Goldhaber-Fiebert & Wein, 2013), and social conditions (Behrman & Butler, 2007), could improve the tendency of people to engage in self-employment. In this regard, the World Health Organization has been monitoring country initiatives on maternal and infant nutrition to early detect and effectively manage maternal problems, children's obesity and social conditions to avoid unfavorable birth weights and accordingly reduce the likelihood of adverse adulthood outcomes (Breda & Robertson, 2016).

Our findings have important implications. First, we contribute to our understanding of entrepreneurship by examining for the first time the effect of birth weight on self-employment. Existing studies linking human physiology to management focus on “relatively few physiological characteristics and relatively few outcomes” (Nofal et al., 2018, p. 16). In entrepreneurship research, physiological evidence is limited to the influence of hormones, physical attractiveness, and facial cues with no research examining the impact of birth weight (Nofal, Nicolaou & Symeonidou, 2017). By uncovering a significant relationship between birth weight and the likelihood of becoming self-employed, we contribute to the small but growing body of research on physiology in entrepreneurship. Additionally, our study responds to research calling for further studies examining the influence of birth weight on medium- and long-run adult outcomes (Figlio et al., 2014).

Second, by studying the mediating role of anxiety in the relationship between birth weight and self-employment, we attempt to explicate the theoretical foundation of the relationship between birth weight and self-employment. Specifically, we show that some people are physiologically more prone to anxiety because of their birth weight and accordingly are less likely to engage in self-employment.

Third, our study attempts to partly address various methodological issues in the birth weight literature, such as 1) the problem of endogenous findings (Conley et al., 2006) and 2) random error issues (Behrman & Rosenzweig, 2004; Xie et al., 2014), by using instrumental variable– (Nicolaou et al., 2017), panel– (Li et al., 2016b) and twin–designs (Black et al., 2007; Figlio et al., 2014; Petersen & Aarøe, 2015). Furthermore, in response to claims indicating that extant research underestimates the influence of birth weight by modeling its effect linearly (Xie et al., 2014), we follow Almond et al. (2005) and use a quadratic curvilinear function to estimate the effect of birth weight on the tendency to engage in self-employment. Finally, little has been written about how influences of birth weight may vary across time and whether those effects differ heterogeneously across different demographic groups (Behrman & Rosenzweig, 2004; Figlio et al., 2014). By examining three different samples from three different countries, two of which are longitudinal and one natural experiment, we add to that literature.

This research has several limitations. First, the outcome variable (i.e. self-employment) is more focused on the exploitative rather than the explorative dimensions of entrepreneurship (Henrekson & Sanandaji, 2014). Thus, it is important that future research examines other entrepreneurial outcomes, such as business ownership and company creation. Yet, in study 1, we use a measure in which participants were identified as being entrepreneurs rather than self-employed, which increases the likelihood that our measure captures both the explorative and exploitative dimensions of entrepreneurship. In addition, although our measures of anxiety have been previously used to assess anxiety, they may also be inferior to other negative emotions such as psychological distress, depression and neuroticism. Yet, evidence suggests that there is a considerable overlap between the scales measuring these variables (Luteijn & Bouman, 1988).

Second, our study does not examine the interactive effect of birth weight and other biological and environmental factors on the likelihood of engaging in self-employment. Hence, we encourage researchers to examine the interactive influence of birth weight and other biological factors, such as genetics, hormones, and neurological functions, on the likelihood of self-employment. In addition, future research should

explore interactions between birth weight and environmental factors. For instance, researchers are urged to investigate the moderating role that environmental factors, such as family environments, may play in the relationship between birth weight and self-employment.

Third, although our study examines three different samples from three different countries, our findings cannot be generalized to other countries. As Behrman and Rosenzweig (2004) argue: there are considerable differences in the distribution of birth weight across different countries; therefore, we are unable to assert whether variations in culture or nationality influence the association between birth weight and the likelihood of self-employment. Accordingly, future research on samples from different countries may help determine the generalizability of our findings and provide interesting insights as to how such factors may affect the relationship between birth weight and self-employment.

Fourth, the anxiety measures that we use may be inferior to other measures. However, given the need to examine mediation across three different samples, the similar patterns of results observed with these different measures make it less likely that the findings are an artifact of these instruments.

Our research has implications for the practice of management. Since our analyses show that people with certain birth weights are more likely than others to become self-employed, public policies governing health conditions, such as maternal care (Goisis et al., 2017), childhood obesity screening policies (Yang et al., 2013), and social conditions (Behrman & Butler, 2007), may help in improving people's tendencies towards self-employment. Furthermore, an understanding of how environmental factors (e.g. maternal care, better social conditions) moderate the influence of birth weight on self-employment would enable policymakers to minimize any negative effects of low birth weight on self-employment. Previous research suggests that public policies may moderate the negative influences of birth weight on individual propensities (Figlio et al., 2014). In addition, our study suggests that if organizations are interested in encouraging individuals to engage in entrepreneurial and corporate venturing activities, they should try to alleviate anxiety levels of employees. This may be achieved by altering job conditions to assuage any negative

influences of anxiety at work. Similarly, if policymakers, incubators, and accelerator programs are interested in promoting the likelihood that individuals engage in self-employment, they should identify ways to moderate anxiety levels.

3.6. CONCLUSION

Using a three-study framework, we find a significant curvilinear relationship between birth weight and the tendency to become self-employed. We also find evidence of the mediating role of anxiety. We hope that other researchers will join us in furthering our understanding of the role of birth weight in self-employment.

Chapter 4: Anxiety and Entrepreneurship

4.1. ABSTRACT

There is increasing evidence of the role of mental conditions in the tendency to engage in entrepreneurship. Yet, extant literature is unclear about the role of the most prevalent mental condition worldwide, anxiety, in entrepreneurship. In this paper, we contribute to this literature by exploring the relationship between anxiety and the likelihood of engaging in entrepreneurial activities using five samples – one cross sectional, three longitudinal and a sample of twins. We find a negative relationship between anxiety and the tendency to engage in entrepreneurship. Our findings also suggest that improving individuals' financial conditions can attenuate the negative influence of anxiety on the propensity to engage in entrepreneurship.

4.2. INTRODUCTION

“Mental illness can impair people’s abilities to engage in or fully meet the requirements of certain jobs” (Follmer & Jones, 2018). Yet, only recently have researchers started to investigate the influence of mental conditions, such as dyslexia (Logan, 2009), attention-deficit hyperactivity disorder (ADHD) (Thurik et al., 2016; Verheul et al., 2016; Wiklund, Hatak, Patzelt & Shepherd, 2018; Wiklund et al., 2016; Wiklund et al., 2017a; Wiklund et al., 2017b), obsessive-compulsive personality disorder (Wolfe & Patel, 2017a), and depression (Hessels et al., 2018) on the tendency of people to engage in entrepreneurship. Despite this emerging literature, and although anxiety is the most prevalent mental condition worldwide (Bystritsky, Khalsa, Cameron & Schiffman, 2013), research to date is unclear about the influence of anxiety on the tendency of people to become entrepreneurs (Shepherd & Patzelt, 2017).

“Anxiety refers to multiple mental and physiological phenomena, including a person's conscious state of worry over a future unwanted event, or fear of an actual situation” (Evans et al., 2005, p. 162; Evans et al., 2012). Research suggests that when negative emotions become extremely dominant, they can tip over into anxiety (Lo et al., 2017). However, unlike negative emotions, anxiety inhibits various behaviors and attitudes (Geenen, Urbig, Muehlfeld, van Witteloostuijn & Gargalianou, 2016), such as information processing (Joslyn & Haider-Markel, 2018; Kerr, Engel, Schlesinger-Raab, Sauer & Hölzel, 2003), emotional processing (Artemenko, Daroczy & Nuerk, 2015), and performance (Katzir, Kim & Dotan, 2018). Yet, although we have consistent evidence of the role of negative emotions in entrepreneurship (Baron, 2000; Shepherd, Covin & Kuratko, 2009; Shepherd & Patzelt, 2018), existing literature provides mixed evidence of the relationship between anxiety and the likelihood of engaging in entrepreneurship (Shepherd & Patzelt, 2017). Specifically, while some studies argue that anxiety inhibits entrepreneurial actions (Freeman, Staudenmaier, Zisser & Andresen, 2018; Wiklund et al., 2017b), other studies find that anxiety is not significantly related to entrepreneurship (Grzywacz & Bass, 2003; King-Casas, Sharp, Lomax-Bream, Lohrenz, Fonagy & Montague, 2008; Prottas & Thompson, 2006; Rahim, 1996; Stephan & Roesler, 2010; Wolfe & Patel, 2017a).

Moreover, the potential for reverse causality cannot be ruled out in explaining this relationship. For instance, there is evidence that entrepreneurship can induce high levels of anxiety and stress (Follmer & Jones, 2018; Ganster & Rosen, 2013; Wiklund et al., 2016). Although these mixed arguments “muddy the waters somewhat, they also represent a number of research opportunities” (Shepherd & Patzelt, 2017). Most importantly, while it has the potential to further our understanding of entrepreneurship, this area of research is still in its infancy, and is far more complex than we once thought (Wiklund et al., 2017b). Particularly, research suggests a more complex, non-linear relationship between anxiety and the tendency to become an entrepreneur that is dependent on certain conditions (Cacciotti & Hayton, 2015). Yet, there is no research revealing what these conditions might be.

In this paper, our aim is two-fold. First, we aim to complement and apply Gray’s Reinforcement Sensitivity Theory to contribute to the aforementioned ongoing debates on the potential influence of anxiety on the tendency of people to engage in entrepreneurship. This theory suggests that underpinning any behavior are two systems; the behavioral activation system (BAS) and the behavioral inhibition system (BIS). In understanding the influence of anxiety on entrepreneurship, we invoke the role of the BIS. To do so, we propose a five-study framework. As research argues that measures of anxiety “should not be interpreted as diagnostically significant for an anxiety disorder, but should be used to measure the presence of symptoms”, we use four different clinical measures of anxiety: 1) state-trait anxiety inventory, 2) panic disorder, 3) career-related anxiety, and 4) the teacher-rated Bristol Social Adjustment Guide (BSAG) to triangulate our measures and calibrate the severity of anxiety symptoms in examining the relationship between anxiety and the likelihood of engaging in entrepreneurship (Julian, 2011, p. S467).

Second, we seek to investigate the interactive role of anxiety and financial situation in shaping the tendencies of people to engage in entrepreneurship. In doing so, we highlight how environmental factors can assuage the influence of anxiety conditions on the tendency to engage in entrepreneurship.

Employing longitudinal and twin designs, as well as fixed effects, correlated random effects, the Mundlak-Chamberlain estimator, and two-stage least squares

instrumental variable regressions which somewhat account for various endogeneity issues, and using five samples from the Northern Finland Birth Cohort (NFBC 1966), the National Survey of Midlife Development in the United States (MIDUS), the Understanding Society UK Household Longitudinal Study, and the UK National Child Development Study (NCDS), we find that anxiety negatively relates to the likelihood of engaging in entrepreneurship. We also find some support for the moderating role that financial situation plays in the association between anxiety and the propensity to engage in entrepreneurship.

Our research makes a number of contributions. First, our study contributes to the growing body of research on mental conditions in entrepreneurship. Though mental illness shapes the cognitions, affect and behavior of many workers, “the fields of industrial-organizational psychology and management understand little about their experiences” (Follmer & Jones, 2018). In addition, although the psychology literature has established a strong link between anxiety-related disorders and adult outcomes, research to date has been unclear in explaining the link between anxiety conditions and entrepreneurship (Shepherd & Patzelt, 2017). Given the central role of anxiety in affecting individuals’ management outcomes (Vignoli, 2015), we attempt to offer an additional insight into the role of anxiety conditions in entrepreneurship. Moreover, in so doing, we respond to the call for more work on the role of mental conditions in entrepreneurship (Wiklund et al., 2017b).

Second, by examining the moderating role of financial situation, we highlight the importance of situational factors in alleviating the negative influence of mental conditions on the probability of engaging in entrepreneurship. In so doing, our work responds to the call for research explaining how the impact of anxiety on entrepreneurial outcomes is dependent on the presence of certain conditions, such as financial circumstances (Cacciotti et al., 2016). Moreover, by examining this relationship using longitudinal datasets, we respond to the call for research examining the cumulative influence of anxiety on entrepreneurship over time (Cacciotti & Hayton, 2015; Ganster & Rosen, 2013).

Third, our research contributes to the literature on the dark side of entrepreneurship (DeNisi & Alexander, 2017). Though research in entrepreneurship

has uncovered various predispositions related to the tendency of people to engage in entrepreneurship, the negative aspects of the entrepreneurial personality have largely been ignored (Miller, 2015). Moreover, it is not known whether contextual factors can compensate for extremely high levels of certain characteristics (DeNisi, 2015). This paper adds to this literature by suggesting that contextual factors can compensate for extreme levels of negative emotions if properly addressed.

4.3. THEORETICAL BACKGROUND

The influence of “mental health conditions has been at the center of a growing stream of entrepreneurship research” (Wolfe & Patel, 2017a, p. 125). For instance, Logan (2009) found that dyslexics have a high tendency towards engaging in entrepreneurship. Other evidence suggests that younger individuals as well as males with obsessive-compulsive personality disorders are more likely to become self-employed (Wolfe & Patel, 2017a). Existing work also indicates that depression positively affects the tendency of people to exit entrepreneurship (Hessels et al., 2018).

In addition, recent studies report positive relationships between ADHD and entrepreneurial orientation (Thurik et al., 2016), entrepreneurial action and success (Wiklund et al., 2016) as well as other entrepreneurial characteristics, such as need for achievement, autonomy/independence, and risk-taking, which in turn affect people’s tendencies to engage in entrepreneurship (Dimic & Orlov, 2014). Further research suggests that impulsivity-related disorders, including ADHD, have several favorable aspects for entrepreneurship, such as positive emotions towards uncertain opportunities, opportunity exploitation, and persistence with executing entrepreneurship (Wiklund et al., 2017a). Additionally, Verheul et al. (2016) have found that people with certain aspects of ADHD, specifically hyperactive individuals, exhibit higher tendencies towards self-employment. In line with this study, other research indicates that the association between ADHD and the propensity towards entrepreneurship is attributed to hyperactivity symptoms and not attention ones (Antshel, 2017). In support of this evidence, Wiklund et al. (2017b) found that while inattention is negatively associated with the tendency to engage in entrepreneurship, hyperactivity positively influences the tendency to engage in entrepreneurship.

4.3.1. Anxiety and Entrepreneurship

Despite the recent findings on the relationships between mental conditions, and entrepreneurial outcomes, evidence of the influence of the most prevalent mental condition worldwide – anxiety – on entrepreneurial outcomes is unclear. Anxiety promotes pessimistic perceptions about future outcomes, which often result in risk-avoidant decision-making (Maner et al., 2007). Given that entrepreneurship involves decision-making in the realm of a priori risk-taking (Lerner, Hunt & Verheul, 2018b), researchers have conceptually proposed that anxiety negatively influences the tendency of people to engage in entrepreneurship. Research suggests, for instance, that anxiety triggers feelings of uncertainty, causing procrastination and low engagement in entrepreneurship (McMullen & Shepherd, 2006; Wiklund et al., 2017a). However, other studies show that anxiety is not significantly related to entrepreneurship (Grzywacz & Bass, 2003; King-Casas et al., 2008; Prottas & Thompson, 2006; Rahim, 1996; Stephan & Roesler, 2010; Wolfe & Patel, 2017a).

The mixed arguments regarding the influence of anxiety on engaging in entrepreneurship can be attributed to the role of the behavioral inhibition system. Specifically, Gray's Reinforcement Sensitivity Theory (RST) demonstrates that the influence of anxiety on the tendency to engage in entrepreneurship is dependent on the BIS (Lerner, Hatak & Rauch, 2018a). People with less active BIS are more likely to engage in entrepreneurship because they show limited reactions of anxiety and avoidance in response to anxiety-related signals such as novelty and uncertainty. On the other hand, very active BIS individuals tend to have increased anxiety which inhibits their tendencies towards entrepreneurship (Wiklund et al., 2017a). However, although extant empirics have incorporated the role of the BIS into research examining the influence of anxiety on the tendency of people to engage in entrepreneurship, research suggests that existing measures of BIS 1) do not capture the physiological aspects of mental conditions (Lerner et al., 2018b), 2) are limited in terms of their coverage of the anxiety functions attributed to the BIS (Newman & Malterer, 2009) and 3) are considered more of a negative emotionality indicator than a measure specific to anxiety (Poythress, Edens, Landfield, Lilienfeld, Skeem & Douglas, 2008).

Accordingly, it could be that those measures vary in the extent to which they capture anxiety and thus are the reasons for this mixed literature.

Because the RST is a biological model of individual differences in emotion and motivation (Corr, 2004), investigating the role of the BIS to examine mental conditions requires measures that meet clinical criteria (Lerner et al., 2018b), such as state-trait anxiety inventory (Spielberger, Gorsuch & Lushene, 1970), panic disorder (Boshuisen, Ter Horst, Paans, Reinders & den Boer, 2002; Massion, Warshaw & Keller, 1993; Mohlman, de Jesus, Gorenstein, Kleber, Gorman & Papp, 2004), wellbeing anxiety (Warr, 1990), general state anxiety (Spielberger, 1979), and the teacher-rated Bristol Social Adjustment Guide (BSAG) (Welham, Isohanni, Jones & McGrath, 2008). Moreover, because clinical anxiety is mainly a result of genetic factors and childhood stimuli (Fox et al., 2015), such measures lower the potential for reverse causality. Therefore, based on the aforementioned literature and because evidence suggests that the relationship between anxiety and risk-avoidance decision-making is not merely attributable to the presence of other mediating factors but is specific to anxiety (Maner et al., 2007), we suggest that anxiety directly inhibits the tendency of people to engage in entrepreneurship. We thus hypothesize that:

Hypothesis 1: There is a negative relationship between anxiety and the tendency to engage in entrepreneurship.

Beyond the direct link between anxiety and the tendency to engage in entrepreneurship, researchers argue that this relationship can be more complex (Cacciotti & Hayton, 2015). For instance, the RST suggests that the effect of anxiety on the tendency of people to engage in entrepreneurship exists when the BIS is in some conflict with another system - namely the behavioral activation system (BAS) (Geenen et al., 2016). The BAS is a motivational system that activates certain behaviors, such as impulsivity, when confronted with potential rewards and financial outcomes. This demonstrates that other factors, such as rewards, financial standards, and socio-economic conditions, can moderate the influence of anxiety on the propensity to engage in entrepreneurship. This argument is supported by the biological theory of entrepreneurship which suggests that mental conditions can influence the tendency of people to engage in entrepreneurship directly and by interacting with other factors,

including family, socioeconomic, financial, and educational factors (Nofal et al., 2017; Nofal et al., 2018).

Moreover, existing work from behavioral economics indicates that the BAS and BIS are sensitive to factors such as individuals' financial circumstances (Geenen et al., 2016; Lerner et al., 2018b). For instance, research shows that the influence of BAS factors, specifically novelty-seeking, on approaching creative tasks is dependent on the level of financial constraints (Scopelliti, Cillo, Busacca & Mazursky, 2014). Applying this logic to the influence of BIS on the propensity to engage in entrepreneurship, we expect to find that individuals' financial situation plays a significant moderating role in the relationship between anxiety and the tendency to engage in entrepreneurship.

In addition, family and individuals' own financial status are important predictors of the tendency of people to engage in entrepreneurship (Dunn & Holtz-Eakin, 2000; Kim, Aldrich & Keister, 2006). For example, Holtz-Eakin, Joulfaian and Rosen (1994) found that family assets have a positive role in the transition into self-employment. Dunn and Holtz-Eakin (2000) also found that both parental financial circumstances as well as individuals' financial assets positively contribute to the transition into self-employment. In line with this evidence, Cetindamar, Gupta, Karadeniz and Egrican (2012) found that individuals' financial capital has a positive impact on entry into entrepreneurship. Therefore, we argue that individuals' financial situation may attenuate the negative effect of anxiety on the tendency to engage in entrepreneurship. Hence, we hypothesize that:

Hypothesis 2: The relationship between anxiety and the tendency to engage in entrepreneurship is positively moderated by financial situation.

4.4. METHODS

4.4.1. Study 1

Sample

To examine our hypotheses, we start by investigating the NFBC. The NFBC is a longitudinal epidemiological program that examines the risk factors of preterm births and the impact of adverse outcomes on consequent morbidity. Recently, the

scope of the NFBC has been widened to include social outcomes, such as scholastic performance, stress, depression, and others (e.g. Herva et al., 2006; Isohanni, Jävelin, Jones, Jokelainen & Isohanni, 1999). The NFBC of 1966 comprises 12,231 individuals born in 1966 in two provinces in Finland; Oulu and Lapland. Across a period of over 40 years, individuals and their parents were approached through medical tests, parental surveys, and observations as well as self-reported surveys. Five waves were collected in years 1966, 1967, 1980, 1997 and 2012. In this study, we use the latest 2012 wave because it includes all the variables that are required for the purpose of our study, and our final sample includes 4,101 individuals.

Measures

Entrepreneurship: The dataset includes respondents' occupations. We construct our binary outcome by coding those who select entrepreneurship as one, and other occupations as zero.

Anxiety: Anxiety is measured using the Six-Item Short-Form State Trait Anxiety Inventory (STAI-6). STAI is a common measure of anxiety used in clinical settings as it captures both state and trait anxiety (Spielberger, 1979; Spielberger et al., 1970). State anxiety is a transient momentary emotion that results from social situations that impose some stress, while trait anxiety is considered a predisposition to act with anxiety in stressful situations (Spielberger, 1971). To calculate the total STAI score, we reverse the scores of the positive items, sum the scores for all the six items and then multiply the summed score by 20/6 (Bekker, Legare, Stacey, O'Connor & Lemyre, 2003; Spielberger et al., 1970).

Financial Situation: Financial situation is measured by asking respondents about the extent to which their income is sufficient on a scale from 1 to 4¹⁰.

Controls: We control for the effect of a number of factors; sex, education (Nicolaou et al., 2017), knowledge of changes happening in work (Calás, Smircich & Bourne, 2009), job security, involvement in job planning (Randolph-Seng, Mitchell,

¹⁰ The detailed scales are available at:
https://www oulu.fi/sites/default/files/Talous%20tyoelama%20ja%20voimavarakysely_0.pdf

Marin & Lee, 2015), general health, and general life assessment (Stephan, 2018). We do not control for the influence of age because all respondents are 46 years old.

Analysis and Results

Table 1 presents the correlations. It shows that anxiety is negatively correlated with the tendency to become an entrepreneur. Table 2 presents the Logit Regressions. In model 1, we include the control variables only. In model 2, we add anxiety. We find a significant negative relationship between anxiety and the tendency to become an entrepreneur. In model 3, we examine the interactive effect of anxiety and financial situation on the tendency to engage in entrepreneurship. We find a significant positive interactive influence of anxiety and financial situation on the tendency to become an entrepreneur (see figure 1).

Table 1
Study 1 Correlations

	1	2	3	4	5	6	7	8	9	10
1.Entrepreneurship	1.00									
2.Anxiety	-0.04	1.00								
3.Sex	-0.26	0.06	1.00							
4.Education	-0.12	0.08	0.18	1.00						
5.Knowledge of Job changes	-0.01	-0.07	0.01	-0.11	1.00					
6.Job Security	-0.07	-0.08	-0.06	-0.08	0.24	1.00				
7.Involvement in Job planning	-0.46	-0.08	0.13	-0.07	0.45	0.30	1.00			
8.General Health	0.01	-0.20	-0.04	-0.12	0.14	0.18	0.15	1.00		
9.Financial Sufficiency	-0.07	-0.09	0.18	-0.08	0.18	0.12	0.26	0.21	1.00	
10.General Life Rating	0.02	-0.18	-0.07	-0.07	0.11	0.13	0.14	0.26	0.13	1.00

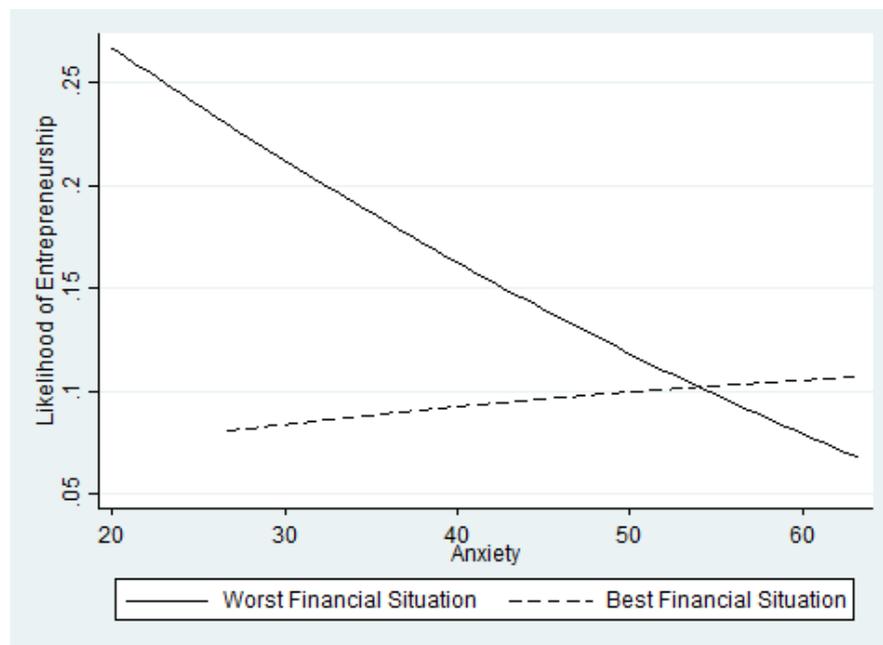
Note: All correlations at or above |0.02| are significant at $p < .1$ or below.

Table 2
Study 1 Regressions

Outcome: Entrepreneurship	(1)		(2)		(3)	
	β	<i>z</i>	β	<i>z</i>	β	<i>z</i>
Anxiety			-0.02**	-2.13	-0.07**	-2.35
Anxiety*Financial Situation					0.02*	1.70
Sex	-0.63***	-5.98	-0.63***	-5.93	-0.62***	-5.90
Education	-0.11***	-3.38	-0.11***	-3.27	-0.11***	-3.30
Knowledge of Job changes	0.36***	6.20	0.36***	6.21	0.36***	6.21
Job Security	0.04	0.59	0.04	0.52	0.04	0.52
Involvement in Job planning	-1.50***	-16.46	-1.51***	-16.51	-1.52***	-16.53
General Health	0.09	1.09	0.06	0.79	0.06	0.77
Financial Sufficiency	0.07	1.09	0.06	1.01	-0.78	-1.57
General Life Rating	0.09	1.12	0.08	0.90	0.08	0.97
Constant	0.82**	2.91	1.92***	3.09	4.02***	2.91
Observations		4,101		4,101		4,101

Note: *** $p < .01$, ** $p < .05$, * $p < .1$

Figure 1
Anxiety and likelihood of entrepreneurship in Study 1



4.4.2. Study 2

Research suggests that the influence of mental conditions on the tendency to engage in entrepreneurship may vary overtime, indicating that our estimations may be tentative and highly dependent on the time span in which the data was collected (Nofal et al., 2018). Moreover, measuring anxiety and the tendency to engage in entrepreneurship at the same point in time may yield various reverse causality issues. For these reasons, it is “impractical to examine their effects all at once in a single study to capture person-related effects collectively” (Li et al., 2016b). Thus, we re-examine our hypotheses using longitudinal data collected over a period of 10 years using MIDUS 2 and MIDUS 3 datasets.

Sample

MIDUS is a collaborative, interdisciplinary investigation of the predictors and outcomes of midlife development. It includes data on physical health, psychological well-being, and social responsibility. The first wave of the MIDUS study (i.e. MIDUS 1) collected survey data from a total of 7,108 participants in 1995/96. A longitudinal follow-up of the original MIDUS study was conducted in 2004/06 (i.e. MIDUS 2). Of the 7,108 participants in MIDUS 1, only 4,963 successfully participated in phone

interviews of about 20 to 30 minutes in length and completed two self-administered questionnaires. In MIDUS 3, the University of Wisconsin Survey Center sought to re-interview living MIDUS longitudinal sample who had completed the MIDUS 2 telephone interview. Of the 4,963 individuals, a sample of 4,460 individuals participated in MIDUS 3. Data is available separately for each wave. We cross-linked the last two waves that include business ownership information resulting in a sample of 1,095 individuals.

Measures

Entrepreneurship: The outcome is measured by asking respondents if they own a business/farm in the two waves [1: *Yes*, 2: *No*].

Anxiety: We measure anxiety using the calculated panic score for each individual assessed using 6 items in a telephone interview. People with high panic scores “have panic attacks in anticipation of imminent exposure to a horde of strangers at a business event” (Craske & Stein, 2016). In both waves, symptoms were assessed in a phone interview using the composite international diagnostic interview short form (Kessler, Andrews, Mroczek, Ustun & Wittchen, 1998a), which is a fully structured diagnostic interview that measures the prevalence of mental disorders including anxiety. It is also regarded as very effective for usage for clinical diagnoses (Kessler et al., 1998b; Wittchen, 1994). Panic disorder captures both the severity and the persistence of anxiety and is prevalent in 2-5% of the world’s population.

Financial Situation: We measure individuals’ financial situation by asking respondents to rate their financial situation on a scale from 0 to 10, with 0 corresponding to the worst financial situation, and 10 corresponding to the best financial situation (Kim, Fouad, Maeda, Xie & Nazan, 2018).

Controls: We control for education, age, sex, ethnicity (Nicolaou et al., 2017), work demands, and work flexibility which is assessed using two items; flexibility in choosing work tasks, and flexibility in choosing how to do the tasks (Dijkhuizen, Gorgievski, van Veldhoven & Schalk, 2016).

Analysis and Results

Table 3 lists the correlations between the different variables in the study. It shows that anxiety is negatively correlated with the tendency to become an entrepreneur. Table 4 presents the regressions – we employ a logit function because of the binary nature of the outcome. We first run random effects estimations. In model 1, we run the analysis with the control variables only, while in models 2 and 3, we add anxiety, and the interactive term of anxiety and financial situation respectively. Because our sample includes individuals from the same family, we adjust the standard errors to allow for serial correlation across individuals within the same family. We find an insignificant negative relationship between anxiety and the tendency to own a business. We also found no evidence of the interactive effect of anxiety and financial situation on business ownership.

In order to alleviate the potential presence of omitted variables, we estimate three Fixed Effects models. To analyze the dataset using Fixed Effects estimation, there needs to be variation in the outcome within each individual. If a person owned a business in one of the waves, the business should not be owned in other waves; otherwise, there would be no individual variation in the outcome and cases would drop out. For this reason, estimating a Fixed Effects model drops a number of observations, thus only 276 observations contribute to our Fixed Effects estimations. We find that neither anxiety nor the interactive term of anxiety and financial situation influence business ownership.

An alternative way to include all the observations that were dropped out from the Fixed Effects estimation is to employ a Mundlak-Chamberlain's logit estimator (Papke & Wooldridge, 2008; Semykina & Wooldridge, 2010). This allows us to use all the observations and increase our sample size. In applying this estimator, we have to satisfy the assumption that the observed effects are uncorrelated with the error term. This is done by including the means of all time-varying covariates within the random effects model (Gayle & Lambert, 2018; Mundlak, 1978). We adjust the standard errors to allow for serial correlation across individuals in the same family. We find a significant negative relationship between anxiety and the tendency to own a business.

However, our findings do not support the hypothesis that financial situation moderates the relationship between anxiety and business ownership (see figure 2).

Figure 2

Anxiety and likelihood of entrepreneurship in Study 2

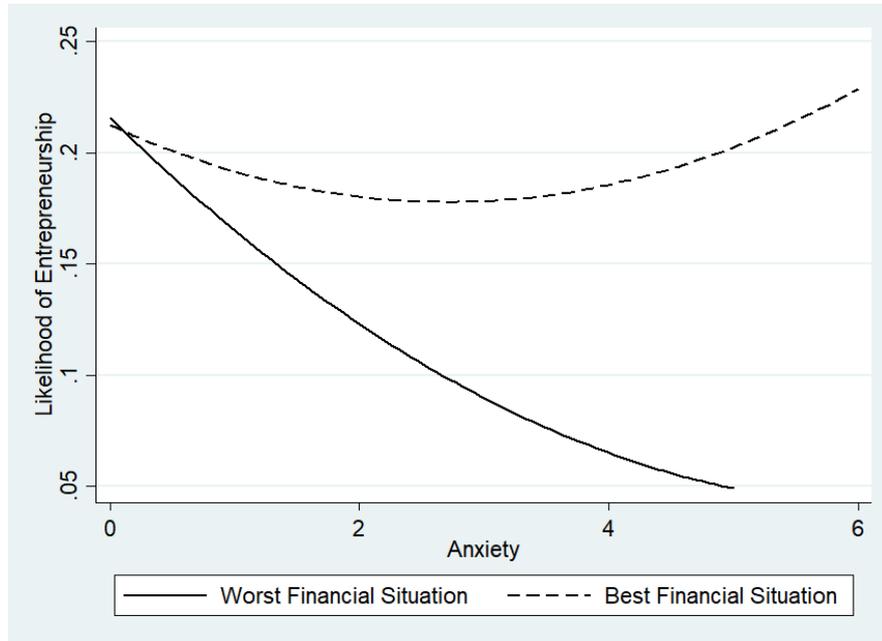


Table 3
Study 2 Correlations

	1	2	3	4	5	6	7	8	9
1.Entrepreneurship	1.00								
2.Anxiety	-0.08	1.00							
3.Age	0.11	-0.16	1.00						
4.Sex	-0.19	0.24	-0.08	1.00					
5.Education	0.02	-0.07	-0.03	-0.10	1.00				
6.Financial Situation	0.05	-0.13	0.17	-0.11	0.17	1.00			
7.Work Freedom	-0.41	0.06	-0.00	0.13	-0.16	-0.15	1.00		
8.Work Demands	-0.00	-0.11	0.28	-0.01	-0.06	0.10	0.05	1.00	
9.Ethnicity	-0.00	-0.04	0.02	-0.06	0.04	-0.03	0.02	0.04	1.00

Note: All correlations at or above |0.03| are significant at $p < .1$ or below.

Table 4
Study 2 Regressions

Outcome: Entrepreneurship	(1)		(2)		(3)		(4)		(5)		(6)	
	(RE)		(RE)		(RE)		(FE)		(FE)		(FE)	
	β	z										
Constant	-0.70	-0.78	-0.61	-0.67	-0.70	-0.76						
Anxiety			-0.13	-1.14	0.17	0.67			-0.28	-1.28	0.80	1.16
Anxiety*Financial Situation					-0.05	-1.22					-0.18	-1.56
Age	0.03***	3.18	0.03***	3.11	0.03***	3.06	0.00	0.13	0.00	0.08	-0.00	-0.02
Sex	-0.89***	-4.22	-0.87***	-4.13	-0.88***	-4.13						
Education	-0.04	-0.94	-0.04	-0.97	-0.04	-0.99	0.06	0.25	0.07	0.31	0.10	0.43
Financial Situation	-0.01	-0.26	-0.02	-0.33	0.00	0.01	0.03	0.38	0.03	0.38	0.07	0.81
Work Flexibility	-1.24***	-8.84	-1.25***	-8.81	-1.30***	-8.82	-0.52***	-2.61	-0.50***	-2.50	-0.53***	-2.61
Work Demands	-0.06	-0.53	-0.06	-0.59	-0.06	-0.57	-0.01	-0.06	-0.06	-0.34	-0.02	-0.13
Ethnicity	-0.00	-0.69	-0.00	-0.71	-0.00	-0.77						
Mean of Age												
Mean of Education												
Mean of financial Situation												
Mean of Work Freedom												
Mean of Work Demands												
Mean of Anxiety												
Observations	3,700		3,700		3,707		276		276		276	
Number of Cases	2,698		2,698		2,698		138		138		138	

Table 4 (continued)

Outcome: Entrepreneurship	(7)		(8)		(9)	
	(MC)		(MC)		(MC)	
	β	z	β	z	β	z
Anxiety			-0.32*	-1.66	-0.16	-0.36
Anxiety*Financial Situation					-0.03	-0.37
Age	-0.01	-0.62	-0.01	-0.69	-0.01	-0.72
Sex	-0.89***	-2.86	-0.88***	-2.80	-0.88***	-2.80
Education	0.06	0.44	0.04	0.31	0.04	0.33
Financial Situation	0.03	0.27	0.03	0.26	0.03	0.32
Work Flexibility	-0.55**	-2.54	-0.55**	-2.57	-0.55***	-2.57
Work Demands	-0.03	-0.15	-0.05	-0.25	-0.04	-0.24
Ethnicity	-0.00	-0.41	-0.00	-0.55	-0.00	-0.43
Mean of Age	0.07**	2.38	0.07**	2.43	0.07**	2.45
Mean of Education	-0.14	-0.94	-0.13	-0.83	-0.13	-0.85
Mean of financial Situation	-0.08	-0.59	-0.08	-0.60	-0.08	-0.60
Mean of Work Flexibility	-1.60***	-5.19	-1.60***	-5.16	-1.61***	-5.14
Mean of Work Demands	-0.14	-0.49	-0.12	-0.44	-0.13	-0.45
Mean of Anxiety			0.23	0.83	0.22	0.81
Constant	0.77	0.52	0.81	0.54	0.77	0.51
Observations	2,097		2,097		2,097	
Number of Cases	1,095		1,095		1,095	

Note: RE = random effect; FE= fixed effects; MC = Mundlak-Chamberlain estimator.

The variation in the number of observations between models is due to the missing values in some of the variables.

***p < .01, **p < .05, *p < .1

4.4.3. Study 3

Because some of the findings in Study 1 are not replicated in Study 2, we re-test our hypotheses in Study 3 using a different sample from the UK to add further fidelity to our findings.

Sample

In Study 3, we use the Understanding Society dataset. The overall purpose of Understanding Society is to provide high quality longitudinal information about subjects such as health, work, education, income, family, and social life to help understand the long-term influences of social and economic change, as well as policy interventions on the general well-being of the UK population. The study collects both objective and subjective indicators and has been used in multiple social disciplines such as sociology economics, business and management, geography, psychology, and health sciences. Data is available separately for each wave. We cross-linked waves 2, 4, and 6 that include anxiety and self-employment information, and 15,113 individuals contribute to our analyses.

Measures

Entrepreneurship: In each wave, the outcome is measured by asking respondents if they are employed, or self-employed. We code self-employed responses as one, and other responses as zero.

Anxiety: We measure anxiety using the Wellbeing Anxiety subscale, originally devised by Warr (1990) (i.e. “Anxiety-Contentment” scale). Research regards this measure as suitable to be applied in clinical settings (Mason, O'keeffe, Carter & Stride, 2016; Warr, 1990). It is assessed by asking respondents in each wave, “Thinking of the past few weeks, how much of the time has your job made you feel calm”, “contented”, “relaxed”, “tense”, and “uneasy”. Responses were coded on a five-point scale: 1] all of the time, 2] most of the time, 3] some of the time, 4] occasionally, and 5] never. If a single item from the subscale is missing, the mean value of the remaining two items was imputed by Understanding Society. Higher values on the scale represent lower levels of anxiety. Accordingly, we reverse the scale to be consistent with the previous studies.

Financial Situation: We assess individuals' financial situation by asking respondents about their monthly amount of money saved (Chisholm et al., 2017).

Controls: We control for the potential influences of education, social class, satisfaction with health, general life satisfaction, strain, sex, age (Nicolaou et al., 2017; Stephan, 2018), expected financial status in the future, and permanency of work (Baron, 2010; Davidsson, 1989).

Analysis and Results

Table 5 lists the correlations between the different variables in the study. It shows that anxiety is negatively correlated with the tendency to become an entrepreneur. Table 6 presents the Regressions – we employ a logit function because of the binary nature of the outcome. In model 1, we use Random Effect estimation to examine the influence of the control variables on the tendency to engage in self-employment. In model 2, we include our independent variable; anxiety. We find a significant negative relationship between anxiety and the tendency to engage in self-employment. In model 3, we find an insignificant interactive positive effect of anxiety and financial situation on the tendency to become self-employed.

To minimize the potential for endogeneity, we run Fixed Effects estimation. To apply this estimator, there needs to be variation in the self-employment within each individual across time. Because there is no within individual variation in many of the cases, only 246 individuals contribute to our Fixed Effects estimation. We estimate our fixed effects model using control variables in model 4, while in model 5, we add anxiety and in model 6 we add the interaction term of both anxiety and financial situation. We replicate our previous findings and show a significant negative relationship between anxiety and the tendency to engage in self-employment. We also find that there is a positive interactive influence of anxiety and financial situation on the tendency to engage in self-employment (see figure 3). Because self-employed individuals may include non-entrepreneurs such as taxi drivers and micro business owners, we also examine our hypotheses after dropping self-employed individuals who have no employees. We find similar results in model 7 (see Table 6).

Table 5
Study 3 Correlations

	1	2	3	4	5	6	7	8	9	10	11	12
1.Entrepreneurship	1.00											
2.Anxiety	-0.13	1.00										
3.Financial Situation	0.10	0.03	1.00									
4.Education	0.03	0.12	0.20	1.00								
5.Age	0.27	-0.01	0.12	-0.01	1.00							
6.Expected Future Financial Status	-0.01	-0.01	0.02	-0.02	0.33	1.00						
7.Social Class	-0.02	-0.14	-0.26	-0.43	-0.17	-0.04	1.00					
8.Health Satisfaction	-0.01	-0.14	0.05	0.04	-0.06	-0.02	-0.03	1.00				
9.Life Satisfaction	0.02	-0.24	0.08	0.01	-0.02	0.00	-0.03	0.52	1.00			
10.Sex	-0.21	0.09	-0.17	0.05	-0.03	0.09	0.00	0.01	0.02	1.00		
11.Strain	-0.09	0.48	-0.02	0.09	-0.05	-0.01	-0.09	-0.02	-0.33	0.11	1.00	
12.Permanency of Work	0.25	-0.11	-0.06	0.02	-0.25	-0.09	0.11	0.04	0.01	0.03	-0.04	1.00

Note: All correlations at or above |0.01| are significant at $p < .1$ or below.

Table 6
Study 3 Regressions

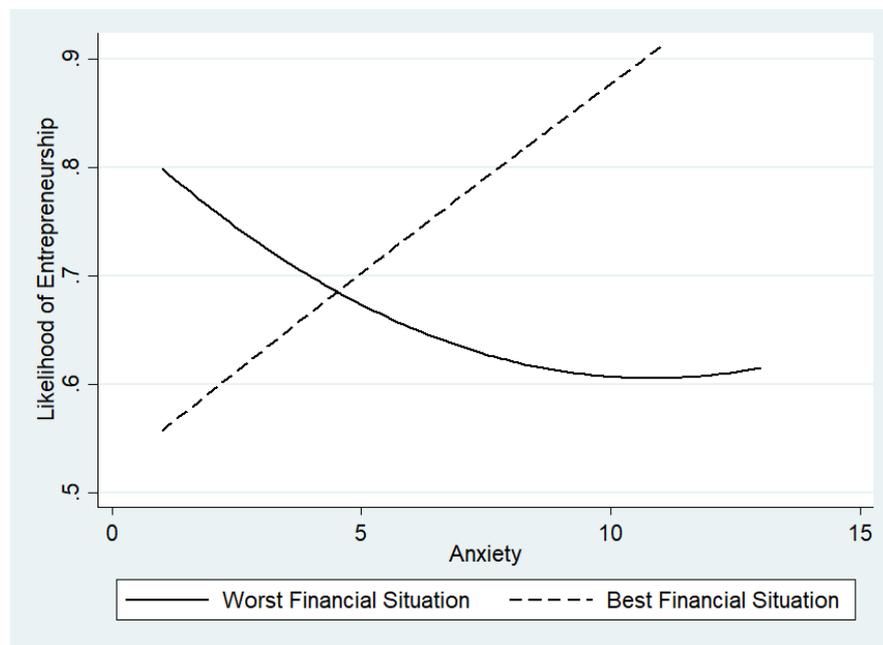
Outcome: Entrepreneurship	(1)		(2)		(3)	
	(RE)		(RE)		(RE)	
	β	z	β	z	β	z
Anxiety			-0.17***	-6.76	-0.19***	-6.69
Anxiety*Financial Situation					0.00	0.89
Financial Situation	0.00***	2.81	0.00***	2.75	0.00	0.86
Education	0.06***	4.21	0.06***	4.50	0.06***	4.52
Age	0.11***	21.07	0.11***	20.62	0.11***	20.62
Expected Future Financial Status	-0.31***	-5.49	-0.31***	-5.39	-0.31***	-5.37
Social Class	0.22***	4.23	0.20***	3.80	0.20***	3.77
Health Satisfaction	-0.03	-1.07	-0.04	-1.19	-0.04	-1.20
Life Satisfaction	0.03	0.64	-0.00	-0.07	-0.00	-0.09
Strain	-0.23***	-3.25	-0.03	-0.41	-0.03	-0.42
Permanency of Work	2.23***	13.44	2.20***	13.09	2.20***	13.08
Sex	-1.42***	-11.48	-1.42***	-11.24	-1.42***	-11.25
Constant	-11.83***	-21.85	-11.46***	-21.03	-11.43***	-20.92
Observations		23,936		23,936		23,936
Number of Cases		15,113		15,113		15,113

Table 6 (continued)

Outcome: Entrepreneurship	(4)		(5)		(6)		(7)	
	(FE)		(FE)		(FE)		(FE)	
	β	z	β	z	β	z	β	z
Anxiety			-0.17***	-3.30	-0.26***	-3.69	-0.39***	-3.48
Anxiety*Financial Situation					0.00**	1.97	0.00**	2.20
Financial Situation	0.00*	1.69	0.00*	1.79	-0.00	-0.62	-0.00	-1.43
Education	0.117	0.91	0.14	1.07	0.17	1.19	0.17	0.81
Age	0.18***	3.87	0.16***	3.37	0.15***	3.12	0.60***	7.08
Expected Future Financial Status	-0.02	-0.19	-0.01	-0.12	-0.02	-0.17	0.03	0.13
Social Class	0.06	0.54	0.09	0.78	0.09	0.79	0.05	0.26
Health Satisfaction	-0.01	-0.15	-0.02	-0.30	-0.03	-0.44	-0.15	-1.23
Life Satisfaction	-0.02	-0.16	-0.05	-0.42	-0.05	-0.47	0.14	0.84
Strain	-0.11	-0.67	0.05	0.31	0.06	0.36	0.39	1.44
Permanency of Work	1.33***	4.71	1.29***	4.44	1.34***	4.54	1.25***	2.51
Sex								
Constant								
Observations	582		582		582		420	
Number of Cases	246		246		246		178	

Note: RE = random effect; FE= fixed effects. Models 4, 5, 6, and 7 have less number of observations because of the lack of variation in our entrepreneurship measure across time. ***p < .01, **p < .05, *p < .1

Figure 3
Anxiety and likelihood of entrepreneurship in Study 3



4.4.4. Study 4

Although studies 2 and 3 use a Fixed Effects approach and account for various factors that may confound our estimates, Fixed Effect models only control for factors that do not change overtime. For instance, if early family characteristics change overtime, the Fixed Effects estimator would not capture their influences on both anxiety and the likelihood of self-employment. A robust way to address this problem is to use a twin design. A twin design acts as a Quasi-experiment that controls for all factors shared between twins, including genetic factors and all shared environmental factors such as family environments, cohort influences, and neighborhood effects (Ashenfelter & Rouse, 1998; Shane et al., 2010b). Hence, in this study we sample a cross-section of twins from the USA to examine the relationship between anxiety and the tendency to become self-employed.

Sample

MIDUS 1 is regarded as the first national sample of US twin pairs. A number of 1,996 twins were recruited to participate in this wave. Yet, 1,103 individuals with complete information contribute to our analyses.

Measures

Entrepreneurship: The outcome is measured by asking respondents if they are employed, or self-employed. Self-employed individuals were coded as one and employees were coded as zero.

Anxiety: As in Study 2, we measure anxiety using the calculated panic score for each individual (Kessler et al., 1998a).

Financial Situation: We measure individuals' financial situation by asking respondents about their financial situation on a scale from 1 to 10, with 0 corresponding to the worst financial situation and 10 corresponding to the best financial situation (Kim et al., 2018).

Controls: We control for age, rearing status, years twins lived together, and education (Arvey et al., 2016; Nicolaou et al., 2017). We also control for sex and zygosity for analyses involving both monozygotic and dizygotic twins. We do not control for age in models employing the twin-twin estimator because all twins have the same age.

Analysis and Results

Within-twin estimation. Our correlation matrix shows that anxiety is significantly negatively correlated with the tendency of people to engage in self-employment (see table 7). The within twin estimator is a fixed effects approach. It uses monozygotic twins to control for the influences of all genetic factors and common environmental factors such as familial environments by subtracting the within twins means of all variables included in the models from their observed values for all twins. Therefore, if an individual is not self-employed, the co-twin has to be self-employed; otherwise, there will be no within-twin variation. For this reason, in our estimations, only 18 twins contribute to our analysis of monozygotic twins. Hence, we were not able to estimate our models using the within twin estimator.

Correlated random effects estimation. An alternative way is the correlated random effects estimator. It employs a Fixed Effects approach, removes selection biases, provides less confounded coefficients and controls for numerous self-selection

effects by adding another predictor to the model; the mean of anxiety with each twin pair (Ashenfelter & Rouse, 1998; Petersen & Aarøe, 2015).

Table 7 presents the correlations. It shows that anxiety is negatively correlated with the tendency to engage in self-employment. Table 8 presents the regressions. We first use only monozygotic twins (i.e. 426 twins). In model 1, we run our analysis with the control variables only. In model 2, we add anxiety as well as the average of anxiety within twin pairs and in model 3 we include the interaction term of anxiety and financial situation. Since twins share various factors, many of the variables of interest tend to be correlated within each pair of twins. Accordingly, we use the clustered standard error formula to allow for serial correlation between twins within each family (Stock & Watson, 2014). We find an insignificant negative relationship between anxiety and the tendency to become self-employed. Including the interactive effect of anxiety and financial situation, we find a negative relationship between anxiety and the tendency to become self-employed. We also find a significant positive interactive effect of anxiety and financial situation on the tendency to engage in self-employment. We re-estimate the models using both monozygotic and dizygotic twins (i.e. 1,103). Specifically, in model 4 we re-estimate our analysis using control variables only. In model 5, we add anxiety and the average of anxiety within twin pairs. We find an insignificant negative relationship between anxiety and the tendency to become self-employed. In model 6, we include the interactive effect of anxiety and family financial situation. Consistent with the previous studies, we find a significant negative relationship between anxiety and the likelihood of self-employment. We also find evidence supporting our hypothesis that financial situation moderates the relationship between anxiety and the tendency to become self-employed (see figure 4).

Table 7
Study 4 Correlations

	1	2	3	4	5	6	7	8	9
1.Entrepreneurship	1.00								
2.Anxiety	-0.18	1.00							
3.Financial Situation	-0.06	-0.12	1.00						
4.Education	-0.04	0.00	0.09	1.00					
5.Sex	0.01	0.22	-0.08	-0.17	1.00				
6.Zygosity	-0.06	-0.04	-0.06	-0.01	0.03	1.00			
7.Reared with Biological Parents	-0.06	0.17	-0.09	-0.09	0.06	-0.03	1.00		
8.Reared with Adoptive Parents	0.06	-0.17	0.10	0.09	-0.06	0.03	-0.99	1.00	
9.Total years with co-twin	-0.09	-0.11	0.04	0.07	-0.00	-0.21	-0.31	0.30	1.00

Note: All correlations at or above |0.02| are significant at $p < .1$ or below.

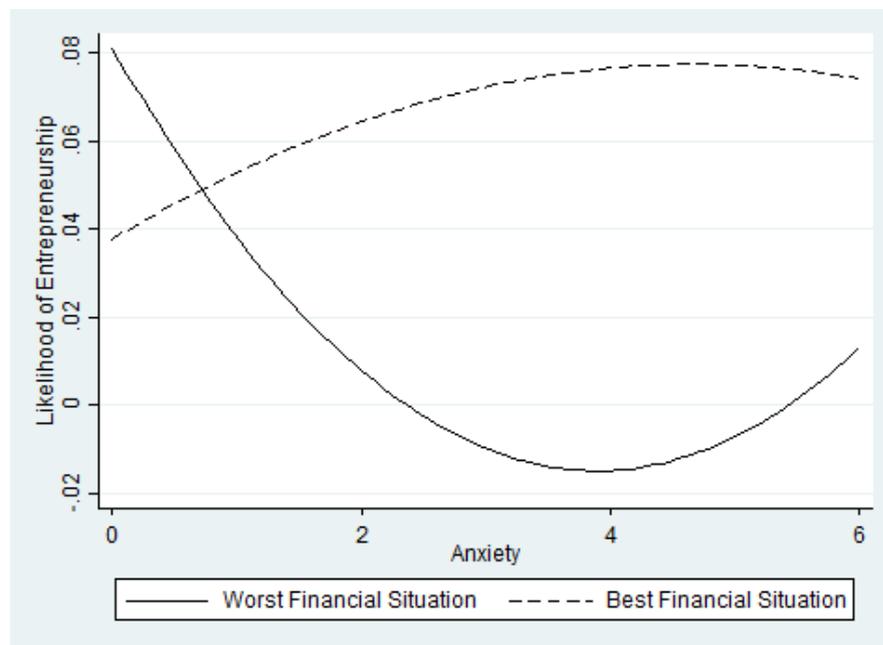
Table 8
Study 4 Regressions

Outcome: Entrepreneurship	(1)		(2)		(3)		(4)		(5)		(6)	
	Monozygotic Twins only						Monozygotic and Dizygotic Twins					
	β	z	β	z	β	z	β	z	β	z	β	z
Anxiety			-0.72	-1.22	-2.40*	-1.90			-0.28	-0.94	-3.24**	-2.10
Anxiety*Financial Situation					0.25**	2.02					0.40**	2.17
Financial Situation	-0.26*	-1.66	-0.27*	-1.70	-0.31*	-1.82	-0.07	-0.66	-0.07	-0.67	-0.12	-1.18
Education	0.04	0.26	0.06	0.39	0.07	0.42	-0.05	-0.59	-0.05	-0.55	-0.04	-0.47
Sex	0.53	0.76	0.57	0.84	0.57	0.83	0.02	0.05	0.05	0.13	0.03	0.10
Zygoty							-0.26	-1.17	-0.26	-1.15	-0.25	-1.09
Mean of Anxiety	0.01	0.02	0.37	0.73	0.41	0.79	-0.24	-0.80	-0.03	-0.08	-0.00	-0.00
Reared with Biological Parents							-1.59	-0.92	-1.67	-0.94	-2.13	-1.16
Reared with Adoptive Parents							-0.18	-0.74	-0.20	-0.77	-0.27	-1.03
Total years with co-twin	-0.00	-0.04	-0.01	-0.05	-0.01	-0.07	-0.10	-1.35	-0.10	-1.35	-0.11	-1.34
Constant	-4.39	-1.47	-4.41	-1.49	-4.26	-1.41	2.27	0.55	2.40	0.57	3.90	0.90
Observations	426		426		426		1,103		1,103		1,103	
Number of Cases	269		269		269		720		720		720	

Note: MZ = monozygotic; DZ= dizygotic.

***p < .01, **p < .05, *p < .1

Figure 4
Anxiety and likelihood of entrepreneurship in Study 4



4.4.5. Study 5

Although Studies 1, 2, 3, and 4 use longitudinal data, fixed effects regression and twin studies to examine the relationship between anxiety and the tendency to engage in entrepreneurship and use clinical measures to assess anxiety, there can still be some potential for reverse causality. To address this issue, we use a measure of anxiety that was assessed at the age of 7 before individuals joined the labor market. To account for further endogeneity issues, we employ an instrumental variable approach using data collected in a period of over 40 years.

Sample

We use the UK NCDS dataset which monitors more than 17,000 individuals born in 1958 in England, Scotland, and Wales. This dataset was initially designed to investigate the social and obstetric factors related to stillbirth, and infant mortality. Sample units were followed up at the ages of 7, 11, 16, 23, 33, 41, 46, 50, and 55 to monitor their health, education, social, economic, and biomedical information using different methods such as paper, electronic, and self-reported questionnaires, clinical records, medical examinations, ability tests, physical measurements, educational

assessments, and diaries. Data is available separately for each wave, and we have a total of nine waves. We cross-linked the last six waves that include self-employment information, and wave two which includes anxiety data. In this study, 3,538 individuals with complete information contribute to our analysis.

Measures

Entrepreneurship: The outcome is measured by asking respondents about their occupations. Self-employed individuals were coded as one, and all other occupational groups were coded as zero (Blanchflower & Oswald, 1998).

Anxiety: We measure anxiety using the teacher-rated Bristol Social Adjustment Guide (BSAG) assessed at the age of 7. Extant studies show that the BSAG is a valid indicator of anxiety (Jæger & Holm, 2012; McDermott, 1980; Montgomery et al., 1999; Stansfeld et al., 2011). It captures 12 syndromes; specifically, anxiety, depression, anxiety for acceptance by other children, unforthcomingness, writing off of adults, and adult standards, withdrawal, restlessness, inconsequential behavior, miscellaneous nervous symptoms, miscellaneous symptoms, hostility towards adults, and hostility towards other children.

Financial Situation: Financial situation is assessed by asking individuals about their financial status on a scale from 1 to 5, with 5 corresponding to *finding it very difficult*, and 1 corresponding to *living comfortably* (Brown, 2010). We reverse the scale to be consistent with the previous studies.

Controls: We control for sex, ethnicity, mother and father occupation, and whether the person has neurosis, or not (Lindquist et al., 2015; Nicolaou et al., 2017; Stephan, 2018).

Instruments: We use two instruments; mother age at time of birth and mother smoking variability during pregnancy. We justify our instruments below.

Analysis and Results

Table 9 lists the correlations between the different variables in the study. Table 10 presents the regressions – we employ a Logit function because of the binary nature of the outcome. In model 1, we run the analysis with the control variables. In model

2, we include anxiety. We find a significant negative relationship between anxiety and the tendency to become self-employed. In model 3, we add the interaction term of anxiety and the tendency to engage in self-employment. We find support for our interaction hypothesis, specifically a positive interactive effect of anxiety and financial situation on the tendency to engage in self-employment (see figure 6). As self-employed individuals may include non-entrepreneurs such as taxi drivers, we examine our hypotheses in model 4 after dropping self-employed cases who have no employees. We find similar results.

To alleviate concerns about endogeneity, we employ a Two-stage Least Squares approach, using two exogenous instruments, specifically mother smoking during pregnancy, and age of mother at the time of birth. Our instrumental variables need to be; 1) associated with anxiety and 2) uncorrelated with the error term (Delis et al., 2017). Extant studies suggest that maternal smoking (Thapar et al., 2003), and mother age during birth (Repetti, Taylor & Seeman, 2002) may influence the mental health of the offspring. Moreover, there is no research indicating that those factors influence the tendency of the offspring to engage in self-employment. We examine the validity of our instruments by reporting the Hansen's J-test of overidentifying restrictions and find that the two variables are exogenous (Chi-squared p-value is 0.7876, and J-statistic = 0.073). We also conduct the Cragg-Donald Wald F-test to examine whether our instruments are weak. The test rejects the null of weak identification with F-statistic value equal to 13.31 (>10) (Stock & Watson, 2014) and indicates that our instrumental variables could be utilized to examine the effect of anxiety. Therefore, our tests show strong statistical support for our instrumental-variable specification in the analysis of the relationship between anxiety and the tendency to engage in self-employment.

There are two ways to estimate Two-stage Least Squares models with binary longitudinal outcomes; the Pooled Correlated Random Effects Probit Regression, and the Two-stage Instrumental estimation (Wooldridge, 2010). Hence, we first use Pooled Correlated Random Effects Probit estimations. We adjust the standard errors to allow for serial correlation across time by using the cluster-robust standard error option within each cross-sectional identifier (Petersen & Aarøe, 2015; Stock &

Watson, 2014). As presented in Table 10 in model 5, we find a significant negative relationship between anxiety and the tendency to become self-employed. For further fidelity, we re-estimate our model using the Two-stage Instrumental estimation procedure in model 6. However, running the analysis in two stages may result in inaccurate standard errors (Papke & Wooldridge, 2008; Semykina & Wooldridge, 2010; Stock & Watson, 2014). For this reason, we use a bootstrapping procedure to account for the potential biases in standard errors and obtain adequate estimates (Guan, 2003). We replicate the negative relationship between anxiety and the likelihood of self-employment. As the factors affecting self-employment are likely to affect individuals' financial situation as well, we limit our instrumental variables specification to the influence of anxiety on the likelihood of self-employment, but we do not adopt this approach in the interaction analysis.

Figure 5

Anxiety and likelihood of entrepreneurship in Study 5

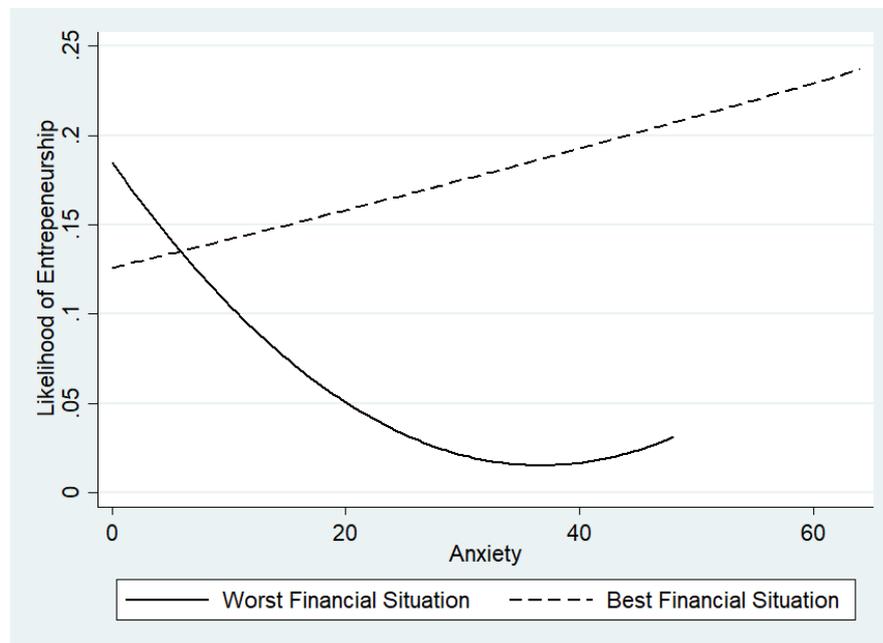


Table 9
Study 5 Correlations

	1	2	3	4	5	6	7	8	9	10
1. Entrepreneurship	1.00									
2. Anxiety	-0.02	1.00								
3. Mother Smoking during Pregnancy	-0.03	0.03	1.00							
4. Mother Age at Birth time	-0.00	-0.00	-0.01	1.00						
5. Financial Situation	0.03	-0.10	0.01	-0.01	1.00					
6. Sex	-0.31	-0.18	0.00	-0.01	0.01	1.00				
7. Ethnicity	0.09	0.18	0.08	-0.07	-0.06	-0.21	1.00			
8. Father Occupation	-0.05	0.08	0.02	-0.03	-0.07	0.02	0.08	1.00		
9. Mother Occupation	-0.03	0.06	0.03	0.00	-0.04	-0.00	-0.12	0.31	1.00	
10. Neurosis	-0.09	0.12	-0.03	-0.00	-0.07	0.17	-0.83	0.06	0.04	1.00

Note: All correlations at or above |0.02| are significant at $p < .1$ or below.

Table 10
Study 5 Regressions

Outcome: Entrepreneurship	(1)		(2)		(3)		(4)		(5)		(6)	
	(RE)		(RE)		(RE)		(RE)		(Pooled-IV)		(2SLS Bootstrap)	
	β	z	β	z	β	z	β	z	β	z	β	z
Anxiety			-0.03***	-2.73	-0.10**	-2.50	-0.18**	-1.97	-0.10**	-2.04	-0.57*	-1.65
Anxiety*Financial Situation					0.02*	1.77	0.04*	1.90				
Financial Situation	0.01	0.08	-0.00	-0.05	-0.13	-1.27	0.01	0.40	-0.05	-1.05	-0.41	-1.53
Sex	-2.06***	-12.94	-2.14***	-13.09	-2.14***	-13.04	-0.92*	-3.36	-0.59***	-6.21	-3.39***	-4.10
Ethnicity	0.47	1.25	0.53	1.40	0.50	1.32	0.30	0.56	0.24*	1.65	1.42*	1.92
Father Occupation	-0.06**	-2.26	-0.05**	-2.07	-0.05**	-2.04	-0.05	-0.99	0.01	0.45	0.03	0.56
Mother Occupation	-0.03	-0.80	-0.02	-0.67	-0.02	-0.68	-0.11*	-1.69	0.01	0.51	0.04	0.68
Neurosis	-0.71	-0.88	-0.62	-0.75	-0.60	-0.73	0.73	0.70	0.16	0.58	1.22	0.89
Constant	-4.73***	-7.81	-4.54***	-7.31	-3.99***	-5.87	-6.99***	-6.26	0.04	0.05	-0.28	-0.10
Observations	9,056		9,056		9,056		7,265		8,818		8,818	
Number of Cases	3,538		3,538		3,538		2,852		3,442		3,442	

Note: RE = random effect; Pooled-IV = pooled instrumental variable.

***p < .01, **p < .05, *p < .1

4.5. DISCUSSION

Recent research has drawn attention to the role of mental conditions in entrepreneurship. Though anxiety is the most prevalent mental condition worldwide (Bystritsky et al., 2013), extant studies relating anxiety to entrepreneurship have been mixed. Research suggests that revisiting the RST is required to shape and ground the relationship between anxiety and the tendency to engage in entrepreneurship (Geenen et al., 2016; Lerner et al., 2018a). The RST suggests that identifying the role of anxiety in entrepreneurship depends on the activations of the BIS and BAS and requires measures that match clinical settings (Lerner et al., 2018b). Responding to this call, this paper invokes the RST and examines the influence of anxiety on the tendency to engage in entrepreneurship using measures of anxiety that were previously used for clinical diagnoses in five samples from Finland, the UK and the US. Across the studies, we find evidence of a negative relationship between anxiety and the tendency to engage in entrepreneurship.

Our findings also show evidence of the moderating role that financial situation plays in the relationship between anxiety and the tendency to engage in entrepreneurship. This result suggests that improving the financial situation of individuals attenuates the negative influence of anxiety on the tendency to engage in entrepreneurship. In doing so, we revisit and explicate the role of the RST in entrepreneurship by providing the first empirical evidence supporting the argument of Geenen et al. (2016) who suggest that the interaction between the BIS and the BAS plays an important role in the relationship between anxiety and entrepreneurship.

Moreover, we used three different measures of entrepreneurship; self-reported entrepreneurial activity, business ownership, and self-employment, in our studies. While we find consistent results in studies using self-reported entrepreneurial activity, and self-employment, study two that uses business ownership as a proxy to measure entrepreneurship shows no significant interactive effects of anxiety and financial situation on business ownership. Authors argue that based on the outcome variable, the RST “disguises possible distinct sub-scale-specific effects and thereby, potentially contributes to the emergence of inconsistent results” (Geenen et al., 2016, p. 205). In

this regard, Lerner et al. (2018a) argue that identifying any significant associations between the BIS, the BAS and entrepreneurial outcomes is dependent on the entrepreneurial activity in question. This suggests that our measures may not be measuring the same entrepreneurial activity. Therefore and building on arguments that both self-employment and business ownership may include non-entrepreneurs such as taxi drivers and farmers (Henrekson & Sanandaji, 2014), in three studies, we run robustness checks on self-employed individuals who only have subordinate employees and exclude individuals who are sole self-employed – the operationalization that has been previously adopted by other researchers to capture the entrepreneurial activity of individuals (e.g. Toft-Kehler, Wennberg & Kim, 2014; Wennberg, Wiklund, DeTienne & Cardon, 2010). We obtain similar results and find a significant interactive effect of anxiety and financial situation on the tendency to engage in entrepreneurship.

4.6. IMPLICATIONS FOR THEORY AND PRACTICE

Our paper has several implications for theory, and practice. First, our research furthers our understanding of the role of mental conditions in entrepreneurship. To date, the few studies that have examined the influence of mental conditions on the tendency to engage in entrepreneurship have tended to focus on ADHD, narcissistic personality disorder, bipolar disorder, obsessive-compulsive personality disorder, dyslexia, and depression (Anglin, Wolfe, Short, McKenny & Pidduck, 2018; Hessels et al., 2018; Johnson, Madole & Freeman, 2018; Logan, 2009; Nofal et al., 2018; Wiklund et al., 2017a; Wolfe & Patel, 2017a). By uncovering a significant relationship between anxiety and the likelihood of engaging in entrepreneurship, we contribute to the small but growing body of research on mental conditions in entrepreneurship. Building on prior research that links anxiety to various mental conditions (Follmer & Jones, 2018; Follmer & Jones, 2017; Stephan, 2018), our findings represent an important step into examining how mental conditions may influence the tendency of people to become entrepreneurs.

Second, our study shows that while mental health; specifically, anxiety, can inhibit the tendency of people to engage in entrepreneurship, improving people's financial situation can assuage these negative influences. This finding revisits and

explicates the contribution of the RST to entrepreneurship in two ways. First, it addresses the problem of inconsistent findings on the role of the BIS in entrepreneurship by showing that the influence of the BIS on entrepreneurial outcomes can be dependent on individuals' financial situations. Second, to our knowledge, it provides the first empirical evidence of the interactive role of the BIS and BAS in entrepreneurship. In other words, although researchers argue that there are conflicts between the dimensions of the BIS, such as fear, and the BAS, such as financial rewards, which in turn influence the tendency of people to engage in entrepreneurship (Corr, 2002; Geenen et al., 2016), there has been no research examining such interactive effects. By investigating the interactive impact of two key dimensions of the BIS and BAS, specifically anxiety and financial situation, on the tendency to engage in entrepreneurship, we contribute to this literature.

Overall, our research responds to various calls. Specifically, Hessels et al. (2018) argue that research is challenged to obtain a deep understanding of the complex relationships between mental conditions and entrepreneurship given the sparseness of empirical data on such topics. By providing evidence of an interactive effect using five different samples from three different countries, we try to address this call. Moreover, we address other calls for more research relating mental conditions to management outcomes (Follmer & Jones, 2018; Wiklund et al., 2017b). In addition, we empirically respond to the problem of having mixed propositions about anxiety and entrepreneurial outcomes (Shepherd & Patzelt, 2017).

Finally, our work adds to research on the dark side of entrepreneurship (DeNisi & Alexander, 2017) by showing that anxiety negatively influences the tendency of people to engage in entrepreneurship. The negative aspects of entrepreneurial characteristics have largely been ignored (Miller, 2015), and research has been unclear about whether contextual factors can counterbalance for extremely high levels of certain characteristics (DeNisi, 2015).

We also contribute to practice by highlighting the importance of maintaining good mental health for functioning in entrepreneurship. We highlight the importance of considering financial factors to attenuate the negative effects of mental conditions, such as anxiety, on entrepreneurial outcomes. We emphasize that it is critical for

companies to address anxiety to increase the likelihood that people inside their organizations engage in corporate entrepreneurship and corporate venturing activities.

4.7. LIMITATIONS AND FUTURE RESEARCH

This research has several limitations. First, the dependent variables used in our studies focus only on exploitative aspects of entrepreneurship. It is subsequently important for future research to investigate the influence of anxiety on other entrepreneurial outcomes, such as entrepreneurial orientation and opportunity recognition.

Second, our study examines two pathways through which anxiety may influence the tendency to become an entrepreneur; anxiety direct effects, and interactions with financial situation. Yet, the RST suggests that other environmental factors such as potential rewards may interact with anxiety to influence the likelihood of becoming an entrepreneur. Thus, further research on other environmental moderators is needed. Moreover, research should also investigate interactions between mental conditions, and other biological factors, such as cortisol, to fully understand the conditions contributing to the relationship between anxiety and the tendency to engage in entrepreneurship. Anxiety could also influence the likelihood of engaging in entrepreneurship through other psychological factors and attitudes. Therefore, future research should examine potential mediators to further our understanding of the relationship between anxiety and the propensity to be an entrepreneur.

Third, despite the ongoing efforts to investigate the role of mental conditions, including ADHD, depression, and OCPD, in entrepreneurship, further research on other mental conditions such as dyslexia, bipolar, autism, and schizophrenia is needed to uncover how people with these mental conditions react to entrepreneurship. This would also speak to practice; for instance, as evidence on ADHD has changed many of the long-held beliefs about the ability of people with ADHD to join entrepreneurial careers, further studies on these mental conditions could be of a similar level of importance.

4.8. CONCLUSION

In this study, we highlight the importance of good mental health for engaging in entrepreneurship. We also emphasize the importance of environmental factors, such as financial situation, in attenuating the negative effects of poor mental health on the tendency to engage in entrepreneurship. These findings contribute to our understanding of the role of mental conditions in entrepreneurship. We conclude by encouraging future research on the relationship between other mental conditions and entrepreneurship.

Chapter 5: Breastfeeding and Entrepreneurship

5.1. ABSTRACT

There is increasing evidence of the role of biological factors in the tendency to engage in entrepreneurship. In this paper, we contribute to this literature by exploring for the first time the relationship between breastfeeding duration and the likelihood of engaging in entrepreneurship using two longitudinal datasets from the UK. After partly mitigating endogeneity concerns using the Mundlak-Chamberlain estimator and two-stage least squares instrumental variable regression, we find a positive relationship between breastfeeding duration and the tendency to become an entrepreneur. We also propose a mediating psychological mechanism – openness to experience – to explain this relationship.

5.2. INTRODUCTION

“Some people are more likely than others to come up with new business ideas, start companies, and engage in the other activities that entrepreneurs undertake” by dint of their biology (Shane & Nicolaou, 2015a, p. 71). Although research has uncovered various biological predispositions to entrepreneurship (Nofal et al., 2018; Unger et al., 2015), we still know very little about the role of early life biological factors in entrepreneurship. This is surprising, given that early life biological factors can have a very large role in the development of adult outcomes (Petersen & Aarøe, 2015). In this paper we attempt to partly fill this gap by examining for the first time the relationship between breastfeeding duration and the tendency to engage in entrepreneurship.

“Breastfeeding has evolved over millions of years as a multitiered interaction to meet the biological and psychological needs of the progeny, enhancing its well-being and survival chances” (Raju, 2011, p. 257). The importance of breastfeeding not only exists because of the nutritional value of the milk but also due to the social aspect of the experience of breastfeeding. Specifically, the time, the gaze, and the verbal interactions infants and mothers have during breastfeeding promote various psychological traits and attitudes that develop early in life and become relatively stable in adulthood, such as self-efficacy (Cable, Bartley, McMunn & Kelly, 2011), intelligence (Gale & Martyn, 1996), openness to experience, and agreeableness (Sutin et al., 2016), which can influence numerous adult outcomes including the tendency to engage in entrepreneurship. Yet, we do not know whether breastfeeding plays a role in entrepreneurship.

Moreover, researchers have suggested that openness to experience is an important pathway linking biology to entrepreneurship (Shane & Nicolaou, 2015a). Building on this evidence as well as studies showing that a) breastfeeding duration positively influences openness to experience (Sutin et al., 2016), and b) openness to experience is an important predictor of entrepreneurship (Zhao & Seibert, 2006), we propose a mediating psychological mechanism – openness to experience – to explain the relationship between breastfeeding duration and entrepreneurship.

After partly accounting for endogeneity using two longitudinal datasets, we show a positive relationship between breastfeeding duration and the tendency to engage in entrepreneurship. We also find that openness to experience mediates this association.

This paper makes the following contributions. First, we contribute to the growing literature on the biological foundations of entrepreneurship (Rauch & Frese, 2007; Unger et al., 2015). While there is work in entrepreneurship on hormones, genetics, and mental conditions, there is limited research on the role of early-life biological factors in entrepreneurship (Nofal et al., 2018). We add to this literature and fill a void recently raised by Nofal et al. (2018, p. 17), who argue that “research in this area is characterized by being highly conceptual with limited empirical evidence”.

Second, we contribute to the literature on the long-term effects of breastfeeding on personality development (Sutin et al., 2016). By uncovering the mediating role of openness to experience, we show that breastfeeding is vital for personality development, which can have important occupational consequences. Moreover, we respond to the call for “more integrated, longitudinal research on birth” in psychology to reveal how psychological and biological components shaped in early life may relate to adult outcomes (Saxbe, 2017, p. 81).

5.3. THEORY DEVELOPMENT

Neonatal factors and early childhood experiences affect various adult outcomes (Petersen & Aarøe, 2015). For instance, research shows that neonatal factors influence occupational earnings (Black et al., 2007), human capital accumulation (Figlio et al., 2014), intelligence (Goisis et al., 2017), educational attainment (Conley & Bennett, 2000), openness to experience, extraversion, neuroticism, agreeableness, conscientiousness, risk-taking (Schmidt et al., 2008), and adaptation (Hahn-Holbrook, Holt-Lunstad, Holbrook, Coyne & Lawson, 2011).

5.3.1. Breastfeeding and Entrepreneurship

An important neonatal factor that plays a large role in adult outcomes is breastfeeding (Sutin et al., 2016). It is one of the first behaviors that individuals engage in after birth. “It is a process in which physical, biochemical, hormonal, and

psychosocial exchange takes place between the mother and her infant” (Raju, 2011, p. 257). In this sense, it offers various psychological benefits that are vital for the development of various adult outcomes (Gale & Martyn, 1996). For instance, research shows that breastfeeding is positively associated with openness to experience and optimism, and negatively related to neuroticism, anxiety, and hostility (Sutin et al., 2016). Evidence also suggests that being breastfed positively contributes to psychological well-being in adulthood (Cable et al., 2011). Further research indicates that breastfeeding is positively associated with the cognitive functioning of individuals in early and middle childhood (Mortensen, Michaelsen, Sanders & Reinisch, 2003). Other evidence suggests that individuals who are breastfed have fewer behavioral problems (Liu, Leung & Yang, 2013). Breastfed individuals report higher intelligence scores in adulthood (Mortensen, Michaelsen, Sanders & Reinisch, 2002). Additionally, there is evidence of a positive relationship between breastfeeding and educational achievement in childhood and adulthood (Horwood & Fergusson, 1998). Moreover, studies report a positive influence of breastfeeding on parent-child relationship (Weaver, Schofield & Papp, 2018). Furthermore, research indicates that breastfeeding is positively correlated with socioemotional development (Metwally et al., 2016).

Some of these factors explain who becomes an entrepreneur. For instance, studies show that breastfed individuals tend to be more open to experience (Sutin et al., 2016), and entrepreneurs tend to be the same (Zhao & Seibert, 2006). Moreover, people who are breastfed have been shown to exhibit variations in some behavioral patterns that are associated with the tendency to engage in entrepreneurship, such as attention deficit hyperactivity disorder, bipolar disorder, and depression (Johnson et al., 2018; Liu et al., 2013; Nofal et al., 2018). Thus, some of the factors previously related to breastfeeding also affect entrepreneurship.

In addition, extant literature supports a plausible relationship between breastfeeding and the tendency to engage in entrepreneurship. Specifically, invoking the developmental origins theory that posits that neonatal factors and early life experiences influence numerous adult outcomes (Rillamas-Sun, Sowers, Harlow & Randolph Jr, 2012), neonatal factors, including breastfeeding, can play an important role in entrepreneurship. Bioactive components of breast milk facilitate the

development of individuals' immune system and reduce inflammation which affects individuals' psychological functioning (Sutin et al., 2016), which can in turn influence their tendencies towards entrepreneurship (Nofal et al., 2018). Moreover, as Raju (2011, p. 257) argues, "an infant suckling at his or her mother's breast is not simply receiving a meal, but is intensively engaging in a dynamic, bidirectional, biological dialogue". In fact, breastfeeding promotes a sensory dialogue between the mother and the infant creating a dynamic interaction which makes individuals more open to engage in various behaviors, such as entrepreneurship. Individuals who experienced, for instance, the formation of social bonds with their mothers during breastfeeding may be more open towards engaging in entrepreneurship. Therefore, we expect a positive association between breastfeeding duration and the tendency to engage in entrepreneurship.

Hypothesis 1: There is a positive association between breastfeeding duration and the tendency to engage in entrepreneurship.

5.3.2. Breastfeeding, Openness to Experience and Entrepreneurship

Whether through biology or through other psychological and social outcomes, openness to experience is a key predisposing factor that may explain the relationship between breastfeeding and the tendency to engage in entrepreneurship. It has been related to breastfeeding through both a social and a biological mechanism. Socially, breastfed individuals are assumed to have experienced stronger bonding with their mothers encouraging them to be more explorative and open to experience (Raju, 2011). Biologically, breastfeeding is reflective in terms of the nutritional status of individuals. The lack of breast milk directs a newborn's oxygen and nutritional stores towards survival rather than brain development, which has long run consequences for mental development (Aboud & Yousafzai, 2015). Researchers thus argue that the personality of a malnourished individual is less likely to have completely developed leading to lower openness to experience (Sutin et al., 2016). Therefore, whether through the social aspects or through biology, evidence suggests that breastfed individuals may be more open to experience.

At the same time, there is evidence that entrepreneurship is a better fit for people who are open to experience. A person high in openness to experience is more likely to recognize entrepreneurial opportunities and engage in entrepreneurship (Zhao & Seibert, 2006). Research suggests that biological factors, including genetic factors, and hormones such as oxytocin, influence openness to experience which affects the tendency to engage in entrepreneurial activities (Nofal et al., 2018). Thus, the influence of biological factors on openness to experience and the tendency to engage in entrepreneurship combined with the reported associations between breastfeeding and openness to experience, as well as the relationships between openness to experience and entrepreneurship, suggest that part of the influence of breastfeeding on the tendency to engage in entrepreneurship may be through openness to experience.

Hypothesis 2: Openness to experience mediates the relationship between breastfeeding duration and the tendency to engage in entrepreneurship.

5.4. METHODS

To test our hypotheses, we use the British Cohort Study of 1970 (BCS) and the National Child Development Study (NCDS). As various individual and familial factors can influence both breastfeeding duration and the tendency of the off-spring to engage in entrepreneurship, our models can suffer from omitted variable biases. Therefore, we account for endogeneity in two ways. Specifically, in the first study, we account for endogeneity using the Mundlak-Chamberlain estimator, while in the second study we address the potential endogeneity by adopting an instrumental variable approach, and test for mediation. We present our studies in turn.

5.4.1. Study 1

Sample

The BCS70 is a longitudinal cohort study that followed the lives of around 17,000 individuals in Britain since April 1970. Since then, there have been eight ‘sweeps’ of all cohort members at ages 5, 10, 16, 26, 30, 34, 38, and 42. The BCS70 collects information on health, physical, educational, and social development, economic circumstances, and other factors.

We follow Leslie, Manchester, Park and Mehng (2012) and use cases with complete information. This results in a final sample of 547 individuals.

Measures

Entrepreneurship: The dataset includes respondents' occupations. We constructed our binary outcome by coding self-employment as one and other occupations as zero for each year. In addition, because self-employment may include non-entrepreneurs such as farmers and taxi drivers, we examine the robustness of the results by limiting our analyses to self-employed individuals who have employees (Wennberg et al., 2010).

Breastfeeding duration: Information about breastfeeding practices was collected from the mother when individuals were 5 years old. Mothers were asked about the duration of breastfeeding with choices ranging from never fed to more than three months [1: Never breast-fed; 2: Breastfed for up to one month; 3: Breastfed for over a month to three months; 4: breastfed for over three months].

Controls: We control for a number of factors that could influence our results (Sutin et al., 2016). Specifically, we control for the age of the mother, maternal education, social rating of the neighbourhood, number of individuals in the household, birth order, the birth weight of the offspring, the education of the offspring, mother employment status, whether the mother and the respondent have ever separated, ethnicity, and gender. We also control for the financial status of the individual. Moreover, as mothers of twins find it more difficult to breastfeed their offspring compared to mothers of singletons, we control for whether our sample units are twins or singletons.

Analysis and Results

Table 1 presents the correlations, while table 2 presents the regressions. Fixed effects estimation does not apply because our independent variable does not change across time. This means that subtracting the average duration of breastfeeding from the reported values of the duration of breastfeeding will not estimate the coefficients as the whole variable will be removed from the model. Therefore, we use random effects estimation. One way to reduce endogeneity and control for factors that are fixed

over time is to apply the Mundlak-Chamberlain estimator. This “model produces the estimators of β_1 that are identical to usual fixed effects estimators” (Semykina & Wooldridge, 2010, p. 17). This is because “the unobserved effects are proxied by the observables which are time averages of the independent variables and this helps in dealing with more general unobserved heterogeneity” (Araujo, Lastauskas & Papageorgiou, 2017, p. 1532). Thus, in applying this estimator, we include the means of all time-varying covariates as predictors within the random effects model (Gayle & Lambert, 2018; Mundlak, 1978).

The correlation matrix shows that breastfeeding duration is significantly positively correlated with the likelihood of engaging in entrepreneurship. Our regressions present six models and two different operationalisations of the dependent variable. In model 1, we estimate our model with the controls only. In model 2, we include the duration of breastfeeding and find a significant positive relationship between breastfeeding and the tendency to become self-employed. Applying the Mundlak-Chamberlain estimator in model 3 we find similar results that support the first hypothesis. Because self-employment may include non-entrepreneurs such as taxi drivers, in models 4, 5, and 6 we drop all cases that report themselves as self-employed with no employees (Wennberg et al., 2010), and replicate the findings (see table 2).

Table 1
Study 1 Correlation Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1. Entrepreneurship	1.00													
2. Breastfeeding duration	0.08	1.00												
3. Financial Situation	-0.01	-0.04	1.00											
4. Education	-0.18	0.11	-0.06	1.00										
5. Sex	-0.26	-0.04	0.06	0.07	1.00									
6. Ethnicity	-0.09	-0.11	0.03	-0.04	0.29	1.00								
7. Mother Education	-0.02	0.33	-0.02	0.21	-0.07	-0.05	1.00							
8. Birth Order	0.06	-0.02	0.06	-0.10	-0.14	0.02	-0.16	1.00						
9. Mother Age	-0.03	0.05	0.04	0.03	-0.03	-0.01	-0.02	0.45	1.00					
10. Twin Status	-0.21	-0.95	-0.06	-0.07	-0.29	0.29	-0.08	0.46	0.12	1.00				
11. Household Number	0.06	0.07	0.03	-0.08	-0.10	0.11	-0.12	0.81	0.23	0.30	1.00			
12. Mother Employment Status	0.13	-0.02	0.02	-0.01	-0.12	-0.27	0.08	0.10	0.01	0.14	-0.04	1.00		
13. Separation from the mother	0.29	-0.17	0.07	-0.09	0.05	0.09	-0.04	0.01	0.09	-0.02	0.03	-0.09	1.00	
14. Neighbourhood Rating	0.04	0.10	0.03	0.08	-0.03	-0.05	0.20	-0.05	0.12	-0.08	-0.08	-0.03	0.03	1.00

Note: All correlations at or above |0.04| are significant at $p < 0.05$ or below.

Table 2
Study 1 Regressions

	(1)	(2)	(3)
		Self-employment	
Breastfeeding duration		0.37** (2.09)	0.32* (1.73)
Financial Situation	0.01 (0.07)	0.01 (0.09)	-0.03 (-0.17)
Education	-0.24*** (-3.26)	-0.25*** (-3.23)	-0.28*** (-3.56)
Sex	-1.58*** (-3.88)	-1.47*** (-3.57)	-1.47*** (-3.59)
Ethnicity	-0.39 (-1.23)	-0.37 (-1.19)	-0.37 (-1.10)
Mother Education	-0.10 (-0.78)	-0.20 (-1.38)	-0.24 (-1.50)
Birth Order	-0.10 (-0.34)	-0.01 (-0.05)	0.08 (0.27)
Mother Age	-0.02 (-0.48)	-0.04 (-0.87)	-0.06 (-1.22)
Household Number	0.21 (0.87)	0.14 (0.59)	0.19 (0.72)
Mother Employment	0.33** (2.38)	0.37*** (2.58)	0.39** (2.49)
Separation	2.28** (2.49)	2.49*** (2.76)	2.20** (2.10)
Neighbourhood Rating	0.08 (0.68)	0.05 (0.40)	0.03 (0.21)
Mean of Education			0.42 (1.33)
Mean of Financial Situation			0.06 (0.16)
Twin Status	-2.01 (-1.15)	-1.78 (-1.01)	Omitted
Constant	-2.65 (-1.62)	-2.31 (-1.38)	-2.60 (-1.44)
χ^2	37.31***	38.73***	38.78***
Observations	2,701	2,681	2,467
Number of Cases	547	543	494

Table 2 (continued)

	(4)	(5)	(6)
	Self-employment with employees only		
Breastfeeding duration		0.44** (2.29)	0.47** (2.07)
Financial Situation	0.16 (0.94)	0.17 (0.97)	0.11 (0.44)
Education	-0.32*** (-3.12)	-0.32*** (-3.14)	-0.36*** (-3.01)
Sex	-1.48*** (-2.79)	-1.34** (-2.52)	-1.36** (-2.34)
Ethnicity	0.03 (0.20)	0.06 (0.35)	0.01 (0.05)
Mother Education	0.12 (0.76)	0.02 (0.12)	-0.02 (-0.08)
Birth Order	-0.47 (-1.47)	-0.36 (-1.13)	-0.29 (-0.83)
Mother Age	0.05 (1.02)	0.02 (0.34)	0.02 (0.27)
Household Number	0.42* (1.72)	0.32 (1.32)	0.25 (0.82)
Mother Employment	0.35** (2.00)	0.38** (2.16)	0.44** (2.09)
Separation	2.03** (1.99)	2.39** (2.32)	1.28 (0.77)
Neighbourhood Rating	-0.06 (-0.40)	-0.07 (-0.45)	-0.04 (-0.24)
Mean of Education			-0.12 (-0.25)
Mean of Financial Situation			-0.21 (-0.33)
Twin Status	0.22 (0.15)	0.59 (0.39)	Omitted
Constant	-7.14*** (-4.20)	-6.56*** (-3.73)	-5.73** (-2.37)
χ^2	31.93***	35.66***	26.27***
Observations	2,370	2,355	2,162
Number of Cases	480	477	433

Note: z-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

The number of observations vary in each model because of the missing values in the breastfeeding duration, education and financial situation variables. Moreover, dropping all cases with missing values in any of the models among all the models yield similar results.

5.4.2. Study 2

Although study one uses a longitudinal sample to capture the influence of breastfeeding duration on the tendency of people to engage in self-employment over time, breastfeeding duration captures various parental factors that can influence the likelihood of self-employment such as family financial situation and socio-economic conditions (Flacking, Dykes & Ewald, 2010). Therefore, the aim of study two is to re-examine hypothesis one using a two-stage least squares instrumental variable approach to try to alleviate the potential endogeneity. We also investigate hypothesis two by examining whether the relationship between the duration of breastfeeding and the tendency to engage in entrepreneurship is mediated by openness to experience.

Sample

The purpose of the National Child Development Study was to investigate the social and obstetric factors related to infant mortality and still births. Respondents were approached at the ages of 7, 11, 16, 23, 33, 41, 46, 50, and 55 to collect information about their health, education, social, economic, and biomedical conditions using different methods, including questionnaires, medical examinations, educational assessments, and diaries. This resulted in nine waves. We cross-linked the waves that include breastfeeding and self-employment information. As in the previous study, we use list-wise deletion of missing cases. Accordingly, 3,138 individuals contribute to our analysis.

Measures

Entrepreneurship: The dataset includes respondents' occupations. We constructed our binary outcome by coding self-employment as one and other occupations as zero for each year. As in the previous study, in our robustness tests, we drop self-employed individuals without employees because self-employment may include non-entrepreneurs such as taxi drivers.

Breastfeeding duration: Information about breastfeeding practices was asked to the mother when individuals were 7 years old [1: Never breast fed; 2: Breast fed under one month; 3: Breast fed over one month].

Openness to experience: Cohort members were administered an openness to experience questionnaire at the age of 50 years using 10 statements (e.g. I am full of ideas, I have a vivid imagination). Cohort members selected their responses on a five-point scale ranging from “1 = very inaccurate” to “5 = very accurate”. The internal consistency reliability is within the acceptable range, with a Cronbach’s alpha value of 0.89.

Instruments: We use four instruments to alleviate endogeneity issues. Specifically, our instruments include: a) the number of antenatal visits the mother did during pregnancy, b) mother smoking during pregnancy, c) rupture of membranes during pregnancy, and d) mother method of delivery in birth. Instruments should be correlated with breastfeeding but not with the likelihood of self-employment (Nicolaou et al., 2017). Theoretically, prior studies argue that these factors may influence breastfeeding practices of the mother (Bell, White-Traut & Rankin, 2013), but we have no evidence showing that these factors influence the tendency of people to become self-employed. For instance, the larger the number of antenatal visits the mothers do during pregnancy, the more nutritional counselling and education they get about the importance of breastfeeding practices (Biks, Tariku & Tessema, 2015). Mother smoking may also affect the taste of breast milk which in turn may disrupt the desire of the offspring to be breastfed (Mennella, Yourshaw & Morgan, 2007). Rupture of membranes during pregnancy as well as mode of delivery are associated with less maternal and perinatal morbidity which in turn affects the ability of the mother to breastfeed the offspring (Kayiga, Lester, Amuge, Byamugisha & Autry, 2018). For example, evidence suggests that mothers who experience caesarean section are more likely to report pain when breastfeeding, and thus breastfeed for a shorter duration (Amy & Sue, 2014). Empirically, we checked a) the Hansen’s J-test of over identifying restrictions which investigates whether our instruments are associated with the error term, and b) the Cragg-Donald Wald F-test which examines whether our instruments are weak. Both tests support the choice of our instruments. Thus, we have both theoretical and statistical support for the choice of our instruments.

Controls: Consistent with study one as well as extant literature, we control for the age of the mother, whether the person is a twin or singleton, maternal education,

birth order, birth weight, mother marital status at birth, ethnicity, gender, education, and the financial status of the individual. Furthermore, because mental conditions may influence the tendency of people to engage in entrepreneurship, we control for individuals' mental well-being assessed at the age of 50. We also control for mothers' and fathers' occupations.

Analysis and Results

Table 3 presents the correlations and table 4 presents the regressions. Again, we use random effects estimation because fixed effects estimation does not apply as the duration of breastfeeding variable does not change across time. In addition, we use the Mundlak Chamberlain's estimator in models 3, 4, 7, and 8. The Mundlak Chamberlain's estimator employs a fixed effect approach and accounts for various endogeneity issues by controlling for the means of all time varying covariates (Gayle & Lambert, 2018; Mundlak, 1978).

We estimate eight models. In model 1, we estimate our model with the controls only. In model 2, we include the duration of breastfeeding. We find a significant positive relationship between the duration of breastfeeding and the tendency to become self-employed. We apply the Mundlak-Chamberlain estimator in model 3 and find support for the first hypothesis. To alleviate endogeneity issues, model 4 estimates a two-stage least squares instrumental variable regression. The Hansen's J test shows that that our instruments are exogenous (Chi-squared p-value is 0.2328 and J-statistic = 4.279) and the Cragg-Donald Wald F-test suggests that our instruments are not weak (F-statistic value = 28.95). Our results confirm the positive significant relationship between breastfeeding duration and the tendency to become self-employed. In line with the previous study and as self-employment may include non-entrepreneurs such as taxi drivers, we drop individuals whose activity history shows them as self-employed with no employees. We replicate the same findings in models 5, 6, 7, and 8 (see table 4). In model 8, we re-estimated the Hansen's J-test of over identifying restrictions and the Cragg-Donald Wald F-test. Our results show that our instruments are exogenous and strong (i.e. Chi-squared p-value is 0.1284, J-statistic = 5.678 and F-statistic value = 36.59).

Table 3
Study 2 Correlation Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	
1. Entrepreneurship	1.00																		
2. Breastfeeding duration	0.05	1.00																	
3. Antenatal Visits	0.03	0.05	1.00																
4. Mother's Smoking during Pregnancy	-0.05	-0.04	-0.04	1.00															
5. Rupture of Membranes during Pregnancy	0.02	0.01	-0.01	-0.01	1.00														
6. Mother's Method of Delivery	-0.03	-0.05	-0.02	0.01	-0.06	1.00													
7. Sex	-0.18	-0.01	-0.04	-0.00	-0.05	0.04	1.00												
8. Education	-0.02	0.08	0.04	-0.05	0.04	-0.02	0.02	1.00											
9. Ethnicity	0.02	0.00	-0.04	-0.00	0.01	0.02	0.05	-0.03	1.00										
10. Financial Situation	-0.03	-0.01	-0.05	0.02	0.02	-0.00	-0.00	-0.17	0.06	1.00									
11. Mother Age	-0.02	-0.07	0.00	-0.00	0.01	0.04	-0.01	0.07	0.01	-0.01	1.00								
12. Mother Marital Status	0.08	-0.17	-0.22	0.03	-0.06	-0.01	0.03	0.05	0.09	0.08	-0.38	1.00							
13. Twin Status	0.01	-0.19	-0.03	-0.18	.	0.13	-0.01	-0.01	-0.06	0.02	0.08	-0.08	1.00						
14. Birth Order	0.04	-0.01	0.06	-0.01	0.02	-0.02	-0.01	0.04	-0.05	-0.02	-0.07	-0.05	-0.06	1.00					
15. Mother Education	-0.09	-0.14	0.02	0.13	0.05	-0.07	0.01	-0.33	-0.02	0.07	-0.17	0.04	-0.13	-0.07	1.00				
16. Mental Well-being	-0.01	0.05	0.05	-0.00	0.00	-0.01	0.01	0.12	0.01	-0.20	-0.01	-0.05	-0.04	-0.02	-0.02	1.00			
17. Father Occupation	0.01	-0.08	-0.05	0.02	-0.03	-0.01	-0.02	-0.05	0.01	0.02	0.41	0.08	0.09	0.04	-0.05	-0.01	1.00		
18. Mother Occupation	0.05	-0.04	0.04	-0.01	-0.03	-0.02	-0.01	-0.05	0.06	0.01	0.25	-0.05	0.16	-0.07	0.02	-0.02	0.25	1.00	

Note: All correlations at or above |0.02| are significant at $p < 0.05$ or below.

Table 4
Study 2 Regressions

	(1)	(2)	(3)	(4)
		Self-employment		
Breastfeeding Duration		0.28*** (2.92)	0.28*** (2.90)	
Instrumented Breastfeeding Duration				0.71* (1.69)
Sex	-1.30*** (-8.55)	-1.30*** (-8.05)	-1.30*** (-8.04)	-0.33*** (-2.98)
Education	-0.02 (-0.62)	-0.02 (-0.66)	0.11 (0.62)	0.01 (0.26)
Ethnicity	0.09 (1.25)	0.08 (1.13)	0.08 (1.07)	0.02 (0.85)
Financial Situation	-0.03 (-0.49)	-0.06 (-0.87)	-0.08 (-1.02)	-0.01 (-0.23)
Mother Age	-0.02 (-1.29)	-0.01 (-0.80)	-0.01 (-0.77)	0.00 (0.54)
Mother Marital Status	0.43 (1.41)	0.57 (1.36)	0.57 (1.35)	0.28** (2.41)
Twin Status	0.01 (0.02)	0.27 (0.73)	0.27 (0.73)	Omitted
Birth Order	0.12 (0.71)	0.23 (1.24)	0.23 (1.27)	0.06 (1.04)
Mother Education	-0.42*** (-4.57)	-0.39*** (-4.03)	-0.40*** (-4.10)	-0.03 (-0.37)
Mental Well-being	-0.01 (-0.68)	-0.01 (-0.85)	-0.01 (-0.61)	-0.00 (-0.88)
Father's Occupation	-0.11* (-1.93)	-0.08 (-1.30)	-0.08 (-1.33)	-0.01 (-0.34)
Mothers' Occupation	0.09*** (2.83)	0.07** (2.24)	0.07** (2.23)	0.02** (2.06)
Mean of Education			-0.14 (-0.78)	-0.03 (-0.89)
Mean of Financial			0.13 (0.85)	-0.03 (-0.55)
Constant	-2.77* (-1.82)	-3.72* (-1.87)	-3.95** (-1.98)	-2.44*** (-2.82)
χ^2	100.85***	94.18***	94.29***	141.81***
Observations	9,377	8,483	8,483	7,795
Number of Cases	3,138	2,838	2,838	2,608

Table 4 (continued)

	(5)	(6)	(7)	(8)
	Self-employment with employees only			
Breastfeeding Duration		0.26** (2.57)	0.26*** (2.59)	
Instrumented Breastfeeding Duration				0.86*** (2.99)
Sex	-1.24*** (-7.75)	-1.21*** (-7.15)	-1.21*** (-7.14)	-0.27** (-2.57)
Education	-0.06 (-1.60)	-0.06 (-1.48)	0.08 (0.40)	0.01 (0.23)
Ethnicity	0.09 (1.13)	0.08 (0.91)	0.08 (0.91)	0.014 (0.63)
Financial Situation	-0.07 (-0.90)	-0.09 (-1.24)	-0.09 (-1.03)	-0.01 (-0.25)
Mother Age	-0.03* (-1.92)	-0.03 (-1.54)	-0.02 (*1.53)	0.00 (0.63)
Mother Marital Status	0.63* (1.81)	0.85* (1.67)	0.85* (1.68)	0.32** (2.50)
Twin Status	-0.50 (-1.19)	-0.20 (-0.46)	-0.19 (-0.45)	Omitted
Birth Order	0.09 (0.51)	0.18 (0.93)	0.18 (0.94)	0.06 (1.09)
Mother Education	-0.41*** (-4.23)	-0.39*** (-3.80)	-0.40*** (-3.84)	0.01 (0.10)
Mental Well-being	-0.01 (-0.76)	-0.01 (-0.70)	-0.01 (-0.68)	-0.00 (-1.18)
Father's Occupation	-0.10 (-1.63)	-0.07 (-1.17)	-0.08 (-1.19)	-0.00 (-0.21)
Mothers' Occupation	0.11*** (3.49)	0.10*** (2.92)	0.10*** (2.91)	0.02** (2.03)
Mean of Education			-0.15 (-0.74)	-0.04 (-1.23)
Mean of Financial			-0.01 (-0.04)	-0.05 (-1.20)
Constant	-3.66** (-2.12)	-4.89** (-2.07)	-4.84** (-2.04)	-2.80*** (-3.88)
χ^2	86.94***	77.30***	78.30***	182.52***
Observations	8,758	7,923	7,923	7,298
Number of Cases	2,930	2,650	2,650	2,441

Note: z-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

The number of observations vary in each model because of the missing values in the variables of interest. Meanwhile, dropping all cases with missing values in any of the models among all the models yield similar results.

Mediation Test

Openness to experience was measured only once at the age of 50 years at sweep 8. Therefore, in testing for mediation, we only use the cross-sectional sample of sweep 8. We employ a generalized structural equation model to examine whether openness to experience mediates the relationship between the duration of breastfeeding and the likelihood of self-employment. In table 5a, we present the direct and indirect effects of the duration of breastfeeding on the likelihood of self-employment. Our findings show that openness to experience partially mediates the relationship between breastfeeding and the likelihood of self-employment. We replicate this finding when we drop all self-employed individuals with no employees (see table 5b).

Table 5a

Indirect Effect of Breastfeeding on the likelihood of Self-employment in Study 2

	Path a	Path b	Path c	Path Significance	Overall Indirect Significance
Breastfeeding duration → Openness to Experience	0.20** (2.01)			Sig. at p<0.05	
Openness to Experience → Entrepreneurship		0.03** (2.33)		Sig. at p<0.05	Sig. at p<0.05
Breastfeeding duration → Entrepreneurship			0.14** (2.02)	Sig. at p<0.05	P-value = 0.045

Note: N= 2,674 individuals.

z-statistics in parentheses.

Table 5b
Indirect Effect of Breastfeeding on the likelihood of Self-employment with
Employees only in Study 2

	Path a	Path b	Path c	Path Significance	Overall Indirect Significance
Breastfeeding duration → Openness to Experience	0.19* (1.73)			Sig. at p<0.1	
Openness to Experience → Entrepreneurship		0.04** (2.82)		Sig. at p<0.05	Sig. at p<0.05
Breastfeeding duration → Entrepreneurship			0.15* (1.78)	Sig. at p<0.1	P-value = 0.049

Note: N= 2,573 individuals.

z-statistics in parentheses.

5.5. DISCUSSION

Previous work has shown that neonatal factors are important predictors of various adult outcomes. We extend this evidence by examining for the first time the relationship between breastfeeding duration and the tendency to engage in entrepreneurship. Using two longitudinal samples, we find a significant effect of breastfeeding duration on the tendency to engage in self-employment. Because self-employment may include non-entrepreneurs such as farmers, we exclude self-employed individuals with no employees, and our findings are consistent. It is noteworthy that the effect size of breastfeeding on the tendency to engage in entrepreneurship is greater than the effect sizes of other important factors, such as education and financial situation. In addition, we find evidence that openness to experience partially mediates the relationship between breastfeeding duration and the tendency to engage in entrepreneurship.

Our results have implications for theory. First, although neonatal factors can influence various aspects of human behavior (Petersen & Aarøe, 2015), their influences have been ignored in the entrepreneurship literature, in which physiological

attention has been restricted to the influence of hormones and physical attractiveness (Nofal et al., 2018). By uncovering, for the first time, a relationship between breastfeeding duration and the likelihood of engaging in entrepreneurship, we contribute to the body of research on physiology in entrepreneurship.

Second, studies argue that mediating cognitive and psychological processes explain the role of biology in entrepreneurship (Nofal et al., 2018). Our research provides evidence of this mechanism, suggesting that breastfeeding may predispose individuals to be more open to experience, which affects their tendency to engage in entrepreneurship. In so doing, we contribute to the literature on the long-term influences of breastfeeding on personality development. Specifically, we show that breastfeeding practices significantly matter for personality development and in turn have important occupational consequences.

Our research has implications for practice. Our study suggests that the psychological and social aspects of breastfeeding matter for entrepreneurship. Hence, as researchers argue, even if breastfeeding is not an option, caregivers are advised to engage people early in life in the social environments that make them more open to experience and allow them to acquire the social capabilities necessary for their cognitive, emotional, and social development (Gilead & Liberman, 2014; Sutin et al., 2016), which can improve their tendencies to engage in entrepreneurship.

5.6. LIMITATIONS AND FUTURE RESEARCH

This research has limitations. First, there are other mechanisms that may explain the influence of breastfeeding on the tendency to engage in entrepreneurship (Nofal et al., 2018). For instance, we encourage researchers to examine the interactive role of breastfeeding and other biological factors in entrepreneurship.

Second, this research examines the mediation of openness to experience in the relationship between breastfeeding duration and entrepreneurship. However, the mediation of openness to experience is examined cross-sectionally which might create endogeneity. Therefore, we urge scholars to re-examine this mediation using longitudinal samples and natural experiments of twins and adoptees.

Third, although our study examines two different samples from the UK, our findings cannot be generalized to other countries. Accordingly, future research on samples from other countries may help determine the generalizability of our findings and provide interesting insights as to how such factors may affect the relationship between breastfeeding and entrepreneurship.

5.7. CONCLUSION

This paper highlights the important role that neonatal factors, specifically breastfeeding, play in entrepreneurship. We show that breastfeeding can affect individuals' openness to experience and the tendency to engage in entrepreneurship. These findings contribute to our understanding of the biological perspective in entrepreneurship.

Chapter 6: Conclusion

This thesis contributes to the growing literature on the biology of entrepreneurship. It fills some of the gaps in the literature by systematically reviewing extant research linking biology to management, examining the relationship between birth weight and the tendency of people to become self-employed as well as the association between anxiety and the likelihood of entrepreneurship and investigating the relationship between breastfeeding and the tendency to engage in entrepreneurship.

In so doing, Chapter 2 presents a number of studies that show that the biological basis of entrepreneurship has been a growing research area, with more than 133 journals world-wide publishing at least one article on the biological perspective in management during the past few years (Nofal et al., 2018). It also lays down the mechanisms relating biology to management outcomes and presents an agenda highlighting avenues for future research.

Chapter 3 contributes to the small growing literature on the role of physiology in entrepreneurship. It examines the influence of birth weight on the tendency to become self-employed. It finds evidence for a curvilinear relationship between birth weight and the tendency to become self-employed. This chapter also proposes a mediating psychological mechanism – anxiety – to explain this association and finds support for this.

Chapter 4 expands the literature on mental conditions and entrepreneurship and investigates the relationship between anxiety and the likelihood of engaging in entrepreneurship. The literature on the dark side of entrepreneurship has been largely ignored and research on mental conditions in entrepreneurship has been focusing on mental conditions that positively impact entrepreneurship. In this chapter, we contribute to this literature by exploring the relationship between anxiety and the likelihood of engaging in entrepreneurial activities. Our findings show a negative relationship between anxiety and the tendency to engage in entrepreneurship. Our results also suggest that improving individuals' financial conditions can attenuate the negative influence of anxiety on the propensity to engage in entrepreneurship.

Chapter 5 addresses the gap on the influence of early life biological factors on the tendency to become an entrepreneur. It explores for the first time the relationship between breastfeeding duration and the likelihood of engaging in entrepreneurship and finds a positive relationship between breastfeeding duration and the tendency to become an entrepreneur. In this chapter, we also propose a mediating psychological mechanism – openness to experience – to explain this relationship.

In sum, this thesis aims to contribute to role of biology in entrepreneurship theoretically and empirically. Yet, many gaps still exist. To boost the field forward, 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 proclivity, entrepreneurial biases and entrepreneurs' thinking styles (Nofal et al., 2017; Nofal et al., 2018). Researchers are also urged to provide further empirical evidence showing how biology and environmental factors interact to influence the tendency of people to engage in entrepreneurial outcomes (Quaye et al., 2012a). For example, research examining whether environmental factors, such as organizational support, encouragement, and financial rewards, influence the effect of biology on entrepreneurship. More empirical work is also needed on how people's biological make up can drive them to self-select certain environments to engage in entrepreneurship (Nicolaou & Shane, 2009).

There is also further research pertaining to specific biological strands needed (Nofal et al., 2018). For example, extant work investigating the specific genetic variants influencing entrepreneurship has been unsuccessful, with detected genes explaining very low percentage of the variance of entrepreneurship (Quaye et al., 2012b; van der Loos et al., 2013b). Subsequently, more research is urged to detect other genetic variants related to entrepreneurship. For instance, research on polygenic risk scores may be a useful avenue in this endeavor (Belsky et al., 2016). In addition, existing empirical studies on hormones and entrepreneurship have focused on few hormones, including testosterone, cortisol and epinephrine. Researchers need to examine the influence of hormones, such as serotonin, dopamine, melatonin and oxytocin on entrepreneurship.

Moreover, since research on the role of neurodevelopmental in entrepreneurship has focused on few mental conditions such as ADHD, dyslexia, bipolar and OCPD, other research on other neurodevelopmental disorders is encouraged (Logan, 2009; Wiklund et al., 2018). For instance, researchers are urged to investigate the role of certain mental conditions, such as anxiety, schizophrenia and autism in entrepreneurship. 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).

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Appendix

Table S-1

Keywords and Search Terms

	Genetics		Physiology	Neuroscience
Business	<ul style="list-style-type: none"> ✓ Biology and business ✓ Gene and business 	and	<ul style="list-style-type: none"> ✓ Biology and business ✓ Hormone and business ✓ Testosterone and business ✓ Dopamine and business ✓ Cortisol and business ✓ Oxytocin and business ✓ Serotonin and business ✓ Physiology and business 	<ul style="list-style-type: none"> ✓ Biology and business, ✓ Neuroscience and business
Management	<ul style="list-style-type: none"> ✓ Biology and management ✓ Gene and management 	and	<ul style="list-style-type: none"> ✓ Biology and management ✓ Hormone and management ✓ Testosterone and management ✓ Dopamine and management ✓ Cortisol and management ✓ Oxytocin and management ✓ Serotonin and management ✓ Physiology and management 	<ul style="list-style-type: none"> ✓ Biology and management ✓ Neuroscience and management
Leadership	<ul style="list-style-type: none"> ✓ Biology and leadership ✓ Gene and leadership 	and	<ul style="list-style-type: none"> ✓ Biology and leadership ✓ Hormone and leadership ✓ Testosterone and leadership ✓ Dopamine and leadership ✓ Cortisol and leadership ✓ Oxytocin and leadership ✓ Serotonin and leadership ✓ Physiology and leadership 	<ul style="list-style-type: none"> ✓ Biology and leadership ✓ Neuroscience and leadership

Entrepreneurship	<ul style="list-style-type: none"> ✓ Biology and entrepreneurship ✓ Gene and entrepreneurship 	<ul style="list-style-type: none"> ✓ Biology and entrepreneurship ✓ Hormone and entrepreneurship ✓ Testosterone and entrepreneurship ✓ Dopamine and entrepreneurship ✓ Cortisol and entrepreneurship ✓ Oxytocin and entrepreneurship ✓ Serotonin and entrepreneurship ✓ Physiology and leadership 	<ul style="list-style-type: none"> ✓ Biology and entrepreneurship ✓ Neuroscience and entrepreneurship
Organizational Behavior	<ul style="list-style-type: none"> ✓ Biology and Organizational Behavior ✓ Gene and Organizational Behavior 	<ul style="list-style-type: none"> ✓ 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 	<ul style="list-style-type: none"> ✓ Biology and Organizational Behavior, ✓ Neuroscience and Organizational Behavior
Strategy	<ul style="list-style-type: none"> ✓ Biology and Strategy ✓ Gene and Strategy 	<ul style="list-style-type: none"> ✓ Biology and Strategy ✓ Hormone and Strategy ✓ Testosterone and Strategy ✓ Dopamine and Strategy ✓ Cortisol and Strategy ✓ Oxytocin and Strategy ✓ Serotonin and Strategy ✓ Physiology and Strategy 	<ul style="list-style-type: none"> ✓ Biology and Strategy, ✓ Neuroscience and Strategy

Occupational Health and Safety	✓ Biology and Occupational Health and Safety	✓ Biology and Occupational Health and Safety	✓ Biology and Occupational Health and Safety,
	✓ Health and Safety	✓ Hormone and Occupational Health and Safety	✓ Neuroscience and Occupational Health and Safety
	✓ Gene 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	

Table S-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 management.
2	Metaphor papers	Compare organizational activities to biology only metaphorically and do not look at the relationships between biology and management.
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 management
4	Proxy papers	Use proxies such as age, gender, and ethnicity for biology.
5	Marketing papers	Do not capture management-related phenotypes
6	Accounting, Economics and Finance papers	Do not capture management-related phenotypes

Table S-3
Summary of Literature: Number of Publications in each Area

Research Area	Number of Articles		
	Genetics	Physiology	Neuroscience
1. Entrepreneurship	22	13	10
2. Leadership	13	30	32
3. Organizational Behavior	42	66	73

Table S-4**Moderators and Mediators that Influence the Genetic Effect on Management**

Research Area	Environmental Moderators	Individual Mediators	Environmental mediators	Physiological Mediators
Entrepreneurship	<ul style="list-style-type: none"> • Family environment • Education 	<ul style="list-style-type: none"> • Neuroticism • Extraversion • Conscientiousness • Openness to experience • Agreeableness • Sensation seeking • Entrepreneurial Intentions • Creativity • Intelligence 		<ul style="list-style-type: none"> • Dyslexia • Dopamine
Leadership	<ul style="list-style-type: none"> • Social environment 	<ul style="list-style-type: none"> • Family experience • Work experience • Cultural endorsement • Proactivity • Rule breaking • Social potency • Social achievement • Dispositional hope • Neuroticism • Extraversion • Conscientiousness • Openness to experience • Agreeableness • Intelligence 		<ul style="list-style-type: none"> • Dopamine • Serotonin
Organizational Behavior	<ul style="list-style-type: none"> • Education • Socioeconomic status 	<ul style="list-style-type: none"> • Neuroticism • Extraversion • Conscientiousness • Education • Affect • Cognitive abilities • Stress • Job characteristics • Work values • Age • Pay level 	<ul style="list-style-type: none"> • Job demand • Job control • Job complexity 	<ul style="list-style-type: none"> • Dopamine • Serotonin

Figure S-1
Key Journals



Figure S-2
Inherited Phenotypes (Twin Studies)

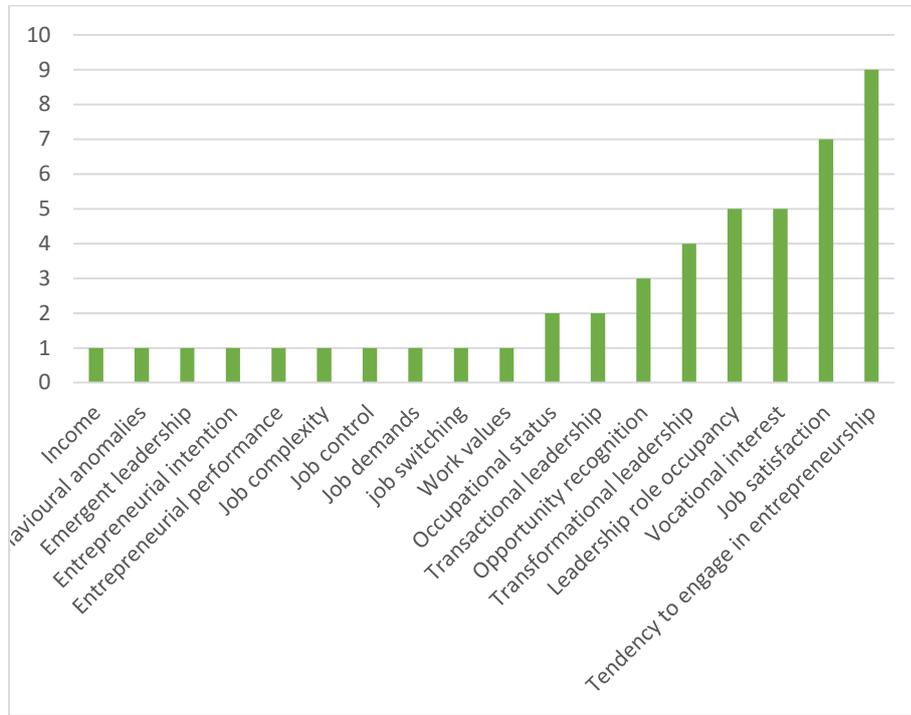


Figure S-3
Testosterone and Organizational Variables

