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Dopamine and entrepreneurship: Unifying entrepreneur personality traits, psychiatric symptoms, entrepreneurial action and outcomes

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ABSTRACT

Research conducted over the last three decades confirms that dopaminergic personality traits (Openness, Extraversion and the Industriousness aspect of Conscientiousness) are prominent among entrepreneurs. We highlight the continuum between dopaminergic traits, dimensions, temperaments, symptoms and psychiatric conditions (bipolar spectrum conditions, ADHD, substance and behavioral addictions, and OCPD) among entrepreneurs, and how behavioral manifestations of this continuum affect entrepreneurial action. Despite the pathological potential, the connection with some favorable outcomes of dopaminergic traits and psychiatric conditions suggests that atypical dopamine physiology may be one biomarker of the neurodiversity that distinguishes, empowers and endangers entrepreneurs. By showing the dopaminergic underpinnings of traits, dimensions, symptoms and conditions among entrepreneurs, we offer a unifying framework that contextualizes findings within the construct of dopaminergic differences – a framework that integrates otherwise isolated findings about the personality traits and psychiatric conditions of entrepreneurs. In other words, the neurodiversity biomarkers and bio-psycho-social characteristics found among entrepreneurs often reflect a polygenic endophenotype that features atypical dopamine physiology.

A cluster of common traits and potentially clinical symptoms in entrepreneurs: So what?

A set of traits and proclivities are often observed in entrepreneurs. At times, these traits and proclivities associate with mental health symptoms and conditions. Understanding the origins and consequences of these is theoretically and practically meaningful. For scholars, understanding of the neuro-psychological underpinnings of entrepreneurial action enables refined theorizing and improved research design. For example, it serves to connect entirely separate lines of entrepreneurship research (that on *personality*, and on *clinical symptoms/conditions*). For policy makers, educators, executive coaches, mental health clinicians, and others engaged with entrepreneurs and their ecosystems – it enables improvements in policy, training, interventions, and support to increase the likelihood that entrepreneurs will achieve better business outcomes and better life outcomes. For would-be and practicing entrepreneurs, it

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enables a grounded basis for enhanced self-awareness and business/decision-making policy – instrumental to harnessing and regulating ones' proclivities and action.

As elaborated in this paper, these common traits and proclivities are unpinned by atypical dopamine physiology. Dopamine is a neurotransmitter and neuromodulator associated with cognition, emotions and behavior required for opportunity recognition and value creation, such as goal engagement. The dopaminergic perspective associated with entrepreneurship connects the (personality) components of Openness, Extraversion, and Industriousness (an aspect of Conscientiousness) – not only with each other, but also to the psychiatric symptoms of bipolar spectrum conditions, attention deficit hyperactivity disorder (ADHD), addictions, and Obsessive-Compulsive Personality Disorder (OCPD). Considering the challenges entrepreneurs face, and that an individual's traits and proclivities interact with the environment—policy makers, those serving entrepreneurs, and entrepreneurs themselves need to consider the individual—environment nexus, and shape it such that the negatives of dopaminergic traits are inhibited while the upsides are empowered for driving entrepreneurial initiatives. Dopaminergic superpowers and vulnerabilities among entrepreneurs can drive both business success and failure, and personal derailment. Knowing this, how can practitioners advance business and life outcomes? Simply stated, self-awareness, emotion regulation, behavioral regulation, and self-care (e.g., adequate sleep, excerise, diet) should be core competencies for entrepreneurship.

1. Introduction

Two, *seemingly* independent, lines of entrepreneurship research have examined the relevance of *personality* and of *psychiatric conditions*. Dopaminergic differences underpin both personality traits and psychiatric conditions implicated in venturing. The neurodivergence reflected by dopaminergic personality traits and the symptoms of associated dopaminergic mental health conditions may differentiate entrepreneurs from neurotypical managers and employees (e.g., Hunt et al., 2022). This paper explores the neurodiversity associated with atypical dopamine neurophysiology among entrepreneurs. It is expressed through an affective-cognitive-behavioral continuum that links personality facets, traits and *trans*-diagnostic dimensions with sub-threshold temperaments, affective states, mental health symptoms, and associated psychiatric conditions.

Three decades of research confirms the prominence of dopaminergic personality traits (Openness, Extraversion, and the Industriousness aspect of Conscientiousness) among entrepreneurs (see review by Kerr et al. 2018). Relatedly, a yet separate and evolving literature suggests that entrepreneurs show elevated levels of dopaminergic psychiatric conditions such as bipolar spectrum conditions, ADHD, addiction (including behavioral addictions), and obsessive-compulsive personality disorder (e.g. Freeman et al., 2018; Johnson et al., 2018; Hunt et al., 2022; Wolfe and Patel, 2017). In essence, dopaminergic traits and psychiatric symptoms are, on average, elevated among entrepreneurs as compared with managers and can be associated with venturing success (e.g. Hunt et al., 2022; Wolfe et al. 2020).[2]

We contribute to the literature by elaborating that the neurodivergent features commonly found among entrepreneurs reflect an underlying polygenic endophenotype, and that one biomarker of this endophenotype features atypical dopamine physiology. Phenotype refers to an organism's observable characteristics and traits including its behavior. A phenotype reflects the interaction of an organism's underlying genetic code, or genotype, with the environment (Wojczynski & Tiwari, 2008). Endophenotype refers to heritable and measurable intermediary phenotypes associated with genotypes that code for conditions such as bipolar disorder and ADHD, as well as other medical conditions (Rommelse et al., 2008; Walters and Owen, 2007). Endophenotype biomarkers include physiological, biochemical, endocrinological, anatomical, cognitive, and neuropsychological differences (Gottesman and Gould, 2003).

By identifying neurodivergent features of entrepreneurs, we provide fresh neuroscience-based perspective on research defining common characteristics of entrepreneurs. Rather than validating correlated variables, such as achieved in the Big Five traits, our approach stresses the neurodiverse origins of individual differences in a more meaningful and biologically-based way. We discuss the co-occurrence of many dopaminergic conditions among entrepreneurs, and provide a unifying theoretical framework that contextualizes findings within the construct of dopaminergic differences. The co-occurrence of dopaminergic characteristics, in turn, defies the mechanistic perspective that looks at the effects of isolated traits or characteristics of entrepreneurs. Thereby, our theorizing contributes to the view that there is no single mechanism (biological or otherwise) that results in effective entrepreneurship (Rietveld et al., 2021). Rather, akin to the three varied individual cases elaborated by Lerner et al. (2018: p58-62), we propose that dopamine-fueled micro-successes build upon themselves in an iterative and incremental success cascade flowing from repeated activation and enactment of sub-threshold dopaminergic traits like ambition, goal pursuit, perseverance, creativity, sociability and positive affect; traits that are associated with bipolar disorder, ADHD, substance use and behavioral addictions, and OCPD.

2. Theoretical foundations

We propose that atypical dopamine physiology plays a central role in shaping personality traits associated with venturing, and that those traits are often associated with dopaminergic psychiatric symptoms and conditions among entrepreneurs. Dopaminergic personality traits are known to facilitate business outcomes in a nuanced manner. For example, positive affect and Extraversion facilitate relationship building, social capital formation and goal engagement; however excessive socializing and euphoria can

[2] To be sure, it is absolutely **not** our contention that all entrepreneurs are similar in this regard.

interfere with executing business operations (Baron et al. 2011; McCabe and Fleeson, 2012). Extreme positive affect and Extraversion are cardinal symptoms of Bipolar Disorder (APA, 2013). The relationship between dopaminergic psychiatric symptoms and business results may also be nuanced. For example, impulsivity (a *trans*-diagnostic personality dimension which is a feature of both ADHD and bipolar spectrum conditions) facilitates the energy, speed and action-orientation required for success – but can also lead to reckless mistakes that create adverse business outcomes (Wiklund, Tucker & Marino, 2017). Relatedly, Lerner et al. (2018: p272) elaborate a dualism model where dopaminergic disinhibition both helps and challenges key activities throughout the entire venturing process.

2.1. Dopaminergic dimensions of entrepreneur personality

Personality is a complex construct that reflects the interaction of persistent neuro-behavioral response predispositions and broad classes of environmental stimuli. Personality traits are embedded in the brain's intrinsic functional neural network architecture (Adelstein et al., 2011; Sampaio et al., 2014; Cai et al., 2020). Heritability is estimated to be around 50% (Bouchard and McGue, 2003; Jang et al., 1996). The Big Five personality traits are Openness, Extraversion, Conscientiousness, Agreeableness, and Neuroticism (McCrae et al., 2008). Each of these traits consist of more narrow sub-traits, called facets (DeYoung et al., 2007; DeYoung, 2010; Jang et al., 1998, 2002). Moreover, originally viewed as independent traits, the Big Five personality traits have been found to inter-correlate within two higher-order metatraits, *Plasticity* and *Stability* (Chang et al., 2012; DeYoung, 2006, 2010, 2013; DeYoung and Gray, 2009; Digman, 1997). Stability is the higher-order metatrait that reflects the shared variance of Neuroticism, Agreeableness, and the Orderliness aspect of Conscientiousness. It represents the tendency to restrain emotions and behavior that could be disruptive – and is primarily related to serotonin (DeYoung, 2010). Plasticity is the higher-order metatrait that reflects the shared variance of Openness, Extraversion and the Industriousness aspect of Conscientiousness; it represents the tendency to explore and engage with possibilities, and reflects the personality manifestations of dopaminergic functioning (DeYoung, 2013).

The dopaminergic system is composed of value coding and salience coding neurons. Dopamine is a neurotransmitter and neuromodulator that plays an overarching role in motivation and a range of behaviors associated with personality traits that are advantageous for entrepreneurship. They predispose people to respond to the environment with dopaminergic behaviors that include sensation and novelty seeking, exploration and approach behavior, opportunity recognition, goal engagement, impulsivity, aggression, achievement striving, creativity, and cognitive abilities (DeYoung, 2013). In relation to venturing, dopamine is posited to motivate reward seeking through the discovery of salient information (opportunity recognition), and through the achievement of goals that lead to rewards (value creation) (Bromberg-Martin et al., 2010; DeYoung, 2010, 2013).

The Big Five personality traits of entrepreneurs have been extensively studied, and relationships with entrepreneurship and performance are well validated (Zhao et al., 2010). Specifically, the five dopaminergic aspects (Openness, Intellect, Enthusiasm, Assertiveness, Industriousness) of three personality traits (Openness, Extraversion, Conscientiousness), are prevalent among successful entrepreneurs (Baum and Locke, 2004; Brandstätter, 2011; Rauch, 2014; Rauch and Frese, 2007; Zhao and Seibert, 2006). While this pattern has been demonstrated repeatedly (see Kerr et al., 2018 for a review), a compelling underlying theoretical explanation of this pattern is, to our knowledge, hitherto lacking. Here, we clarify that the personality trait profile of entrepreneurs includes all of the dopaminergic traits and aspects of the Plasticity meta-trait.

2.2. Dopaminergic physiology and psychiatric conditions of entrepreneurs

The relationship between personality and psychiatric conditions suggests that genetic and neurophysiological factors contribute to both risk for mental health conditions and to variations in personality, that certain personality traits predispose to an enduring vulnerability to certain conditions, that the continuum between traditionally-defined traits and symptoms of psychopathology is more dimensional than categorical, and that it is of interest to determine the genetic contribution to covariation between personality and condition risk (Kendler and Myers, 2010; Krueger et al., 2018; Patzelt et al., 2018). The bidirectional or interactive, inter-regulating effect that personality traits and psychiatric disorders have upon each other is dynamic, reflecting the complex interplay between genes, environmental influences, personality trait enactment and psychiatric symptom activation (Perlstein and Waller, 2022).

We suggest that the genetic and neurophysiological factors that relate to dopaminergic personality traits and associated dopaminergic mental health conditions also contribute to a propensity for entrepreneurship and high variance (including successful) business outcomes. These co-occurring dopaminergic personality traits and mental health conditions are seen as one set of biomarkers of a highly polygenic entrepreneur endophenotype. For example, the Industriousness aspect of Conscientiousness can be associated with a compulsive behavioral dimension characterized by an inability to stop (DeYoung et al., 2007; Lozano and Johnson, 2001). Thus, mental health conditions that have been associated with Industriousness reflect this *trans*-diagnostic dimension, as seen in both obsessive-compulsive personality disorder (OCPD)[3] and addiction, including behavioral addictions (Gorgievski et al., 2014; Yücel et al., 2021). People with "entrepreneurship addiction" can't stop launching businesses (Spivack and McKelvie, 2021). People with substance use problems can't stop drinking and/or self-medicating with drugs. Impulsivity and reward sensitivity are associated with emotional and risky decision-making (Penolazzi et al., 2012), that sometimes leads to positive entrepreneurial outcomes (Wiklund

[3] OCPD has received less attention from entrepreneurship researchers, and due to page-length limitations is not elaborated in the paper. However, it may also be associated with entrepreneurial success (Wolfe and Patel, 2017), and merits further investigation.

et al., 2017). Substance use has also been linked to the impulsivity and reward sensitivity found among people with ADHD and bipolar disorder (Wilbertz et al., 2012; Ramírez-Martín et al., 2020; Boog et al., 2013). This transdiagnostic tendency to choose smaller immediate rewards over larger delayed rewards is modulated by individual differences in dopamine processing in mesolimbic and mesocortical areas (Hahn et al., 2011).

The following sections briefly discuss the dopaminergic conditions of bipolar disorder, ADHD, and addiction – with regard to dopaminergic physiology and entrepreneurship. Thereafter, Table 1 outlines many of the core research papers, covering these three areas and the overall topic.

2.2.1. Dopamine, bipolar disorder, and entrepreneurship

Bipolar disorder, also known as manic-depressive illness, is a largely genetically transmitted neuropsychiatric brain condition with heritability estimated to be as high as 85% (McGuffin et al., 2003). Bipolar conditions cause shifts in mood, energy, sleep, activity levels, cognition, and functioning including pursuit of ambitious goals. Dopamine is a central tenant of bipolar pathophysiology (DeYoung, 2013). Relatedly, trait hypomania and full-blown bipolar disorder are positively associated with dopaminergic personality traits including Extraversion, Openness (DeYoung, 2013; Meyer, 2002; Schalet et al., 2011; Tackett et al., 2008) and the Industriousness aspect of Conscientiousness (Lozano and Johnson, 2001). The same genotype effects are also significantly associated with Openness to Experience at a phenotypic trait level (Peciña et al., 2013).

There is growing evidence suggesting elevated bipolar spectrum conditions are often found among entrepreneurs with positive business outcomes (Akiskal et al., 2005; Biasi et al., 2015; Hunt et al., 2022; Wolfe et al., 2020). This relationship is possibly due to the fact that bipolar spectrum conditions feature dopaminergic characteristics that facilitate entrepreneurship, such as ambition, goal orientation, creativity, perseverance, sociability and positive affect.

Bipolar disorder rarely occurs without the co-occurrence of other mental health conditions and some of these conditions are also elevated among entrepreneurs. For example, bipolar disorder co-occurs frequently with anxiety disorders (42–75% co-occurrence), ADHD (31.4%), and substance use disorders (42.3%) (McElroy et al., 2001; Merikangas et al., 2007) as well as with behavioral addictions (Di Nicola et al., 2010).

2.2.2. Dopamine, ADHD, and entrepreneurship

Attention Deficit/Hyperactivity Disorder is largely a genetically transmitted neuropsychiatric condition that is characterized by impulsivity, hyperactivity, distractibility and atypical motivational states under normal circumstances. Heritability is estimated to be 76% (American Psychiatric Association (APA), 2013; Faraone et al., 2005). The dopaminergic basis of ADHD has been well established by genetic, neuroimaging, and stimulant medication studies (Volkow et al., 2011).

ADHD is a heterogeneous condition with subtypes. Genome-wide association studies and psychometric evaluations of large samples consistently identify ADHD subtypes with elevated Extraversion, and in some cases elevated Openness, reduced Conscientiousness, reduced Agreeableness and baseline Neuroticism; a trait cluster which is suited to entrepreneurship.

Several studies validated a relationship between entrepreneurship and ADHD (e.g., Lerner et al., 2019; Verheul et al., 2016; Hunt et al., 2022). Notably, certain facets of ADHD – hyperactivity-impulsivity, but not inattention – appear particularly germane to entrepreneurship. ADHD rarely occurs in the absence of other mental health conditions. High rates of co-occurrence of ADHD with bipolar disorder are common (Merikangas et al., 2007; McElroy et al., 2001; Sobanski, 2006). ADHD often co-occurs with depression (35% co-occurrence), anxiety disorders (40–60%), substance use disorders (50%), and behavioral addictions (Andreassen et al., 2016; Groen et al., 2013; Yen et al., 2009). Due to the disabilities and comorbidities associated with ADHD, a large body of research suggests that ADHD is associated with diminished life outcomes on average. However, subsets of people with ADHD appear well equipped to excel at entrepreneurship (e.g., Wiklund et al., 2019).

2.2.3. Dopamine, addiction and entrepreneurship

Addiction refers to repetitive engagement in behaviors that are initially rewarding, coupled with loss of control that enables increased engagement over time, tolerance, persistence despite adverse consequences, craving, and withdrawal states (Grant and Chamberlain, 2016). Behavioral addictions parallel substance addictions in their natural history, phenomenology, tolerance, comorbidity, overlapping genetic contribution, neurobiological mechanisms, loss of control, persistence despite awareness of adverse consequences, and response to treatment (Volkow and Boyle, 2018). Reward seeking is the core behavioral feature of addiction. Addictive behavior triggers reward signaling and reward input processing in the mesolimbic dopamine pathway (Koob and Volkow, 2010; Potenza, 2015). Dysregulation of dopamine physiology in neural circuits is intimately linked to both chemical and behavioral addictions (Alcaro et al., 2007; Potenza, 2013, 2015).

Like other behavioral addictions, entrepreneurship addiction urges and surges are triggered (disinhibited) by social and environmental cues (Keskin et al., 2015; Murdoch et al., 2007; Spivack et al., 2014) – such as dynamic market conditions, new opportunities, and active investors with limited investment-time horizons (Wright et al., 1997). Recent work has suggested dopamine as pivotal in the shift from entrepreneurial passion to addiction (Sinha, 2022).

Table 1
Sample Studies involving Dopamine, Personality, Psychiatric Symptoms, and Entrepreneurship.

Paper	Method	General Findings
General Studies		
DeYoung (2013)	Review	Develop theory about dopaminergic personality traits.
DeYoung (2010)	Review	Theorizing about the relationship between Big Five traits and neurobiology.
Lerner et al. (2018)	2 cross-sectional studies: sample of 132 business students, and sample of 99 full-time entrepreneurs	Differential BIS/BAS components predictive of nascent entrepreneurial behavior (in business students), and of venture performance (in entrepreneurs).
Freeman et al. (2018)	Self-report survey examining the prevalence and co-occurrence of five psychiatric conditions among 242 entrepreneurs and 93 comparisons	Mental health directly or indirectly affected 72% of the entrepreneurs in this sample, including those with a personal mental health history (49%) and family mental health history among the asymptomatic entrepreneurs (23%).
Leung et al. (2020)	Survey responses of 182 university students	Study looks at various psychiatric symptoms (inattention, hyperactivity, narcissism, and hypomania), BAS and entrepreneurial intention.
Gish et al. (2022)	Review	Summarizes 23 studies involving the nexus of entrepreneurship and mental health published in Journal of Business Venturing Insights.
Bipolar Spectrum Conditions		
Lo et al. (2017)	Meta-analysis	High relationship between openness and bipolar disorder.
Barnett et al. (2011)	participants with bipolar	Manic symptoms were associated with increased Extraversion in conjunction with decreased Agreeableness.
Akiskal et al. (2005)	263 psychiatric outpatients	Entrepreneurs have a three-fold rate of manic tendencies compared to other professional groups.
Biasi et al. (2015)	National cohort study of 3,361,472 employed Danish adults	Persons who had been treated with lithium–a medication commonly prescribed for the treatment of mania–were more likely to be self-employed compared to the general population, more likely to incorporate their business, and more likely to have income in the top 10% of employed adults.
Freeman et al. (2018)	Self-report study of entrepreneurs in a convenience sample	11% (of 242) entrepreneurs reported having bipolar spectrum disorder compared to a prevalence of 1% among (93) comparison participants.
Hunt et al. (2022)	2 samples involving: representative selection of 1049 entrepreneurs & 1060 managers; and 38 Inc 500 high-growth entrepreneurs	On bipolar spectrum (HPS): Entrepreneurs > Managers; Super Entrepreneurs > Typical Entrepreneurs. Within entrepreneurs, linked to various positive entrepreneurial outcomes.
ADHD		
Verheul et al. (2015)	10,104 students	Scores on the World Health Organization ADHD Self-Report Scale (ASRS) related to higher entrepreneurial career intentions.
Verheul et al. (2016)	Two samples: $n = 7208$ sampled from STAGE cohort of the Swedish Twin Registry; and $n = 13,112$ Dutch students of the GUESSS study	Symptoms of hyperactivity-impulsivity, but not inattention were related to entrepreneurship. ADHD diagnosis increased odds of becoming an entrepreneur by 1.13.
Wiklund et al. (2016)	Multiple case study of 14 entrepreneurs with ADHD diagnosis	Various qualitative insights.
Lerner et al. (2019)	large-scale data collection (N = 9869) and cross-sectional methodology	Positive connection between clinical ADHD and entrepreneurial intentions as well as entrepreneurial action.
Hunt et al. (2022)	2 samples involving: representative selection of 1049 entrepreneurs & 1060 managers; and 38 Inc 500 high-growth entrepreneurs	ADHD: Super Entrep. > Typical Entrep; Super Entrep. > Managers. Within Entrepreneurs: ADHD hyp/impulsivity linked to various positive entrepreneurial outcomes.
Wiklund, Yu, Tucker & Marino, 2017	Longitudinal data of 545 MBA alumni	Hyperactivity is positively associated with entrepreneurial preferences; inattention was negatively associated with entrepreneurship.
Thurik et al. (2016)	306 small business owners	Hyperactivity-impulsivity, but not inattention were related to entrepreneurship.
Dimic and Orlov (2015)	103 participants diagnosed with ADHD and 167 comparison participants	Participants diagnosed with ADHD endorsed significantly greater intent to become an entrepreneur, and diagnoses of ADHD increased the odds of becoming an entrepreneur three-fold.
Voros and Lukovszki (2021)	A randomly selected Hungarian sample of 190 entrepreneurs and 186 organizational employees	ADHD impairs subjective income and health perceptions for entrepreneurs, more so than for wage employees.
Shirokova et al. (2022)	610 Russian SMEs	Managers with hyperactivity/impulsivity ADHD symptoms exhibited greater innovativeness, proactiveness, and risk-taking, while managers with inattention ADHD symptoms exhibited opposite effects.
Tucker et al. (2021)	243 MBA Alumni, time lagged study	People with ADHD may not be efficacious in the entrepreneurial context, and specifically in recognizing opportunities.
Nicolaou et al. (2011)	1335 participants	A single nucleotide polymorphism (rs1486011) of the DRD3 gene on chromosome 3 to be significantly associated with the tendency to be an entrepreneur.
Mannuzza et al., 1993	Prospective research, 91 children with ADHD and 95 controls followed for 16 years	19% of participants with ADHD versus 5% of controls owned and operated their own business as adults.
Addiction		
Spivack et al. (2014)	Interviews with two habitual entrepreneurs	Authors' identify behavioral addiction to entrepreneurship, how addiction symptoms manifest, and aspects of the entrepreneurial experience that reinforce behavioral addiction. (Also, a subsequent measurement study by Spivack and McKelvie, 2021.)

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Table 1 (*continued*)

Paper	Method	General Findings
Lin et al. (2003)	505 employed bus drivers and 506 self-employed bus drivers in Taiwan	Significant elevations in alcohol use among the self-employed group.
Dahl et al. (2010)	A matched case-control study of psychotropic medication prescription among 6221 first time Danish entrepreneurs	Increased prescription of sedative-hypnotic medication in the first two years after starting a business.
Leignel et al. (2014)	1282 self-employed French lawyers and 1153 self-employed French pharmacists	Elevated psychological distress among both groups, significant elevation in cigarette and anxiolytic medication consumption among the lawyers, and significant elevations in smoking, problematic alcohol use, and use of anxiolytic and hypnotic medication among the pharmacists.
Andreassen et al. (2016)	Web-based cross-sectional survey assessing symptoms of psychiatric disorders and workaholism/work addiction among 16,426 Norwegian workers	Elevated rates of ADHD among the 7.8% of this population that met criteria for work addiction. While 32.7% of workaholics had ADHD, only 12.7% of non-workaholics presented with this condition ($p < 0.001$). Rates of obsessive compulsive disorder, anxiety and depression were also elevated among the workaholics. Self-employment (entrepreneurship), higher education, and higher income were also found to be positively associated with work addiction.
Thorgen & Wincent, 2015	704 Swedish habitual and novice entrepreneurs	Obsessive passion was observed among habitual entrepreneurs in association with increased time spent on work, conflict with other life spheres, and ruminations about work.
Gorgievski et al. (2014)	Cross-sectional survey data of 180 Spanish entrepreneurs	Work addiction is related to more negative affect, which in turn is related negatively to performance.
OCPD		
Wolfe and Patel (2017)	43,093 respondents of the 2001–2002 National Epidemiologic Survey on Alcohol and Related Conditions (NESARC 1) survey	OCPD is associated with being self-employed; the relationship is stronger for males and younger individuals.

3. Discussion

Neurodiversity and its affective-psycho-social-behavioral consequences are one dimension of the answer to the fundamental questions of why some people (and not others) venture, and to what ends. Evidence that has accumulated since the mid-1980s suggests that entrepreneurs and those with the propensity for entrepreneurship often reflect a polygenic endophenotype through which dopaminergic differences are pervasively expressed as personality traits, temperaments, sub-threshold mental health symptoms, syndromes, and full-blown psychiatric conditions. These mental health differences co-occur in varying combinations, can be inhibited and disinhibited, and fluctuate in intensity within the intrinsic propensities of the entrepreneur and extrinsic features of the entrepreneurial context, environment, and journey.

Our work, and related studies (see Table 1) suggest that the form of neurodiversity found among entrepreneurs can empower them with dopaminergic success-building positive cognitive, social, emotional and behavioral traits, exceptional motivation, innovativeness and dynamic creativity, indefatigable perseverance, contagious enthusiasm and magnetic charisma. Concurrently, more extreme presentations of these biobehavioral propensities endangers entrepreneurs and their ventures with vulnerability to the disabilities and adverse outcomes associated with more severe symptoms of bipolar disorder, ADHD, OCPD, and perhaps behavioral or substance addiction.

While these traits and symptoms may advantage smart, independent, dominant, iconoclastic, motivated and otherwise unemployable entrepreneurs who thrive in thrilling high-demand, high-risk, high-control startup settings that give them autonomy – they may disadvantage employees and managers who are called upon to fit in and function in high-demand, low to moderate-control work environments. Even in entrepreneurs and fitting entrepreneurial environments, this dopaminergic psychophysiology, uncontrolled (or unbalanced by complementary others and business policy), akin to a hydrogen fueled rocket, may also endanger the very venture itself.

Theory implications. We suggest that entrepreneurs and people with the propensity for entrepreneurship often reflect a polygenic neurobehavioral endophenotype. Psychiatric endophenotypes are measurable intermediary components between complex neuropsychiatric conditions and their underlying genotypes. Our review and arguments suggest a new way to understand entrepreneurs' characteristics – that which specifies endophenotype biomarkers associated with entrepreneurship. Defining an organic foundation of entrepreneurship is more meaningful and consequential than simply looking at covariations of traits with behavior. For example, a dopaminergic explanatory framework helps to parsimoniously explain a cluster of traits and symptoms associated with venturing, as well as why positive attributes of entrepreneurs might sometimes be associated with darker traits like hubris, ruthlessness and deviant behavior (De Nisi 2015; Miller, 2014; Zhang and Arvey, 2009).

Rather than simply suggesting a "too much of a good thing" explanation – our analysis suggests that positive dopaminergic attributes covary with dopaminergic psychiatric conditions, and that both are positively associated with entrepreneurship. Thus, a dynamic set of biological processes, inhibited or disinhibited by changing circumstances and environmental features, explains much of the variance in how personality affects entrepreneurship. Moreover, as the expression and enactment of dopaminergic attributes covary with each other, are modulated by the environment, and may trigger the onset of dopaminergic symptoms and disease, one should go beyond looking into each of them separately (piece-meal) in explaining entrepreneurship. As they are not independent, any prediction between a dopaminergic characteristic and entrepreneurship needs to account for the covariation between the dopaminergic proclivities. Otherwise the effect of these traits are misspecified and may lead to conflicting results. There is thus considerable opportunity for future research delineating the relationship between genes, environmental influences, personality trait

enactment and psychiatric symptom activation.

Another implication of our dopaminergic conceptualization of entrepreneurship is the *trans*-diagnostic nature of dopaminergic traits and symptoms. Because the same dopaminergic traits and symptoms are found in a range of conditions (e.g. impulsivity and creativity are found in ADHD and Bipolar Disorder), categorial diagnostic frameworks such as the DSM-5 cannot be used exclusively to develop diagnostic dopaminergic risk and strength profiles of entrepreneurs. Rather, to understand and represent the transdiagnostic nature of dopaminergic trait-state-symptom-condition psychopathology dimensions, one needs to rely on neuroscience-based dimensional nomenclatures such as the NIMH Research Diagnostic Criteria and the Hierarchical Taxonomy of Psychopathology frameworks (Michelini et al., 2021; Perkins et al., 2020; Latzman et al., 2021). More simply, great care in both conceptualization and the terminology used is important. For example, theories of entrepreneurial action (and coaching strategies) are better served by understanding that an entrepreneur has elevated reward sensitivity and diminished response inhibition, rather than that the entrepreneur meets DSM-5 criteria for ADHD.

Practice implications. The dopaminergic personality traits described above and linked with venturing, and their associated mental health conditions, can be activated or inhibited by environmental factors. Phenotypes express the interaction of a genotype with its environment, including the policy environment that shapes the circumstances in which entrepreneurs live. Environmental, contextual and situational factors can cue, activate and facilitate the expression of the genotypic propensities and phenotypic personality traits which contribute to entrepreneurial capacities and performance. By shaping the environments in which entrepreneurs live in ways that (dis)inhibit enactment of their success-building personality traits, emotionally intelligent innovation ecosystems can increase the liklihood that people with the propensity for entrepreneurship will activate these traits in ways that allow them to start and grow companies.

Relatedly, entrepeneurship education, support systems and stakeholders (e.g. incubators, Small Business Development Centers, investors), and assocaited interventions can be tailored to facilitate entrepeneurs having a nuanced awarness of their own proclivities, effective engagment of complementary others (e.g. a co-founder, mentor, executive assistant, business or life partner), and appropriate business policy (e.g. a 24-h/*sleep-on-it* waiting period or otherwise sign-off by independent advisor, before major decisions – with clear criteria for what is "major," such as contract signing, expendatures greater than X, hiring/firing). Self-awareness, emotional regulation, and behavioral regulation are core competencies in entrepreneurship.

Conclusion. Hyperdopaminergia and differences in dopamine physiology, displayed across a broad spectrum of entrepreneur personality traits and mental health symptoms, syndromes and conditions, constitute an endophenotype of interest. While much remains to be understood regarding the neuroscience of entrepreneurship – the dopamine perspective put forth here, offers an integrative basis for advancement.

CRediT authorship contribution statement

Michael Freeman: Writing – review & editing, Writing – original draft, Conceptualization. **Daniel Lerner:** Writing – review & editing, Writing – original draft. **Andreas Rauch:** Writing – review & editing, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

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