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# Mapping neurological drivers to entrepreneurial proclivity

***Robert Smith***

**Abstract**

This chapter contributes from a theoretical and practical perspective providing an overview of emerging research strands in entrepreneurship and neuroeconomics. This review maps and unites the research in a unified narrative, understandable to economists, entrepreneurship scholars and the scientific and social scientific communities. It links disparate theories and discusses them at a layman's level. We consider how:-

- Entrepreneurial proclivity has a socio-biological context.
- Neuroeconomics facilitate our understanding of organizational processes and of entrepreneurship.
- Neuroscientific tools help to identify the drivers of entrepreneurial proclivity.
- These map the pre-decisional dynamics of the entrepreneurial process.
- Trait research is expanding to consider states, drives and forces.
- The links between genetics, cognition and the neurobiological basis for dyslexia.
- Endocrinal influences such as testosterone effect entrepreneurial proclivity.

From this a conceptual model is developed illustrating linkages with other internal human internal drives such as the theological and libido. We consider whether certain people are genetically and psychologically hardwired to become successful entrepreneurs and if hormones such as testosterone and adrenaline influence human drives. Finally, the theoretical contributions of the research are considered, which point to the emergence of a new genre of entrepreneurship research that is both scientifically and empirically rigorous. In collating these exciting developments in neuroscience, neuroeconomics and neuroentrepreneurship we enhance our understanding of how these inform organizational theory and research methodologies.

## 1. Introduction

The topic of this chapter is interesting both from a theoretical and practical perspective because our understanding of the intricacies and nuances of neurobiological and endocrinal influences upon entrepreneurial proclivity, and thus behaviour, are in their infancy. From a theoretical perspective many exciting possibilities for explaining entrepreneurial behaviour abound. New theories, models and frameworks will undoubtedly emerge. These may well have practical applications in terms of how we seek to explain entrepreneurial behaviour. This particular chapter contributes by combining many strands of neurobiological research

and synthesising them with entrepreneurship research. As such, the chapter will be of interest to entrepreneurship scholars and those in the scientific community interested in neurobiology but who may have a sketchy notion of what entrepreneurship is or is not. It may also be of interest to a broad range of social scientists because it relates to the practical application of cross disciplinary theory.

As a new(ish) academic discipline, entrepreneurship has been said to suffer from science envy. As entrepreneurship research continues to mature it is self evident that its frontiers will require to be constantly remapped as we continue to learn more and more about this societally eulogised cognitive behaviour. Despite the fact that trait research has been somewhat disparaged of late in the social sciences our knowledge of behaviourism continues to expand since trait researchers first began to chart the visible manifestations of entrepreneurial behaviour in the form of trait and personality theories. Trait research operates at the level of what Shane (2003) refers to as the 'individual-opportunity nexus' exploring the interactions, or fit, between the individual(s) and the opportunity. Scholars such as Shane (2003) (2008) and Zhao & Seibert (2006) have been at the forefront of a revival in the use of trait research in entrepreneurial studies. In particular Shane and colleagues (Shane, Locke & Collins, 2003) have mapped the links between traits and motivations.

As scholars we learned not to package our research as being trait based and instead we have turned to research the psychological, the sociological and the philosophical elements of being and thus we concern ourselves with the abstract issues of ontology, epistemology, narrative and identity. We hope that this imbues our research with a more scientific aura but nevertheless, I for one, continue to be drawn back to the simplicity of traits as narrative descriptors for the complex human behaviour that is entrepreneurship. This is so because traits (and states) form the

basis of many storylines in entrepreneur stories and thus in our research quest to understand the nuances entrepreneurial behaviour we have turned to heuristics such as narrative or identity. However, biology and in particular the neurological-endocrinal nexus remains a relatively uncharted territory in relation to developing a deeper understanding of entrepreneurial behaviour. Nevertheless, there is a growing appreciation that trait research in entrepreneurship is currently seeing a revival because previous research had neglected to control for the size of the opportunities that entrepreneurs perceive.

Consequentially, this review paper attempts to map recent breakthroughs in the field which suggest that there may be a neuro-biological underpinning to such behaviour. This is a complex area of study for social scientists without a medical background because whilst traits were frustratingly difficult to isolate and research despite allegedly being relatively constant, the same cannot be said for ephemeral biological underpinnings such as states, moods, drives, urges, ergs and appetites. In discussing neurological and endocrinal influences such as thyroxine, testosterone and adrenalin on entrepreneurial behaviour as a discipline I am perhaps researching at the edge of my knowledge base. It is this quest for 'Verstehen' which drives me. This loose 'conceptual mapping' methodology is useful in helping determine the biological basis of business by plotting biological bases into an understandable format which illustrates that entrepreneurship has a biological basis, albeit a proto-entrepreneurial one.

The purpose of this chapter is therefore to seek to understand how we can take advantage of the emerging area of neuroeconomics to inform how we view organizations by providing an overview of the literature. In doing so, I seek to map and understand the complex causal relationships and biological drivers which

combine to inform concepts such as – beliefs; opportunity recognition; risk-aversion or risk-seeking; personal motivation of individuals within the organization, but in particular amongst members of the entrepreneurial community who set up and manage firms. This overview will permit the mapping of pre-decisional dynamics of the human brain and in the process achieve important new insights into how we as humans organise our work allowing others to challenge classic economic models and their implicit assumptions relating to the ascendancy of rationality as the key organizing principle.

Whilst I agree with the editors that complex organizational decision-making requires the understanding of human cognition and incentive-evaluation using modern economic tools and rigorous experimental methodologies it should not be forgotten that there is also a role to be played by qualitative research methodologies. Neuroscience may well give economics new ways to conceptualise and measure important facets of decision making but these can be triangulated by existing research methods such as in-depth interviews, observational techniques, self-reflective action research and by shadowing entrepreneurs and key organisational players. Scientific tools of neuroeconomics can highlight the role of neural substrates in the 'decision making' processes of entrepreneurs but it still requires a qualitative approach to articulate their behavioural consequences in organizational terms.

Accordingly, this review highlights sound theoretical and empirical contributions and in particular how the literature on neuroeconomics facilitates our understanding of organizational processes and of entrepreneurship. In the process it collates extant work being carried out in the neuroeconomics, neuroentrepreneurship, and neuroscience literature pointing to how an understanding of neuroscience can

inform organizational theory and research methodologies. In particular, this chapter seeks to

- Identify how neuroscientific tools can help to identify the drivers of opportunity perception of the entrepreneur?
- Demonstrate how neuroscientific tools can help us visualize the opportunity analysis of the entrepreneur? This sets up other questions which beg to be answered. For instance, are certain people genetically and psychologically hardwired to become successful entrepreneurs? Do hormones such as testosterone and adrenaline influence human drives?
- Map the pre-decisional dynamics of the entrepreneurial process.

The remainder of this chapter is divided into five further sections. Section two, conducts the literature review and is subdivided into sections which explore – 1) the entrepreneur as driven – in search of entrepreneurial proclivity, which seeks to understand what forces drive entrepreneurial proclivity; 2) we then consider the biological basis for this proclivity; 3) Mapping genetic influences on entrepreneurial proclivity; 4) Examining the cognitive basis of entrepreneurial proclivity; 5) Considering the neurological basis of dyslexia and other learning deficits; 6) Mapping endocrinal influences upon entrepreneurial proclivity. Finally, in 7) we link testosterone research and entrepreneurial behaviour. The main thrust of this section is to consider the neurobiological basis of entrepreneurial behaviour by linking these disparate research outputs together. In section three we analyze the above and develop a conceptual map of the research terrain. In section four we discuss the material assembled and consider other human internal drives such as the theological and libido. The final section assesses the theoretical contributions of the research

drawing out conclusions and implications. In seeking to address these issues the chapter will also address the following research questions:-

- Do neurobiological and endocrinal factors influence entrepreneurial proclivity?
- And if so, what are the implications for society?

## 2. Reviewing the literatures

This section conducts a review of the literatures, identifying area of research activity which will be mapped and analyzed in later sections. One of the issues which remains problematic is that there is no one literature which one can draw upon but numerous including, entrepreneurship, psychology and medicine. Issues which impinge upon and may indeed underpin the behaviour of Carland et al's (Carland et al, 2000) "indefatigable entrepreneur" include - the role of genetic factors in leadership; neural circuits; the effect of hormones on occupational choice; decision making; risk-taking; the drive for power; and finally, reputation are all relevant to the practice of entrepreneurship as a behavioural output. We begin by considering the entrepreneur as driven and in particular entrepreneurial proclivity.

### 2.1. The entrepreneur as driven – in search of entrepreneurial proclivity

Entrepreneurs as individuals are often said to be driven, but many of the questions as to what drives them remains unanswered. This is perhaps not surprising given that we as a research community have yet to develop an accepted universal definition of what constitutes entrepreneurship. For this reason the subject of entrepreneurial proclivity is one which continues to fascinate me. It is a subject which fascinates other

entrepreneurship researchers such as Covin and Slevin (1991), Matsuno et al (2003), Carland et al (2000), Griffith et al (2005), Dess and Lumpkin (2005) … all of whom have researched the antecedents of entrepreneurial drive. Griffith *et al* (2005) refer to entrepreneurial proclivity as being a dynamic capability. A proclivity is defined as a natural or habitual inclination or tendency; or a propensity or predisposition towards pursuing a particular behaviour. This is frustratingly vague and it is also described as a bent. It is connected to a quest for leaning. Perhaps the key to decoding its mysteries lies in taking cognizance of the words 'natural' and 'habitual'. This vagueness extends into the literature on entrepreneurship where different phrases are used to refer to the same concept. For example, Covin and Slevin (1991) refer to '*Entrepreneurial Posture'*, Dess and Lumpkin (2005) refer to '*Entrepreneurial Orientation'* and Matsuno *et al* (2003) refer to '*Entrepreneurial Proclivity'* despite clearly referring to the same predisposition for the masculine cult of risk taking (McCarthy, 2000). Indeed, McCarthy links risk taking to innate personality traits and cognition and suggests that an entrepreneur's perceptions of risk, and capacity to bear risk, evolve over time perhaps indicating that risk taking is not just a static personality trait forged by nature or nurture, reflecting learning in a business context.

The 'nature versus nurture' and 'born versus made' debates have long been familiar to students of entrepreneurial proclivity and one burning question has always been whether certain people are genetically and psychologically hardwired to become successful entrepreneurs. This brings cognitive and neurological factors into play but underlying biological influences are also important.

Shane and Venkatraman (2000) in calling for new approaches to the study of entrepreneurship describe it as the nexus of two phenomena, namely the presence of lucrative opportunities and enterprising individuals (Shane and Venkatraman, 2000:

218). Nevertheless, this does not explain what drives enterprising individuals to succeed where others fail. However, socio-biological approaches such as those discussed in this paper do have the potential to provide answers to such questions. Significantly, such approaches align themselves with existing psychological approaches (Kets De Vries, 1985; Shaver and Scott, 1991) which possess an established scientific basis and thus credibility. In the following sub-sections we look at several interconnected strands in the emerging debate including genetics, cognition, the neurological basis for dyslexia and endocrinal influences such as testosterone, adrenalin and thyroxin. We begin by considering the biological basis for entrepreneurial proclivity.

### 2.2. Considering the biological basis for entrepreneurial proclivity

In general terms, there is a broad acceptance of the influence of biology on business and in particular success (Arnot, 2000: Clippinger, 1999: Sahtouris, 2005). Indeed, biological approaches to entrepreneurship are becoming more common – Aldrich and Martinez (2001), Horide (2001), McKelvey (2003), Mitchell, (2004) and Mitchell *et al* (2002b). Incisively, Arnot (2000) refers to mental energy being the basic foundation of success and in his book details many biological influences upon success. Mention of biological approaches brings the nature – nurture argument into play but as Ridley (2003) has asserted nature and nurture often work together. Entrepreneurship spans psychological and cognitive aspects of organizational behaviour such as perception, cognition, judgment, attitudes, emotion, well-being, motivation, choice, and performance. These topics are inherently integrative, given that perceptions, attitudes, and emotions are rooted in cognition and judgment, and motivation and performance are inextricably linked to choice. The practice of

entrepreneurship revolves around the performance of sound judgment and decision which positions it very much as a product of cognitive human forces.

The idea that entrepreneurs are somehow by the process of evolution designated as 'chosen ones' (Aldrich and Martinez, 2001) is not particularly helpful making it necessary to map the biological precursor to entrepreneurial proclivity which may well be influenced by such considerations as character and personality type not to mention specific life themes (Nardi, 2000: Bolton and Thompson, 2000). However, the human body is more than just a biological vessel through which entrepreneurial behaviour is channelled which entails consideration of genetic influences upon such behaviour.

### 2.3. Mapping genetic influences on entrepreneurial proclivity

Genetics is a discipline within biology and is the science dealing with heredity and variation in living organisms (Griffith *et al*, 2000). The study of genetics entails consideration of DNA, genes and chromosomes. Nicolaou et al (2008) define a gene as a piece of DNA passed from parents to their biological children during reproduction and which influences an observed characteristic of an individual, referred to as a phenotype. Nicolaou et al (2008) quite rightly point out that any findings that are seen in empirical work might not therefore survive the test of replication.

However, a detailed consideration of genetics is out with the scope of this work but genetics are nevertheless important because they influence human development and cognition. Until recently consideration of the genetic influences upon entrepreneurial proclivity were confined to the realms of speculation. Indeed, Newton and Shreeves

(2002) reported on suggestions and deeply held beliefs by business leaders such as Rebecca Smith of A D Morgan that entrepreneurial ability is genetic.

However, the recent study of Nicolaou et al (2008) has provided a skeletal framework upon which further research can build. Indeed they suggest that a significant portion of the variance in who becomes an entrepreneur is accounted for by genetic factors. Thus Nicolaou et al (2008) sought to link personality to extraversion and introversion paying particular attention to the traits of agreeableness, conscientiousness, emotional stability, and openness to experience. In particular, they noted that people who are agreeable are less likely to become entrepreneurs thus positioning entrepreneurs as likely to be of a disagreeable disposition. The final point they make is that such entrepreneurs are prone to the trait of sensation seeking. To reach these conclusions Nicolaou et al used quantitative genetics techniques to compare the entrepreneurial activity of 870 pairs of monozygotic and 857 pairs of (mainly female) same-sex dizygotic twins in the United Kingdom. Their findings indicate relatively high heritabilities for entrepreneurship across different operationalizations suggesting that family environment and upbringing have little effect upon entrepreneurial proclivity. Therefore genetic factors may influence people's tendency to become entrepreneurs because our genes may predispose us to develop traits such as being sociable and extroverted. This in turn may facilitate skills such as salesmanship, vital to entrepreneurial success. Nicolaou et al are confident about their predictions because identical twins share 100% of their genetic composition, while fraternal twins share about 50%, on average therefore differences in the rates at which pairs of identical twins both become entrepreneurs and the rates at which both members of fraternal twins both become entrepreneurs can be attributed to genetics. Indeed, such points of concordance (the numbers of pairs of twins in

which both members are or are not entrepreneurs) make it possible to infer that genetic factors account for the differences. This consideration of genetic factors in explaining why people engage in entrepreneurial activity is an exiting contribution to the literature albeit their assertion that up to fifty percent of someone's propensity to become self-employed could be attributed to genetic factors is quite frankly mind blowing. Although this seminal study does not suggest there in an entrepreneurial gene it has nevertheless, laid the ground work for future research on what specific genes affect entrepreneurship.

There has been a significant rise in research into the genetics of entrepreneurial cognition and behaviour – Nicolaou et al (2008; 2008a and Nicolaou & Shane (forthcoming). Along with this we hare seeing the rise of a new more scientific rhetoric in which research questions are replaced by hypothesis, theories with pheonotypes and the introduction of methodologies such as genetic etiology, bivariate genetics techniques and quantitative genetics. Nevertheless, it is wise to exercise a few words of caution because few behavioural traits can be directly attributed to a particular gene. Toates (2005) discusses the emergence of evolutionary psychology (EP) and the theory of dual-layered behavioural control involving an integration of behaviour, cognition and complex human information processing capabilities. Fittingly, at this juncture we now turn to consider cognition and its part in the entrepreneurial process.

### 2.4. Examining the cognitive basis of entrepreneurial proclivity

Entrepreneurship occurs at the conjunction of opportunities and individuals (Shane & Venkatraman, 2000). Moreover, Baron (2000) argues that cognitive and social factors

influence success in entrepreneurial venturing. For Baron, successful entrepreneurs appear to think differently than other persons in several respects and have more direct thought processes, have high levels of social competence but may be prone to over confidence. Entrepreneurship scholars such as Stewart et al (1999) have long wondered whether entrepreneurial proclivity influences ones occupational and whether there are physiological differences between entrepreneurs and/or managers and the rest of the population? Entrepreneurship is first and foremost a cognitively driven human behaviour and as such cognitive studies have much to contribute to our understanding because cognition links behaviour to emotions, attitudes, moods and states, creativity and intuition (Tomasino, 2007) not to mention thought process intentions (Shepherd and Krueger, 2002).

Research into cognitive aspects of entrepreneurial behaviour is a fruitful area of research. For example, Krueger and Brazeal (1994) researched entrepreneurial potential; Shane and Venkataraman (2000) researched timidy and boldness; Shepard and Krueger (2002) examined entrepreneurial intention; whilst Goss (2005) considered entrepreneurial emotion. Krueger (2008) has turned to consider biases and heuristics. For Tomasino (2007) entrepreneurial behaviour is informed by high degree of creativity and intuition – capacities which remain scientific enigmas. Therefore Tomasino considers that creativity may be a distinct bodily state or psychophysiological coherence influenced by positive emotions. In a similar vein, Schindehutte et al (2006) examined the cognitive and emotional experiences of entrepreneurs. However, cognition is influenced by hormones. Hampson (in press) further argues that endocrine levels can contribute to sex differences in visio-spatial perception and cognition; and Becker et al (2005) accept that there are sex differences in brain and behaviour influenced by the endocrine system. Indeed, Eckel et al (in

press) accept that behavioural differences between the sexes are influenced by hormones linking genetics to the biological discipline of endocrinology to which we will turn in section 2.6, but first we will consider the neurological basis of dyslexia and other learning deficits.

### 2.5. Considering the neurological basis of dyslexia and other learning deficits

Consideration of the effects of learning difficulties such as dyslexia and ADHD, ADD etc is another emerging area of entrepreneurship research which has great potential. Studies include those of Logan (2001), Mannuzza et al 1993, Gilbertson, 2003) and Smith (2008). What is significant is the mathematics of negative attrition in that whether one is studying incidences of dyslexia, ADD, ADHD, criminality, drug addiction, or even delinquency on is struck by the 4 plus to 1 ratio frequently encountered in such studies indicating that boys are more likely than girls to be represented in those behavioural categories than girls. For example ADHD adults are nearly four times as likely to be entrepreneurs as their non-ADHD counterparts (Mannuzza *et. al* 1993) and ADHD is considered to be present in two to five percent of the population (Goodyear and Hynd, 1992). According to Gilbertson ADD is highly hereditary. These factors suggest that there may be an underlying biological or neurological underpinning to these conditions and testosterone is one plausible explanation. For Habib (2000) up to 10% of school-age children fail to learn to read in spite of normal intelligence, adequate environment and educational opportunities because of developmental dyslexia. Habib argues that there is a neurological basis to dyslexia which has been tentatively corroborated by brain scans. Such Neuropsychological studies have provided considerable evidence that the main mechanism leading to these children's learning difficulties is phonological in nature.

Cohen (2003) suggests that high levels of testosterone in the womb can lead to incidences of Autism and Aspergers syndrome in boys. These conditions can influence entrepreneurial proclivity. Moreover, Gilbertson (2003) identifies a tentative link between ADHD and Adrenalin.

### 2. 6. Mapping endocrinal influences upon entrepreneurial proclivity

Hampson and Moffat (2004) refer to the psychobiology of gender and explored the effects of reproductive hormones on the adult nervous system. The human endocrine system is an integrated system of small organs that secrete hormones and regulates metabolism, energy levels and also our moods. The endocrinal glands of interest to us are the thyroid, the adrenal gland and the sexual organs (testes and ovaries). In this study we are primarily interested in testosterone, adrenalin and thyroxine because of their potential to influence entrepreneurial proclivity via the mechanism of Adrenalin or Testosterone rushes. To date the only study which the author could locate which specifically links adrenalin to entrepreneurial behaviour is that of Derr (1986 / 2006). See table 1 below for an overview of their function and how they relate to entrepreneurial behaviour.

**Insert table 1 here.**

It is necessary to concentrate upon the linkages between testosterone, adrenalin and thyroxin because collectively such endocrinal secretions influence mental and physical energy and have the potential to influence entrepreneurial behaviour. Frustratingly for researchers because it is a system - all are interrelated, thus Hampson (2004) links reproductive hormones to cognition.

### 2. 7. Linking testosterone research and entrepreneurial behaviour

Testosterone drives male aggression and sexual interest. We know more about testosterone than many other hormones (Dabbs, 2000). White, Thornhill and Hampson (2006) argue that entrepreneurs have higher levels of testosterone than other men in the population. Using saliva swabs White *et al* tested 31 male business students who had previously invested in and managed their own business. These males had significantly higher testosterone levels than 79 of their male class mates who had no entrepreneurial experience. For White and his colleagues (2006) as a specific heritable characteristic one's testosterone level "*explains something about the likelihood of that individual being significantly involved in creating a new venture"*. They argue that although entrepreneurs may not be born but that one's biological inheritance may influence one's likelihood of engaging in entrepreneurial activities. Thus they argue that biological evolutionary processes select for heritable behaviors providing advantages in terms of survival and reproductive advantage, therefore how we behave is, at least in part, affected by the evolutionary history of our species. Building upon this White, Thornhill and Hampson (2007) argue for a biosocial model of entrepreneurship reiterating the message that new venture creation is more likely among those individuals having a higher testosterone level in combination with a family business background. O'Boyle (1994) taking a biological perspective considered the effects of testosterone on the development of men and ultimately linked it to the work of entrepreneurs. This discussion on testosterone obviously precludes female entrepreneurs. It is well understood that females are not driven to many things by testosterone, nevertheless there are growing numbers of female entrepreneurs. This suggests that there is a weakness in the biological argument for the influence of testosterone on entrepreneurial proclivity. This points to the pressing need for further research. Furthermore, testosterone changes every minute (or fraction

of a minute) and so any experiment that takes one or two samples for measurement is suspect for measurement errors.

In books and films financial-market traders are often dramatised as macho gamblers. It is thus significant that Coates and Herbert (2008) conducted research into the effects of testosterone on trading activity on the Stock Exchange taking saliva samples in the morning and evening and found that the levels of two hormones, testosterone and cortisol, affected traders. Interestingly, Cortisol is linked to uncertainty, novelty and unpredictability. Their findings indicate that testosterone can be equated to commercial success. If traders have high levels of testosterone in the morning then the amount of money they earn per day increases. However, Coates stresses that traders with moderate levels of testosterone do better than those with higher levels. High levels can lean one towards over risky, bullish behaviour. The best traders do not have an ego and approach trading with an attitude of humbleness. Coates and Herbert (2008) were careful to stress that the traders he tested were operating in high pressure trading situations with little opportunity to reflect and that his findings would not be applicable to trading where one has time to reflect before making decisions. Coates and Herbert (2008) suggest that it would be good for both banks and the financial system to employ more women and older men in the markets. Men and women may thus have different biological trajectories. Such a change would produce a much more stable financial system. Coates and Herbert (2008) conclude that cortisol appears to rise in a market crash and increases risk aversion thus exaggerating the market's downward movement. They suggest that testosterone, appears to rise in a bubble effect increasing risk taking thereby exaggerating the market's upward movement. This explains why people caught in bubbles and crashes may find it difficult to make rational choices.

For Kuhnen and Knutson (2005) there is a neurological basis to such financial risk taking. Indeed research by Knutson *et al* (2008) suggests that young men shown erotic pictures were more likely to make a larger financial gamble than if they were shown non-erotic images indicating that money and women trigger may trigger the same brain area in men. It falls short of proving a causal link between testosterone and profitability. Coates, an ex Wall Street trader himself suggests that some trading activity does not make sense in terms of economic or game theory and that it is more akin to them being on a drug induced high. The above research is in keeping with the research of Barber and Odean, (2001) who argue that theoretical models predict that overconfident investors trade excessively. Barber and Odean, (2001) suggest "Boys will be boys". What is significant is that they reached this conclusion by examining 35,000 trading records over a significant time frame. Hormone research certainly suggests that there is a winner model in which competitors have rising testosterone levels. Eventually this leads to over reach and poor decision making. Cooper, Woo, and Dunkelberg (1988) have noticed a similar propensity for often illogical risk taking in entrepreneurs.

What is interesting about T-research in relation to occupation is that for example, male trial lawyers have been found to have higher average T-levels than male non-trial lawyers (Dabbs, Alford, & Fielden, 1998). This pattern is the same for female lawyers suggesting that competitive or combative behaviour raises levels of testosterone and increases energy levels. Adrenalin and testosterone make a heady cocktail. Dabbs et al (1990) have studied the effects of testosterone on occupational choice. According to White *et al* individuals with low testosterone level are less likely to exhibit entrepreneurial behaviour. However, it is not as simple as to argue that T-behaviours equate to 'E-behaviours'. Harris (1999) reviewed the studies investigating

the possible correlation between testosterone and aggression and how testosterone is related to various personality dimensions suggesting that testosterone may have a relationship with sexually dimorphic behaviours and in particular aggression (which can be counterproductive to entrepreneurial proclivity).

Testosterone can be linked to destructive anti social behaviour. Indeed, Stålenheim et al (1998) examined testosterone as a biological marker in psychopathy and alcoholism. In fact Sulivan (2000: 94-98) considers testosterone to be a metaphor for manhood correlated with risk, physicality (and criminality) explaining why boys are action orientated and why the ideologies of masculinity and heroism fuse together in heroic narratives. Dabbs et al (1995) examined testosterone, crime, and prison behavior among 692 adult male prison inmates measuring testosterone from saliva samples. The behaviours were then coded from prison system records. Inmates who had committed personal crimes of sex and violence had higher testosterone levels than inmates who had committed property crimes of burglary, theft, and drugs. Interestingly, inmates with higher testosterone levels also violated more rules in prison, especially rules involving overt confrontation. The findings indicate differences between low and high testosterone individuals in the amount and pattern of their misbehavior. In another study Dabbs *et al* (1990) examined the personalities of college students and compared them against military veterans suggesting that it is likely that testosterone has innate effects that are socially undesirable and can lead to anti social behaviour, delinquency and criminal behaviour particularly in the working classes. Dabbs *et al* also suggest that such behaviour can be attenuated by fostering (pro-social) bonds between the individual and society. Entrepreneurship is a potentially pro-social behaviour.

Having considered the above biological elements of entrepreneurial behaviour in isolation it is now incumbent upon us to consider how such themes combine. Thus in section three we will analyze what the review of the literature tells us in research terms whilst developing a conceptual map of the research terrain.

## 3. Analyzing the above and developing a conceptual map of the research terrain

The material reviewed above investigates the topic both at individual and collective levels in relation to how human drives and forces influence entrepreneurial behaviour. When one begins to assemble the material and concepts in relation to an existing level of knowledge of entrepreneurship theory the one begins to see linkages to existing entrepreneurship theory and behaviours such as charisma, creativity and innovation. In this respect the literature review forms the basis of an empirical framework backed up by methodological approaches such as observation and field based studies. An interesting picture emerged which is illustrated in figure 1.

**Insert figure 1 here.**

The assembled model considers three stages – socio-biological, biological and behavioural. Socio-biological influences can affect ingrained neurobiological disturbances such as dyslexia. In the biological model issues such as physiognomy, ethnicity, fitness levels, stamina and physical and mental wellbeing play a part as does character and personality. Behavioural typologies such as introversion versus extroversion and morality versus criminality may have biological underpinnings. One of the problems with researching states, moods, urges, ergs, appetites and rushes is that these are often proto-cognitional, never mind proto-entrepreneurial and as such cannot be directly observed. Phan et al, (2002) researched such pre-entrepreneurial

states of being. Like hedonistic dispositions and playfulness they must be inferred from other observable behaviours. The pictorial model developed has a cross disciplinary utility because of the broad spread of its knowledge base and because visually it arranges a staggering amount of material and concepts in an understandable format which would require several thousand words more to articulate clearly.

**4. Considering other internal driving forces**

One of the most difficult issues to research in this complex area is that of the interlinked nature of many of the concepts discussed and how many drives, urges and states flow into one another leading to linked human drives. In reflecting and theorizing about human drives which influence entrepreneurial proclivity one of the most obvious and most well researched is that of theological drive and in particular the influence of religious belief upon the formation of the Weberian Protestant Work Ethic. This is so well documented that it is not the place of such a review to regurgitate the work here. Instead, we will briefly consider the subject of sex drive of libido. These (like sex drive) are notoriously difficult to research. However, sex drives and other human impulses ebb and flow with the passing of time and can be subjugated by other drives and impulses and the other pressing priorities of life. As men mature their sex drive can, and do, wane but the embedded behaviours which result from such earlier conditioning and programming often remain constant. In this ontological process other invisible endocrinal chemicals can influence our competitive behaviour and thus perhaps entrepreneurial proclivity.

In this paper, libido and sex drive are considered in the wider Jungian sense of being free creative or psychic energies and not in its narrowest base sense. For Cannon (1991: 223) enterprise is akin to a life force feeding on energy, drive and

creativity. Taken at this level it could be argued that entrepreneurial proclivity and behaviour could well be influenced by latent or subjugated drives and states such as the human sex drive which in turn is shaped by hormones such as testosterone, adrenalin and thyroxin discussed above.

This may strike readers as being a bizarre theoretical lens but the title of the study by Dabbs (2000) "*Heroes, rogues and lovers*" into the linkages between such behaviours and testosterone strike the author as being an apt descriptor of some entrepreneurs. The Psychologist Richard Webster bemoans the lack of a systematic theory which seeks to explain "*the exceptionally violent nature of our own species, the extraordinary range and complexity of our non-sexual reproductive behaviour or the depth and power of the most ordinary human emotions*" (Webster, 1996: 2). According to Webster (1996) the history of science is full of such tentative hypothesis later validated by advances in science.

Economists are also contributing to the emerging argument. Indeed, Dostaler and Morris (1999: 247) link psyche and physiology to economics by discussing the works of Freud and Keynes in relation to money and capitalism. They echo the words of Keynes that sexual drive or libido is a major component of the animal spirit as are also the closely linked behaviours of aggression and sadism. The economist John Maynard Keynes (Keynes 1936: 161) in trying to articulate the animal spirit which animates the entrepreneur was thus perhaps the first economist to envisage entrepreneurial activity as a diversion of the human sex drive from normal sex. Keynes remarked "*It is better that a man should tyrannise over his bank balance than over his fellow citizens and whilst the former is sometimes denounced as being but a means to the latter, sometimes at least it is an alternative*" (Keynes, 1936: 374). Thus Keynes (Keynes, 1936), in laying the foundation stones of macro-economics in his

seminal work the "*The General Theory of Employment, Interest and Money*" was perhaps also laying the foundations of macho-economics in unleashing the animal spirit that is entrepreneurship. Certainly, for Dostaler and Morris (1999: 248), Keynes was suggesting that entrepreneurial speculation and capital accumulation constitute excellent outlets and stimulation for the abundant libido of certain individuals. Indeed, Dostaler and Morris (1999: 251) remarks that "*Moreover, dangerous human proclivities can be canalized into comparatively harmless channels by the existence of opportunities for money making and private wealth"*. With these sobering words of advice we will turn to consider how this chapter has contributed to our theoretical understanding of the neuro-biological basis for entrepreneurial proclivity.

## 5. Assessing the theoretical contributions of this review

Having considered the literature and mapped some neuro-biological precursors to entrepreneurial proclivity, it is now time to return to the research questions. In relation to the first question regarding identifying how neuroscientific tools can help to identify the drivers of opportunity perception of the entrepreneur? The mapping exercise illustrated the breadth of potential topics and research areas to be embraced. This would best be done by forming research alliances between social and pure scientists as is already occurring in the United States between Professor Scott Shane and his colleagues. It would be difficult for us as researchers to routinely ask respondents about their sex life or their emotional states but clearly we need to overcome our hang ups and design ethically bounded research agendas which permit to do so.

In relation to the second research question regarding neuroscientific tools can help us visualize the opportunity analysis of the entrepreneur? The conceptual map has

proven how this can be achieved. We now consider whether certain people are genetically and psychologically hardwired to become successful entrepreneurs and do hormones such as testosterone and adrenaline influence human drives? The research of Nicolaou et al (2008) into genetic and endocrinal influences certainly indicates that this may well be the case. The work of Smith (2008) on dyslexia also suggests that there may be a neurological element to entrepreneurial proclivity. However, these studies are a long way from providing conclusive proof of the supposition. Collectively, the work of White et al (2006) and (2007); the study Nicolaou et al (2008) and Coates and Herbert (2008) provides tentative corroboration that hormones such as testosterone and adrenaline influence human drives thus answering the second research question. Together these studies illustrate the part played by biological underpinning in the entrepreneurial process.

The work of Shane & colleagues is both erudite and impressive and it sees the scientification of trait theory. Indeed, it is difficult to argue against and is strangely compelling. In this respect it is far removed from early non-scientific trait research in which proof of trait was provided by case studies, examples, narratives and consensus. When entrepreneurship theory is merged with quantitative and scientific verification it becomes very powerful as an explanatory tool. It almost sees the birth of a new breed of entrepreneurship theorists and researchers. It is far removed from the qualitatively inclined social constructionist scholarship with its narrative and philosophical underpinnings in which this author is comfortable with. I can see it, I can feel it and I can believe in it but I cannot read nor verify the data. It is beyond my pail. We are perhaps entering a new era of experimental entrepreneurship in which more rigorous scientific controls can be introduced. According to Krueger (2008) understanding entrepreneurial behavior requires that we focus at the deepest, most

fundamental levels through the lenses of cognitive and developmental psychology. Interestingly, Norris Krueger recently ran an interdisciplinary workshop focusing on the experimental investigation of entrepreneurial behaviour from the perspectives of economics, cognitive, social and developmental psychology, neuroscience, philosophy and evolutionary anthropology. One of the areas of interest was in biological / neurological bases of entrepreneurial behaviour. This is an example of deep cognitive research. Krueger welcomes such research as a way to escape the limitations of observational research.

This chapter makes a tentative contribution to the literature of entrepreneurship by mapping and therefore aligning several inter-related neurobiological precursors to entrepreneurial behaviour. Although it stops short of developing and testing new theory it does nevertheless highlight possible avenues of future research. Moreover, it makes a minor theoretical contribution to the fields of applied psychology and entrepreneurship being anchored as it is in phenomena relevant to organizations. This work integrates different theories, propositions, or research streams into a unified framework and potential behavioural model. This study should be evaluated on how the marshalled data and narratives resonate with readers and whether it has indeed yielded valid answers to the important research questions set. This work breaks new ground and has the potential to make a lasting impact providing that ethical empirical research can be conducted to test the hypothesis that sex drive influences entrepreneurial proclivity. Consideration of entrepreneurship as being a manifestation of sexual drive is to date an untested hypothesis. It may well be a theory whose time has yet to come. However without a public airing and a rigorous debate this protean theory may remain in the cognitive realm of wishful thing.

Nevertheless, as a student of entrepreneurship I find the emerging arguments, implications and conclusions of this debate on the biological determination of entrepreneurial proclivity mildly disconcerting because if we ever arrive at a stage where instead of writing a business plan to acquire start up capital for an entrepreneurial venture we are forced to submit a laboratory sample to be tested for our testosterone levels or perhaps even whether we possess a gene which determines whether we are likely to be dyslexic or not – then the fun and excitement of entrepreneurship may well wane. What will become of the proverbial poor boy or bright girl deemed to be merely 'normal'. Professor Tim Sector's assertion that in future business schools and employers could identify ways of selecting those who were most likely to succeed is not so benign a statement as it first appears.

Another flaw is introduced by the possibility that in future parental choice may be exerted in selection breeding stock which is high in heritable entrepreneurial capital. Producing and cloning genetically predisposed entrepreneurs is the stuff from which science fiction is written. In addition, it has been suggested that genes have been shown to affect the level of education an individual receives, and thus by (bio)logical extension more highly educated people are likelier to become entrepreneurs because they are better able to recognise new business opportunities when they arise. This is at variance with the mythology of the entrepreneur as being high school drop outs.

Thus by paying too much attention to biological determination we are perhaps in danger of creating a new entrepreneurial caste whom like the privileged 'Jedi' in George Lucas's Star Wars are deemed to have extraordinary powers. It is akin to ascribing certain individuals with the theological status of an elect.

In this respect I concur with the sentiment of Baumol (1991) who in referring to the limits on observing mega-entrepreneurial events of the kind that create new

industries remarked, "*Each one is unique. If you could describe it completely you could replicate it, and it would become management instead of entrepreneurship*". Nevertheless, Coates and Herbert (2008) scoff at suggestions that scientists and business owners can use science to recruit genetically modified employees with entrepreneurial traits or even supplement the testosterone levels of employees because it takes time to develop trading mentality. It is all fair and well to seek to understand human behaviour in its entirety and point out to individuals with certain conditions (such as dyslexia) that there is reason for their difference and that this may predispose them towards an entrepreneurial trajectory but to deliberately select them for such a proclivity is perhaps a step to far. In this respect we must beware of being seduced by the scientific nature of such research because although biology creates a predisposition or potential for certain behaviours it cannot fully determine complex behaviours such as entrepreneurial proclivity.

**References**

Aldrich, H. E., & Martinez, M. (2001) "*Many are called, but few are chosen: An evolutionary perspective for the study of entrepreneurship*", Entrepreneurship: Theory and Practice, 41-56.

Arnot, R. B. (2000) "*The Biology of Success"*, Little, Brown and Company.

Barber, B. M., & Odean, T. (2001) "*Boys will be boys: Gender, Overconfidence and common stock investment"* The Quarterly Journal of Economics, Vol, 116, Issue 1, 261-292.

Baron, R. A. (2000) "*Psychological Perspectives on Entrepreneurship: Cognitive and Social Factors in Entrepreneurs' Success*", Current Directions in Psychological Science, Vol. 9, Number 1, February 2000, 15-18(4).

Baumol. W, J. (1991) "*Entrepreneurship Theory: Existence and inherent bounds*", presented at the Conference on Entrepreneurship Theory, University of Illinois at Urbana-Champaign, October 18-19.

Becker, J. B., Arnold, A. P., Berkley, K. J., Blaustein, J. D., Eckel, L. A., Hampson, E., Herman, J. P., Marts, S., Sadee, W., Steiner, M., Taylor, J., & Young, E. (2005) "*Strategies and methods for research on sex differences in brain and behaviour*", Endocrinology, 146, 1650-1673.

Bolton, B. and Thompson, J. (2000) "*Entrepreneurs, Temperament, Talent, Technique*", Butterworth-Heineman.

Cannon, T. (1991) "*Enterprise Creation, Development and Growth*", London, Butterworth, Heinemann.

Carland, J Carland, J., & Stewart, W. Jr (2000) "*The indefatigable entrepreneur: A study of the dispositions of multiple venture founders*", Journal of Business & Entrepreneurship.

Cattell, R.B & Kline, P. (1977) "*The Scientific Analysis of Personality and Motivation*", London, Academic Press.

Clippinger, J. H. (1999) [Ed] *"The Biology of Business: Decoding the Natural Laws of Enterprise"*, Jossey Bass.

Coates, J. M. & Herbert, J. (2008) Endogenous steroids and financial risk taking on a London trading floor", *Proc. Natl Acad. Sci. USA* 104, 6167-6172.

Cohen, S. B. (2003) "*The Essential Difference: The Truth About the Male and Female Brain"*, Perseus Publishing.

Cooper, A. C., Woo, C. Y. & Dunkelberg, W. C. (1988) "Entrepreneurs' Perceived Chances for Success," *Journal of Business Venturing*, III, 97–108.

Covin, J. & Slevin, D. P. (1991) "*A Conceptual Model of Entrepreneurship as Firm Behavior*", Entrepreneurship Theory and Practice, 16 (1): 7-24.

Dabbs, J. M., Jr. (2000) "*Heroes, rogues, and lovers: testosterone and behaviour*", New York: McGraw-Hill.

Dabbs, J. M., Jr., de La Rue, D., & Williams, P. M. (1990) "*Testosterone and occupational choice: Actors, ministers, and other men*", Journal of Personality and Social Psychology, 59, 1261-1265.

Dabbs J. M. Jr., Hopper, C. H., & Gregory J (1990) "*Testosterone and personality among college students and military veterans*", Personality and Individual Differences, Vol 11, Issue 12, 1990, Pages 1263-1269.

Dabbs J.M.; Carr T.S.; Frady R.L.; Riad J.K. (1995) "*Testosterone, crime, and misbehavior among 692 male prison inmates"*, Personality and Individual Differences, Volume 18, Number 5, May 1995 , pp. 627-633(7).

Derr, C.B. (1982/2006) "*Living on adrenalin: the adventurer entrepreneur*", Human Resource Management, Vol. 21, issue 2-3, 6-12.

Dess, G.G. & Lumpkin, G.T. (2005) "*The role of entrepreneurial orientation in stimulating effective corporate entrepreneurship*", Academy of Management Executive, 19 (1): 147–156.

Dostaler, G., & Morris, B (1999) "*Dr Freud and Mr Keynes on Money and Capitalism*" in Smithin, J. N. [Ed} (1999) - What is Money, London, Routledge.

Eckel, L., Arnold, A. P., Hampson, E., Becker, J. B., Blaustein, J., & Herman, J. P. (in press), "*Research and methodological issues in the study of sex differences and hormone-behavior relations*", In: J. B. Becker, K. J. Berkley, N. Geary, E. Hampson, J. P. Herman, & E. Young (Eds.), Sex on the Brain: From Genes to Behavior. New York: Oxford University Press.

Goss, D. (2007) "*Enterprise Ritual: A Theory of Entrepreneurial Emotion and Exchange*", British Journal of Management, doi:10.1111/j.1467-8551.2006.00518.x

Gilbertson, D (2003) "*ADHD' or 'Latent Entrepreneur Personality Type'*?, http://www.windeaters.co.nz/publications/innovation_entrepreneurship/Adhd2_web.pdf - Accessed online 5.4.2008.

Griffith, D.A., Noble, S. A., and Chen, Q. (2005) "*The performance implications of entrepreneurial proclivity: A dynamic capabilties approach*", Journal of Retailing, Vol. 82, Issue 1, Pages 51-62.

Griffiths A.J.F, Miller J. H, Suzuki, D.T., Lewontin, R.C., and Gelbart, W.M. (2000) "*An Introduction to Genetic Analysis"*, New York: W.H. Freeman and Company.

Habib, M. (2000) "*The neurological basis of developmental dyslexia: An overview and working hypothesis"* Brain, Vol. 123, No. 12, 2373-2399,

Hampson, E. & Moffat, S. D. (2004) "*The psychobiology of gender: Cognitive effects of reproductive hormones in the adult nervous system*", In: A. H. Eagly, A. E. Beall, & R. J. Sternberg (Eds.), The Psychology of Gender (2nd ed), pp. 38-64. New York: Guilford Press.

Hampson, E. (in press) "Endocrine contributions to sex differences in visuospatial perception and cognition", In: J. B. Becker, K. J. Berkley, N. Geary, E. Hampson, J. P. Herman, & E. Young (Eds.), Sex on the Brain: From Genes to Behavior. New York: Oxford University Press.

Hampson, E. (2004) "*Cognitive function: Sex differences and hormonal influences*", In G. Adelman & B. H. Smith (Eds.), Encyclopedia of Neuroscience (3rd ed.) [CD-ROM]. New York: Elsevier Science B.V.

Harris, J. A. (1999) *"Aggression and Violent Behavior"*, Vol 4, Issue 3, Autumn 1999, 273-291.

Horide, I., (2001) "*The Rise and Fall of the Firm: An application of Biology into the Theory of the Firm*", International Journal of Economic Studies, Vol.9, No. 1, March 2001.

Kets de Vries, M. F. R. (1985, November-December) "*The dark side of entrepreneurship"*, Harvard Business Review, 160-166.

Keynes, J. M. (1936) "*The General Theory of Employment, Interest and Money*", London: Macmillan (reprinted 2007).

Knutson, B A, Wimmer, G. Elliott A, Kuhnen, C M, Winkielman, PB. (2008) "*Nucleus accumbens activation mediates the influence of reward cues on financial risk taking: Brain Imaging*", Neuroreport. 19(5):509-513, March 26, 2008.

Krueger, N. F., & Brazeal, D. V. (1994) "*Entrepreneurial potential and potential entrepreneurs"*, Entrepreneurship: Theory and Practice, 18, 91-104.

Krueger, N. (2008) "*Experimental Entrepreneurship: A Research Prospectus & Workshop*", presented at the 2008 USASBE conference, San Antonio Texas.

Kuhnen, C., & Knutson, B. (2005) "*The Neural Basis of Financial Risk-Taking*", Neuron, 47:763-770.

Logan, J. (2001) "*Entrepreneurial Success: A study of the incidence of dyslexia in the entrepreneurial population and the influence of dyslexia on success*", PhD thesis, University of Bristol.

McCarthy, B. (2000) "*The cult of risk taking and social learning: a study of Irish entrepreneurs*", Management Decision, Vol 38, Issue 8, 563-575.

McKelvey, B. (2003) "*Toward a complexity science of entrepreneurship*", Journal of Business Venturing, Vol. 19, Issue 3, May 2004, 313-341.

Mannuzza, S, Klein, RG, Bessler, A, Malloy, P, & LaPadula, M. (1993) "*Adult outcome of hyperactive boys: Education achievement, occupational rank, and psychiatric status*", Archives of General Psychiatry, 49, 565-576.

Matsuno, K., Mentzer, J. T. & Özsomer, A. (2002) "*The Effects of Entrepreneurial Proclivity and Market Orientation on Business Performance*", Journal of Marketing, 66 (7): 18-32.

Mitchell, R. K. (2004) "*Evolutionary Biology Research, Entrepreneurship, and the Morality of Security-Seeking Behaviour in an Imperfect Economy*", Society for Business Ethics, 263–287.

Mitchell, R. K., L. Busenitz, T. Lant, P. P. McDougall, E. A. Morse, and J. B. Smith (2002b), "*Are entrepreneurial cognitions universal? Assessing entrepreneurial cognitions across cultures*", Entrepreneurship Theory & Practice 26(4 [Summer]): 9–32.

Nardi, D. (2000) "*Character and Personality Type*", Telos Publications.

Newton, J., and Shreeves, D. G. (2002) "*An investigation into the relationships between characteristics and life experiences of entrepreneurs*", Journal of Research in Marketing & Entrepreneurship, Vol 4, issue 1, 16-36.

Nicolaou, N., Shane, S. (forthcoming), "Born entrepreneurs? The genetic foundations of entrepreneurship," *Journal of Business Venturing*.

Nicolaou, N., Shane, S., Cherkas, L., Spector, T., (2008), "The Behavioral Genetics of Opportunity Recognition and Opportunity Exploitation",

Nicolaou, N., Shane, S., Cherkas, L., Spector, T., (2008), "Openness to Experience and Opportunity Recognition: Evidence of a Common Genetic Etiology"

Nicolaou, N., Shane, S., Cherkas, L., Hunkin, J., and Spector, T. D., (2008), "*Is the Tendency to Engage in Entrepreneurship Genetic?* Management Science, Vol. 54, No. 1, January 2008, 167-179.

Nicolaou, N., Shane, S., Cherkas, L., Spector, T., (2008), "The influence of sensation seeking in the heritability of entrepreneurship," *Strategic Entrepreneurship Journal*, 2:7-21, 2008.

O'Boyle, E. J. (1994) "*On The Person And The Work Of The Entrepreneur*", Review of Social Economy, Vol 52, Issue 4 Winter 1994, pages 315-337.

Sahtouris, E. (2005) "*The Biology of Business: New Laws of Nature Reveal a Better Way for Business"*,www.via-visioninaction.org/via-li/articles/Sahtouris_BiologyOfBusiness-full_version.pdf. – Accessed 5.4.2008.

Shane, S., and Venkatraman, S. (2000) "*The promise of entrepreneurship as a field of research*", Academy of Management Review, 25, 217-226.

Shane, S., (2003), *A General Theory of Entrepreneurship: The Individual-Opportunity Nexus,* Cheltenham, Edward Elgar Publishing.

Shane, S., Locke, E., Collins, C., (2003), "Entrepreneurial motivation", *Human Resource Management Review,* 13(2): 257-279.

Shane, S., (2008), "Entrepreneurship and the Big Five Personality Traits: A Behavioral Genetics Perspective",

Shepherd, D. A., Krueger, N, F. (2002) "*An Intentions-Based Model of Entrepreneurial Teams' Social Cognition"*, Entrepreneurship Theory and Practice 27**:**2, 167–185.

Schindehutte, M., Morris, M., and Allen, J. (2006) "*Beyond Achievement: Entrepreneurship as Extreme Experience*", Small Business Economics, Volume 27, Numbers 4-5 / December, 2006, 349-368.

Shaver, K.G., & Scott, L.R. (1991) "*Person, process, choice: The psychology of new venture creation*", Entrepreneurship: Theory and Practice, 16, 23-45.

Smith R (2008) "*Being Differently Abled: Learning Lessons from Dyslexic Entrepreneurs*", in Harrison, R. T. and Leitch C. M. (2008) Entrepreneurial Learning, London, Routledge, 291- 312.

Stålenheim, E.G., Eriksson, E., von Knorring, L., & Wide, L. (1998) "*Testosterone as a biological marker in psychopathy and alcoholism*", Psychiatry Research, Psychiatry Research, Vol 77 , Issue 2 , 79 - 88.

Stewart, W. H. Jnr., Watson, W. E., Carland, J. C.," and Carland, J. W. (1999) "*A proclivity for entrepreneurship A comparison of entrepreneurs, small business owners, and corporate managers*", Journal of Business Venturing, Vol. 14, Issue 2, 189-214.

Sulivan, A, (2000) "*Why Men Act the Way they Do: Don't blame them It's the Testosterone*", Readers Digest, 192-99.

Toates, F. (2005) "*Evolutionary Psychology – Towards a More Integrative Model*", Biology and philosophy, Vol 20, Numbers 2-3 / March, 2005.

Tomasino, D. (2007) "*The psychophysiological basis of creativity and intuition: accessing 'the zone' of entrepreneurship*", International Journal of Entrepreneurship and Small Business, Vol. 4, Number 5 / 2007, 528 – 542.

Webster, R. (1996) "*Why Freud was wrong: Sin, Science and Psychoanalysis*", London, Harper Collins.

White, R. E., Thornhill, S., & Hampson, E. (2003), "*Entrepreneurs and evolutionary biology: The relationship between testosterone and new venture creation"*, Frontiers of Entrepreneurship Research [Proceedings of the 23rd Annual Babson-Kauffman Entrepreneurship Research Conference], 201-215.

White, R.E., Thornhill, S. & Hampson, E. (2006) "*Entrepreneurs and evolutionary biology: The relationship between testosterone and new venture creation"*, Organisational Behaviour and Human Decision Processes, 100, 21-34.

White, R. E., Thornhill, S. & Hampson, E. (2007) "*A biosocial model of entrepreneurship: The effect of testosterone and family business background*", Journal of Organizational Behavior, 28: 451-466.

Zhao, H., Seibert, S. E., (2006) "The Big Five personality dimensions and entrepreneurial status: A meta-analytical review", *Journal of Applied Psychology*. Vol 91(2), Mar 2006, 259-271.

**Table 1 – Endocrinal Influences upon entrepreneurial behaviour**

| Endocrinal Hormone | A description of how the hormone affects behaviour. |
|---|---|
| **Testosterone** | Testosterone which influences energy levels, libido and strength. It is an androgenous based steroid hormone produced in the testes of men and in the ovaries of women. However, is found in small quantities in the adrenal glands. It is normally associated with masculinity and aggressiveness but studies suggest that aggressiveness is associated with low testosterone levels, whereas risk-taking behaviour is associated with high levels. The literature suggests that attention, memory, and spatial ability are key cognitive functions affected by testosterone. These of course are all cognitive elements of entrepreneurial proclivity. In adult males testosterone is produced at a level of 40 to 60 times higher than in females therefore males who exhibit e-behaviour are statistically more likely to have high testosterone levels. However, females are more responsive to its effects and there is a wide range of levels across the population. Testosterone levels are not static and are subject to biological rhythms and the effects of aging on its production. Testosterone is said to be a 'virilising agent' and is often regarded as a rejuvenating elixir. This opens up possibilities for further research and the possibility of a cure for flagging (entrepreneurial) libido by prescribing testosterone replacements to prospective entrepreneurs at the new venture stage. |
| **Adrenalin** | Adrenalin boosts the supply of oxygen to our brain and muscles and increases our heart rate to enable us to sustain high energy levels. Despite the fact that there has to date been little research into the influence of adrenalin on E-behaviour journalistic accounts often describe entrepreneurs as 'Adrenalin Junkies'. Indeed, entrepreneurial adventures are fraught with dangers and exhilarations during which adrenalin freely flows and there is the possibility that entrepreneurial behaviour may become addictive and engaged in for fun. |
| **Thyroid** | The thyroid plays a part in regulating energy levels and metabolic rate. It is perhaps one of the least appreciated of the endocrine secretions in relation to e-behaviour but too much thyroxine can lead to hyper activity and increased energy levels. Likewise to little can lead to lethargy and inactivity. It can thus be a behavioural suppressant. It may also have a role to play in communicational difficulties such as dyslexia and dyspraxia. It is worthy of further research. |

| | |
|---|---|
| **Dopamine** | Dopamine increases heart rate, influences motivation for physical activity and the need for sensory variety and therefore may also play a significant part in e-behaviour. However, there are no known studies relating to dopamine. |

**Figure 1 – Mapping neuro-biological precursors to entrepreneurial proclivity**