

6-12-2010

DOES BIOLOGY MATTER? HOW PRENATAL TESTOSTERONE, ENTREPRENEUR RISK PROPENSITY, AND ENTREPRENEUR RISK PERCEPTIONS INFLUENCE VENTURE PERFORMANCE

Cheryl A. Trahms

Texas A&M University, ctrahms@mays.tamu.edu

Joseph E. Coombs

Texas A&M University

Murray Barrick

Texas A&M University

Recommended Citation

Trahms, Cheryl A.; Coombs, Joseph E.; and Barrick, Murray (2010) "DOES BIOLOGY MATTER? HOW PRENATAL TESTOSTERONE, ENTREPRENEUR RISK PROPENSITY, AND ENTREPRENEUR RISK PERCEPTIONS INFLUENCE VENTURE PERFORMANCE," *Frontiers of Entrepreneurship Research*: Vol. 30: Iss. 5, Article 4.

Available at: <http://digitalknowledge.babson.edu/fer/vol30/iss5/4>

This Paper is brought to you for free and open access by the Entrepreneurship at Babson at Digital Knowledge at Babson. It has been accepted for inclusion in Frontiers of Entrepreneurship Research by an authorized administrator of Digital Knowledge at Babson. For more information, please contact digitalknowledge@babson.edu.

DOES BIOLOGY MATTER? HOW PRENATAL TESTOSTERONE, ENTREPRENEUR RISK PROPENSITY, AND ENTREPRENEUR RISK PERCEPTIONS INFLUENCE VENTURE PERFORMANCE

Cheryl A. Trahms, Texas A&M University, USA

Joseph E. Coombs, Texas A&M University, USA

Murray Barrick, Texas A&M University, USA

ABSTRACT

Extant research on the biology of the entrepreneur has recently increased in study with the prevalence of genetic testing, twin studies, neuro-economics and the popular press books on the finger ratio (2D:4D), a marker of the prenatal influence of testosterone on the brain development (Manning, 2008). Previous studies found the smaller 2D:4D ratio (a more masculine or Casanova-like finger length) is positively associated with dominance, aggressiveness, assertiveness, extroversion competitiveness, risk-taking, and sensation seeking, while negatively associated with neuroticism and inhibitions (Manning, 2008). Our most interesting findings conclude that lower 2D:4D ratios (higher levels of testosterone) is negatively associated with both firm performance and commitment to strategic goals.

INTRODUCTION

In accordance with Upper Echelon theory, individual characteristics of the entrepreneur are valid antecedents to explain organizational outcomes, since entrepreneurs are owners as well as chief executive officers-implying a high level of managerial discretion. There are a number of individual differences associated with entrepreneurial activities and risk-taking decisions of the entrepreneur, such as self-efficacy, locus of control, personality, attitude, parental entrepreneurship, gender, and experiential or knowledge-based differences (Rauch & Frese, 2000). New streams of research, such as neuro-economics (Camerer, Lowenstien, & Prelec, 2005) and the increased availability of biological tests and neuroimaging, has prompted an increase in the research linking biology to social science, management, and business (Lowenstien, 2008). The introduction of biological differences into entrepreneurial literature (Shane & Nicholaou, 2009) creates innovative research opportunities to understand which entrepreneurs experience the most success.

While this stream of research linking biological factors to entrepreneurship is in its infancy, the preliminary research has explored the hereditary, biological factors linking entrepreneurs to intelligence, personality and attitudes (Illies, Arvey, & Bouchard, 2006) and the 2D:4D ratio to risk-taking (Manning, 2002). Theoretical research in mainstream journals (e.g. Heaphy & Dutton, 2008; Nicholaou & Shane, 2009) and the addition of books on the topic of behavioral biology focusing on entrepreneurship (e.g. Shane, 2010) illustrate that this new frontier of research is theoretically sound, although insufficient empirical research has been published examining the relationship between entrepreneurial biology and the actions that researchers often equate with entrepreneurial behavior and success. Recent books in the popular press have made the 2D:4D ratio a popular and easily attainable antecedent linking biology to behavior (Manning, 2002; 2008).

This paper will introduce the biological individual difference of 2D:4D (the finger ratio), reintroduce individual differences examined in the entrepreneurship research specifically those found to correlate with 2D:4D ratio, and examine hypothesized relationships among 2D:4D, entrepreneurial risk profiles, goal commitment, and firm performance.

THEORY AND HYPOTHESIS DEVELOPMENT

Shane and Venkataman (2000) assert that entrepreneurship is affected by both environmental and individual factors. Entrepreneurship is at the nexus of the discovery of opportunity and the uniqueness of individuals. Although research has delved into the environment of the entrepreneur, many entrepreneurship researchers adhere to the idea that individual difference have not yet been fully developed (Baron, 2002). The individual characteristics of the entrepreneur are particularly important in a setting where organizational inertia has not built up and the actions of the entrepreneur shape or change the direction of the organization, such as in small entrepreneurial firms.

Research investigating the individual differences of the entrepreneur has focused on psychological variables to distinguish entrepreneurs from non-entrepreneurs. Such work has examined a number of variables including locus of control (Brockhaus, 1980) and risk propensity (Stewart & Roth, 2001). Several individual differences dimensions have been determined to be heredity by behavioral genetic researchers, including personality, attitudes, vocational interests and perceptions of organizational climate (Ilies, et al, 2006). That these differences correlate to biological factors implies that there is a behavioral-genetics link. It is logical that biological factors will play a role in entrepreneurial behavior and eventual firm performance. Nicolaou, et al. (2009) found that 37-42% of the variation in five difference measures of entrepreneurial behavior could be attributed to a biological influence. One of these relationships between biology and entrepreneurial action was a correlation between biological attributes and risk. Recent additions to behavioral neuroscience have proposed an examination of the biological characteristics of the individual entrepreneur (Nicolaou, Shane, Cherkas, & Spector, 2008). Specifically, research has suggested the use of the 2D:4D ratio as a physical manifestation of fetal androgens (Dreber & Hofferman, 2007).

Although a number of methods have been proposed for measuring the effects of fetal androgens on the behavior of adults, the most convenient is the second-to-fourth digit length ratio (2D:4D). A relatively longer fourth finger to second figure (measured in millimeters), equating to a lower 2D:4D ratio. The 2D:4D ratio is negatively related to prenatal and adult testosterone levels and positively associated with estradiol in utero, resulting in higher levels and sensitivity to testosterone in adult hood. Prenatal androgens affect brain development and increase the brain's sensitivity to the effects of circulating testosterone (Coates, Gurnell, & Rustichini, 2009). In addition to sensitivity to circulating testosterone, the 2D:4D ratio also correlated to the average level of circulating testosterone levels in adults (Coats, et al., 2009). Studies have found that during gestation, testosterone has powerful effect on the developing body and brain, and can cause increased confidence, risk preferences, locus of control perception, and search persistence, as well as quickening reaction times. The most common measure is the ratio of the index to ring finger (2D:4D) on the right hand; this ratio is solidified in the 13th week of fetal development. 2D:4D has been found to negatively correlate with competitiveness (Manning & Taylor, 2001) and positively correlate with risk-aversion (Dreber & Hofferman, 2007). Men typically have scores below one and women above one (Manning, 2002).

Extant research into biological differences in entrepreneurs has examined differences related to general occupation categories --more specifically differences that affect career choices (Dabbs, 2000). White et al. (2006) explored the relationship between the biological variable of testosterone and entrepreneurship. They found testosterone was positively associated with an increased likelihood of entrepreneurial experience, mediated by risk propensity-- testosterone affected risk-taking, which affected the probability of entrepreneurial experience.

Another biological link is between the 2D:4D ratio and the locus of control. This may result from interactions between 2D:4D and sex-related factors other than prenatal testosterone, namely estradiol. Work has been done to examine the association between 2D:4D and the effect of concentrations of fetal testosterone and estradiol. Diatzman and Zuckerman (1980) designed a theoretical construct to assess a person's perceived control over his or her own behavior. The classification *internal locus* indicates that the person feels in control of events; *external locus* indicates that others are perceived to have that control. Testosterone, a low 2D:4D ratio, relates to a high level of internal locus of control and estradiol, a high 2D:4D ratio, relates to a higher external locus of controls. This physical characteristic may give us insight into the behavior of those who are already entrepreneurs. Research into biological factors, specifically the finger ratio, may help us understand the role that both individual and situational factors play in the success of some entrepreneurs and the failure of others that has thus far had mixed results.

The entrepreneur faces a unique set of challenges, as the entrepreneurial venture may contain significant decisions and outcomes shrouded in risk and uncertainty. The entrepreneurial risk-taking literature has viewed the entrepreneur, an opportunity-seeker, both as making risk-taking decisions to grow a business and as founding a new venture—an inherently risky decision (Illies et al., 2006). Stewart and Roth (2001) found not only a difference in risk propensity between the entrepreneur and the manager, but also a difference between entrepreneurs, noting a difference between those entrepreneurs that seek growth and those that are more inclined to maintain income. Some attempts to capture the more detailed proxies for cognition have measured risk propensity of the entrepreneur positing that the entrepreneur is fundamentally different than the non-entrepreneur. This research into the relationship between risk and the entrepreneur has been used to explore individual differences finding mixed results.

Risk is an important dimension of entrepreneurship and as such risk has been defined in the entrepreneurial setting reflecting the potential downside loss, and loss of opportunity, not often noted in the traditional measures of risk in the management literature (Janney & Dess, 2006). Risk is a feature of entrepreneurial decision-making, specifically whether disappointing outcomes of decisions might be realized (Sitkin & Pablo, 1992). Risky decisions are based on the individual's predisposition toward risk rather than only situational factors (Bromily & Curtis, 1992). Risk tolerant individuals are likely to self-select into entrepreneurial careers, whereas risk-averse individuals choose traditional employment (Stewart & Roth, 2001). Risk propensity is the individual entrepreneur's current tendency to take or avoid risks (Sitkin & Pablo, 1992).

Risk attitudes are also important in the development of business ventures; indeed, willingness to take risks is positively associated with entrepreneurial activity (Stewart and Roth, 2001). Recent studies have examined the effect that testosterone has on risk. Testosterone is not only associated with physiological characteristics such as the length of fingers, but also, with tendencies of risk-taking. The typical entrepreneur is perceived to have stereotypically male traits (Baron, Markman, & Hirska, 2001) and the empirical findings that lower levels of testosterone and a higher 2D:4D ratio positively correlate with risk-aversion (Dreber & Hofferman, 2007).

Coates, Gurnell and Rustichini (2009) have found that 2D:4D has predictive power for a trader's long-term profitability and business tenure. 2D:4D predicted the sensitivity of London stock traders' profitability to increases both in circulating testosterone and in market volatility. This sensitivity to circulating testosterone has a correlation to risk preference (Apicella, Dreber, Campbell, Gray, Hoffman, and Little, 2008). Coates & Herbert (2008) measure the direct effect of testosterone and risk-preferences in men, proposing that testosterone's effect on risk-taking mediated the level of profit. Those with high testosterone levels react to risk differently than those with low levels of testosterone (Booth, Johnson, & Granger, 1999).

Goal commitment is dependent on numerous internal, external, and relational issues. The two issues most central to the research addressed here is the importance of the goal and the belief that one is able to achieve goals. Obviously, for an entrepreneur the importance of goals cannot be overestimated, as the entrepreneur's success and failure are dependent on his firm's performance. However, a lack of commitment to easy goals is not the same as a lack of commitment to difficult goals (Locke et al., 1988). Hollenbeck and Klein (1987) note few reasons to establish moderate or easy goals, commitment to them is not important.

Rotter's (1966) locus of control classifies generalized beliefs of what influences events along a continuum from internal to external control. The internal locus of control indicates individual can control events; the external locus of control indicates that others are perceived to control events. In relation to the 2D:4D relationship, the lower the ratio, the greater the internal locus of control—belief that control of future outcomes resides primarily in oneself. For those with an external locus of control, goal attainment would be more likely to be perceived as beyond their control. Those with an internal locus of control, faced with a difficult goal, would be more likely to perceive its attainment as within their control, merely requiring more effort. Thus measure of testosterone would seemingly effect the commitment to goals.

Some entrepreneurs are more likely to see opportunities not just because of experience in a similar situation in the past, but also due to the genetically influenced cognitive resources that are available to the entrepreneur (Johnson, 2009). Identification of opportunities, an integral part of the entrepreneurial process, is effected by both information about the opportunity and the decipherability of that information by the entrepreneur (Gaglio & Katz, 2001). The entrepreneur's use of heuristics as a way to simplify the decision-making process leads to a number of biases (Busenitz & Barney, 1997). However, the antecedents that shape the "mental shortcuts" are still a mystery. The individual differences of entrepreneurs serve as antecedents, but still entrepreneurial cognition is a mystery. "Different individuals may experience different doubts in identical situations" (Lipshitz & Strauss, 1997: 150). Traditionally, risk is theorized as an exogenous variable that effects the expected outcomes of a firm; however, Shapiro (1995) suggests that firm leaders see risk as something to be managed and controlled. As such, risk propensity may affect the goal commitment process.

Entrepreneurship is risky; situations that may appear risky in large established firms may not seem as risky in an entrepreneurial context. This is the nature of the perceptions of the entrepreneur. Entrepreneurs often find themselves in new, dynamic situations in which they are less likely to have past experience or information about performance or market trends. The reduction of uncertainty in this situation could be relatively high cost (Busenitz & Barney, 1997).; this coupled with the need to make decisions quickly, leads entrepreneurs to rely on perceptions of risk. The perception of the risk associated with the decisions obviously shapes the risk management decision. For example, March and Shapira (1987) found managers make smaller decisions more heuristically than they do with those that are perceived as larger ones. These

perceptions will shed light on the tendency of entrepreneurs to behave in a certain manner, rather than a prediction that an entrepreneur will behave in a certain manner.

Research has found that goal commitment has significant direct and indirect effects on performance (Chong & Chong 2002; Wentzel 2002). Goal commitment maybe positively correlated to perform when entrepreneurs are committed to achieve goals. A meta-analysis on goal commitment reports it moderates the relation between goal difficulty and performance (Klein, Wesson, Hollenbeck, & Alge, 1999). Goal commitment has been identified as an essential condition if planning and goal setting is to have an impact (Locke, Latham, & Erez 1988). Psychology research shows that goals are significantly more likely to lead to performance gains if individuals are committed to achieving them (Klein, Wesson, Hollenbeck, & Alge, 1999).

H1. Higher level of testosterone and sensitivity to testosterone will be positively associated with risk propensity, such that entrepreneurs with lower 2D:4D ratios will have higher risk propensity than will those entrepreneurs with higher 2D:4D ratios.

H2. Higher level of testosterone and sensitivity to testosterone will be negatively associated with commitment to strategic goals, such that entrepreneurs with lower 2D:4 ratios will have higher commitment to strategic goals than will those entrepreneurs with higher 2D:4D ratios.

H3. Higher level of testosterone and sensitivity to testosterone will be positively associated with firm revenue, such that entrepreneurs with lower 2D:4D ratios will have higher firm revenue than will those entrepreneurs with higher 2D:4D ratios.

H4A .Risk propensity will have a negative association with commitment to goals. Entrepreneurs with higher risk propensity will have lower commitment to (1) strategic and (2) sales goals than those entrepreneurs with lower risk propensity.

H4B. Risk perception will have a positive association with commitment to goals. Entrepreneurs with higher risk perception will have a higher commitment to strategic goals than those entrepreneurs with lower risk propensity.

H5. Goal commitment, to both (1) sales and (2) strategic goals, will have a positive association with firm performance, such that entrepreneurs with higher sales and strategic goal commitment will have higher firm revenue.

DATA AND METHODS

Low & MacMillan (1988) suggest that given the research situation, there are significant needs to integrate different levels of analysis in entrepreneurship research. McNamara and Bromiley (1997) argue that individual and organizational level of analysis is important for theorizing and empirical research. A multilevel approach in entrepreneurial research will help to explain the dynamics of risk and actions at individual and firm levels (Miller, 2007). When looking at behavioral decisions that influence performance, the individual level of analysis is strongly related to the organizational level of analysis, this research is therefore a combination of the two levels of analysis. For this study we will have both objective and self report data at the entrepreneur and firm level, including scans of the hands of the entrepreneurs, survey items self reported by the entrepreneurs, objective firm level performance data, and entrepreneurial level demographic data.

Participants in this study consisted of 90 entrepreneurs associated with a financial services company in the Midwest will participate in this study. Since there are ethnic differences in the 2D: 4D ratio and risk preferences (Manning, et al. 2004), the results we report are based on the Caucasian sample only. This is a group that self classifies themselves as entrepreneurs, although this population is both small business owners and opportunity-seeking, the two commonly held definitions of the entrepreneur (Shane & Venkataraman, 2001). Of the 453 entrepreneurs present at the conference and available to participate in this study, 91 chose to participate in the study of which 90 surveys and hand scans were used in the sample. Seventy-eight of the entrepreneurs (87%) were male and 100% of the sample was Caucasian. Since differences in 2D:4D exist between ethnic populations, the relationship may hold only in ethnically consistent samples (Manning, Stewart, Bundred, & Trivers, 2004). It has also been found that the gender difference of risk preference between men and women declines when the control variable of finger length is included in the analysis —men have lower ratio of finger length than women (Manning, Henzi, & Bundred, 2001).

These entrepreneurs receive a letter with their registration packet one month prior to the conference explaining the nature of academic research and requesting that they participate in the study via survey and hand scan after registering at the conference. Self report on risk propensity, risk perceptions, goal commitment was collected via a survey from the entrepreneurs at a conference in the Midwest in late September and early October. Upon completion of the survey, the participants were asked to place both hands on a scanner for 20 seconds—one scan per participant. The CanoScan LiDE70 scanner was used and placing a piece of black cloth over the hands while they are scanned to capture finger length. (Personal correspondence, Anna Dreber-Almenberg, Harvard Dynamic Evolution department).

Measures

Prior research has found that one hand has a larger magnitude *2D:4D ratio* than the other (McIntyre, 2006). Finger length was measured by a graduate student and one of the authors from the archived and printed hand scans from the conference. The length of fingers was measured as described by John Manning (2002; 2008). The values for the inter-rater reliability were calculated and found to be higher than previous reliability in 2D:4D research (IRR<0.97).The reliability is consistent with the risk related management science research done through the Program for Evolutionary Dynamics at Harvard University. This variable was then reverse coded to better reflect the underlying variable of testosterone in the finger length variable.

Risk propensity is a 6 item survey measure from Lewis Goldberg's proxy for the risk scale in the Jackson Personality Inventory including only the non-reverse coding items. This was then values were averaged across the six items.

Entrepreneurial *risk perceptions* is a six items sequence of vignettes based on the work of MacCrimmon and Wehrung (1988); however, since the items correlate to each other greater than 0.98, the most representative item will serve as a one item presentation of risk perception.

The *commitment to sales goals* is a two survey item measure, and *the commitment to strategic goals* is a one survey item measure, developed as part of a larger research design on the importance of and expertise of executive goals. Items available upon request.

Firm Performance is a measure of total revenue the firm earned in the year corresponding to the survey year. We chose venture revenue as an outcome rather than other types of performance, because it was available in an objective none survey, but industry specific archive and it is a firm-level variable that reflects both relative entrepreneurial success, but also firm performance.

In this study *two control variables* are used, gender and if the entrepreneur has other business ventures he spends more than 20 hours in the week maintaining.

This analysis employed structural equation modeling (SEM) and estimated the model via maximum likelihood using AMOS Version 5 (Arbuckle, 1997). Structural modeling deals with structural issues found in survey designed research, and is increasingly useful in management research analysis (Shook *et al.*, 2004). Missing data was replaced with the mean of the non-missing variables.

RESULTS AND DISCUSSION

Table 1 includes the descriptive statistics of the variables in the study including the means, standard deviations, and correlations. Figure 1 includes the results of the testing of the hypothesized research model, including the lambda coefficients. Four of the 10 hypothesized paths have significant coefficients. The fit statistics illustrate that the data fits the model well: goodness-of-fit index = .99; adjusted goodness-of-fit index = .99; root-mean-square error =.001; root-mean square error of approximation = .001; expected cross-validation index =.98. The chi-square statistics $X^2(16, N=90) = 10.0$ is statistically significant at ($p = .001$).

There is no significant direct path from 2D:4D to risk propensity, thus hypothesis 1 is unsupported. There is significant direct path ($p < 0.01$) from 2D:4D to strategic goal commitment (-0.184), also 2D:4D to firm performance (-0.183; $p < 0.05$). Hypothesis 2 is supported; however, although hypothesis 3 is statistically significant, the direction of relationship does not support the hypothesis. Neither risk perception nor propensity has a statistically significant relationship with strategic goal commitment. Risk propensity to sales goal commitment is statistically significant (0.147; $p < .10$). Hypothesis 4 A(1) and 4 B are not supported. Additionally, the relationship proposed in hypothesis 4A (2) between risk propensity and sales goal commitment is not supported, as the relationship is not in the hypothesized direction. Hypothesis 5, which proposes that commitment to strategic and sales goals are positively associated with firm performance is not supported, as the direction of the relationship between sales goal commitment and firm performance is as hypothesized (0.203), but lacks statistical significance. The relationship between strategic goal commitment and firm performance is significant ($p < 0.10$), but is not is a negative association (-2.23). In summary, the model although a good fit, has several significant relationships that are contrary to that theorized.

Baron believes that entrepreneurs think differently than other people and observes "... [t]hat entrepreneurs often underestimate the risks and overestimate the likelihood of success are well-established facts. Why these tendencies occur, however, remains uncertain" (1998:205). Previous 2D:4D research has found this ratio has explanatory power for both risk propensity and external locus of control. We find these previous studies consistent to our results. The inclusion of the 2D:4D ratio in our empirical model may partially explain the tendencies of some entrepreneurs to underestimate risk (risk propensity) and some level of entrepreneurial success.

THEORETICAL IMPLICATIONS, LIMITATIONS, AND FUTURE RESEARCH

This research proposal is an opportunity to make several theoretical contributions. The use of Upper Echelon is in answer to the call by Hambrick (2007) to take a unique view into the black box of entrepreneur's individual differences and cognition. This use of biological metrics opens an innovative area of research and a completely new area of individual differences to be examined. This research also allows for the empirical testing of several theoretically proposed relationships between biology and previously determined entrepreneurial behaviors associated with success.

This paper will make several important contributions to the biological characteristics and individual differences literatures. This research moves the discussion of venture performance from the firm level to the individual level (more specifically to the individual biological level). This work develops theory to identify and explain biological antecedents to venture performance both directly and through entrepreneurs' risk propensity and risk perceptions. These mediators will help both researchers and practitioners begin to understand the boundaries pertaining to biological differences and firm-level outcomes. For entrepreneurs, this research begins to clarify the biological basis underlying their decision-making processes and biases.

This sample from the financial services industry, controls for industry; however, entrepreneurs across industries might have differing perceptions of risk. There may be a problem with the generalizability of the sample. Although the operationalization of most of the variables have already been tested for reliability and validity, there may be some questions as to the construct validity from individual to firm level constructs. There are general issues of concern in the strategy research the individual differences be measured accurately relative to the research question being asked. Measuring the relationship between individual differences and the organizational level constructs are heavily scrutinized. A wide variety of learned behavior, social influences and other factors may affect both the decision to act entrepreneurially and the subsequent performance of those entrepreneurial actions (White, Thornhill, & Hampson, 2006). Although biological measures, such as hormones as proxied by the 2D:4D ratio, appear to explain some variation in firm success, (higher 2D:4D ratio is associated with lower firm revenue), entrepreneurship is still the nexus of environment and the uniqueness of the entrepreneur. As such, a great number of additional variables will need to be evaluated in conjunction with the 2D:4D in order to determine the validity of these findings as more than an intriguing exploratory study.

This area of research opens a new perspective on individual differences. Scholars called for a more in depth exploration of the extent to which entrepreneurs perceive risk differently (e.g., Busenitz and Barney, 1997). Understanding the source of these differences in risk perception and management opens a new arena for entrepreneurship scholars. This also may lead to additional research in individual differences and competitive advantage, and biological factors that may affect the elements of the Entrepreneurial Orientation construct-- specifically, linking individual entrepreneurial differences to firm level constructs that are used to predict entrepreneurial firm profitability.

There are numerous other measures that may serve as interesting additions to this proposed research. Another interesting area of potential research is the area of innovation. Are those entrepreneurs with higher levels of testosterone generally more innovative? I have already proposed that extreme innovativeness may have a curvilinear effect on performance, however, is this relationship mediated or moderated by any factors? Entrepreneur's who find themselves in high risk situations may experience burnout at differing rates with the mediating or moderating factor being the testosterone level in the entrepreneur. Financial distress may also play a role in the rate of burnout experienced by the entrepreneur.

CONTACT: Cheryl Trahms; ctrahms@mays.tamu.edu; (T): 979-845-9622; (F): 979-845-9641; Mays Business School, Texas A&M University, College Station, TX 77843.

REFERENCES

- Aldrich, H. E., Renzulli, L. A., & Langton, N. (1998). Passing on privilege: Resources provided by self-employed parents to their self-employed children. In *Research in Social Stratification and Mobility, Volume 16* (ed. Leicht, K., pp. 291–317). Greenwich, CT: JAI.
- Alvarez, S. A. & Barney, J. (2007). Discovery and creation: alternative theories of entrepreneurial action. *Strategic Entrepreneurship Journal*, 1(1-2), 11–26.
- Apicella, C. L., Dreber, A., Campbell, B., Gray, P. B., Hoffman, M. & Little, A.C. (2008). Testosterone and financial risk preferences, *Evolution and Human Behavior*, 29(2), 384-390.
- Baron, R. (2002). OB and entrepreneurship: The reciprocal benefits of closer conceptual links. In *Research in Organizational Behavior* (eds. Staw, B., & Kramer, E., 255-269) Greenwich, CT: JAI Press.
- Baron, R. A., Markman, G. D., & Hirska, A. (2001). Perceptions of women and men as entrepreneurs: Evidence for differential effects of attributional augmenting. *Journal of Applied Psychology*, 86, 923–929.
- Booth, A., Johnson, D. R., Granger, D. A. (1999). Testosterone and men's depression: The role of social behavior. *Journal of Health and Social Behavior*, 40(1), 130 –140.
- Busenitz, L., & Barney, J. (1997). Differences between entrepreneurs and managers in large organizations: Biases and heuristics in strategic decision-making. *Journal of Business Venturing*, 12(1), 9–30.
- Byrnes, J. D., Miller, C. & Schafer, W.D. (1999). Gender differences in risk taking: A meta analysis. *Psychological Bulletin*, 125, 367-383.
- Coates, J. M., & Herbert, J. (2008). Endogenous steroids and financial risk taking on a London trading floor. *Proceedings of the National Academy of Sciences*, 105, 6167–6172.
- Coates, J., Gurnell, M., & Rustichini, A. (2009). Second-to-fourth digit ratio predicts success among high-frequency financial traders. *Proceedings of National Academy of Sciences*, 106, 623-628.
- Covin, J. G., & Covin, T. (1990). Competitive aggressiveness, environmental context, and small firm performance. *Entrepreneurship: Theory and Practice*, 14(1), 35-50.
- Covin, J. G., & Slevin, D. P. (1988). The influence of organization structure on the utility of an entrepreneurial top management style. *Journal of Management Studies*, 25, 217-234.
- Covin, J. G., & Slevin, D. P. (1989). Strategic management of small firms in hostile and benign environments. *Strategic Management Journal*, 10(1), 75-87.
- Covin, J. G., & Slevin, D. P. (1991). A conceptual model of entrepreneurship as firm behavior. *Entrepreneurship: Theory and Practice*, 16(1), 7-24.
- Dreber, A., & Hoffman, M. (2007). Risk preferences are partly predetermined. Mimeo: Stockholm School of Economics.
- Freese, J., Li, J. A., & Wade, L. D. (2003). The potential relevance of biology to social inquiry. *Annual Review of Sociology*, 29(1), 233–256.
- Gaglio, C. M., & Katz, J. (2001). The psychological basis of opportunity identification: Entrepreneurial alertness. *Journal of Small Business Economics*, 12(1), 95–111.
- Gist, M. E., & Mitchell, T. R. (1992). Self-efficacy: A theoretical analysis of its determinants and malleability. *Academy of Management Review*, 17(1), 183-211.
- Hambrick, D. C., & Mason, P. A. (1984). Upper echelons: The organization as a reflection of its top managers. *Academy of Management Review*, 9, 193-206.

- Hambrick, D. (2007). Upper echelons theory: An update. *Academy of Management Review*, 32, 334–343.
- Hmieleski, K & Baron, R. 2009. When does entrepreneurial self-efficacy enhance versus reduce firm performance? *Strategic Entrepreneurship Journal*, 2(1), 57-72.
- Hmieleski, K. M., & Baron, R. A. (2006). Optimism and environmental uncertainty: Implications for entrepreneurial performance. In *Frontiers of Entrepreneurship Research*. (ed. Bygrave, W.) Babson Park, MA: Babson College.
- Ilies, R., Arvey, R. D., & Bouchard, T. J. 2006. Darwinism, behavioral genetics, and organizational behavior: a review and agenda for future research, *Journal of Organizational Behavior*, 27(1), 121–141.
- Janney, J. J., & Dess, G. G. (2006). The risk concept for entrepreneurs reconsidered: new challenges to the conventional wisdom. *Journal of Business Venturing*, 21, 385–400.
- Johnson, D. D. P., McDermott, R., Barrett, E. S., Cowden, J., Wrangham, R., McIntyre, M. H. & Rosen, S. P. (2006). Overconfidence in wargames: Experimental evidence on expectations, aggression, gender and testosterone. *Proceedings of the Royal Society*, 273, 2513-2520.
- Johnson, W. (2009). So what or so everything? Bringing behavior genetics to entrepreneurship research. *Journal of Business Venturing*. 24(1), 23-26.
- Keh, H. T., Foo, M. D., & Lim, B. C. (2002). Opportunity evaluation under risky conditions: The cognitive processes of entrepreneurs. *Entrepreneurship: Theory and Practice*, 27(1), 125-149.
- Lipshitz, R., & Strauss, O. (1997). Coping with uncertainty: A naturalistic decision-making analysis. *Organizational Behavior and Human Decision Processes*, 69(1), 149-163.
- Low, M. B., & MacMillan, I. C. (1988). Entrepreneurship: Past research and future challenges. *Journal of Management*, 14(1), 139–161.
- Lumpkin, G. T., & Dess, G. G. (1996). Clarifying the entrepreneurial orientation construct and linking it to performance. *Academy of Management Review*, 21(1), 135-172.
- Lyon, D. W., Lumpkin, G. T., & Dess, G. G. (2000). Enhancing entrepreneurial orientation research: operationalizing and measuring a key strategic decision making process. *Journal of Management*, 26, 1055–1085.
- March, J. G., & Shapira, Z. (1987). Managerial perspectives on risk and risk taking. *Management Science*, 33, 1404-1418.
- Manning, J. T., & Rogan P. T. (2001). Second to fourth digit ratio and male ability in sport: implications for sexual selection in humans. *Evolution and Human Behavior*, 22: 61-69.
- Manning, J. T., Scutt, D., Wilson, J., & Lewis-Jones, R. S. (1998). The ratio of 2nd to 4th digit length: a predictor of sperm numbers and concentrations of testosterone, luteinizing hormone and estrogen. *Human Reproduction*, 13, 3000–3004.
- Manning, J. T., Barley, L., Walton, J., Lewis-Jones, R. S., Trivers, R. L., Singh, D., Thornhill, R., Rhode, P., Bereczkei, T., Henzi, P., Soler, M., & Szwed, A. (2000). The 2nd:4th digit ratio, sexual dimorphism, population differences and reproductive success: evidence for sexually antagonistic genes? *Evolution and Human Behavior*, 21(1), 163–183.
- Manning, J. T., Henzi, P., & Bundred, P. E. (2001). The ratio of 2nd to 4th digit length: a proxy for testosterone, and susceptibility to HIV and AIDS? *Medical Hypotheses*, 57, 761–763.
- Manning, J. T., & Taylor, R. P. (2001). 2nd to 4th digit ratio and male ability in sport: implications for sexual selection in humans. *Evolution and Human Behavior*, 22, 61–69.
- Manning, J. T., Stewart, A., Bundred, P.E., & Trivers, R. L. (2004). Sex and ethnic differences in 2nd to 4th digit ratio of children. *Early Human Development*, 80(1), 161-168.

- McIntyre, M. H. (2006). The use of digit ratios as markers for perinatal androgen action. *Reproductive Biology and Endocrinology*, 4, 1177-1187.
- McNamara, G. & Bromiley, P. (1997). Decision making in an organizational setting: Cognitive and organizational influences on risk assessment in commercial lending. *Academy of Management Journal*, 40, 1063-1088.
- Miller, K. (2007). Risk and Rationality in Entrepreneurial Processes. *Strategic Entrepreneurship Journal*, 1(1), 57-74.
- Miller, D. (1983). The correlates of entrepreneurship in three types of firms. *Management Science*, 29, 770-791.
- Morris, M.H., Kuratko, D.F., & Covin, J.G. (2008). *Corporate entrepreneurship and innovation* (2nd ed.). Mason, OH: South-Western/Thomson Publishers.
- Naman, J. L. & Slevin, D. P. (1993). Entrepreneurship and the concept of fit: A model and empirical tests. *Strategic Management Journal*, 14(1), 137-153.
- Nicolaou N. & Shane S. (in press). Can genetic factors influence the likelihood of engaging in entrepreneurial activity? *Journal of Business Venturing*.
- Nicolaou, N., Shane, S., Cherkas, L., Hunkin, J., & Spector, T. (2008). Is the tendency to engage in entrepreneurship genetic? *Management Science*, 54, 167–181.
- Nicolaou, N., Shane, S., Cherkas, L., & Spector, T. D. (2008). The influence of sensation seeking in the heritability of entrepreneurship. *Strategic Entrepreneurship Journal*, 2, 7–21.
- Norton, W. I. & Moore, W. T. (2006). The influence of entrepreneurial risk assessment on venture launch or growth decisions. *Small Business Economics*, 26, 215–226.
- Nohari, K. & Gulati, S. (1996). Is slack good or bad for innovation. *Academy of Management Journal*, 39, 799 - 825.
- Palich, L. & Bagby, R. (1995). Using cognitive theory to explain entrepreneurial risk-taking: Challenging conventional wisdom. *Journal of Business Venturing*, 10, 425–438.
- Salvador, A., Suay, F., González-Bono, E., & Serrano, M. (2003). Anticipatory cortisol, testosterone and psychological responses to judo competition in young men. *Psychoneuroendocrinology*, 28(3), 364-375.
- Schneider, S. L. & Lopes, L. L. (1986). Reflection in preferences under risk: Who and when may suggest why. *Journal of Experimental Psychology: Human Perception and Performance*, 12, 535-548.
- Shane, S. & Venkataraman, S. (2000). The Promise of Entrepreneurship as a Field of Research. *Academy of Management Review*, 25, 217-226.
- Shaver, K. G. & Scott, L. R. (1991). Person, process, and choice: The psychology of new venture creation. *Entrepreneurship Theory and Practice*, 6(1), 23–42.
- Simon, M., Houghton, S.M., & Aquino, K. (2000). Cognitive biases, risk perception, and venture formation: how individual decide to start companies. *Journal of Business Venturing* 15(1), 113–134.
- Slovic, P., Finucane, M. L., Peters, E., MacGregor, D. G. (2004). Risk as analysis and risk as feelings: some thoughts about affect, reason, risk, and rationality. *Risk Analysis*, 24: 311–322.
- Stewart, W. H. & Roth, P. L. (2001). Risk propensity differences between entrepreneurs and managers: A meta-analytic review. *Journal of Applied Psychology*, 86(1), 145–153.
- Stewart, W. H. & Roth, P. L. (2004). Data quality affects meta-analytic conclusions: A response to Miner and Raju 2004 concerning entrepreneurial risk propensity. *Journal of Applied Psychology*, 89(1) 14–21.
- Tversky, A. & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology*, 5, 207-252.

- Thornton, P., & Flynn, K. (2003). Entrepreneurship, networks, and geographies. In *Handbook of Entrepreneurship Research*, (eds. Z. Acs, & D. Audretsch, pp. 401-236) Kluwer Academic Publishing: Boston, MA.
- Venkataraman, S. (1997). The distinctive domain of entrepreneurship research: An editor's perspective. In *Advances in entrepreneurship, firm emergence, and growth* (eds. J. Katz & R. Brockhaus, 3: 119–138) Greenwich, CT: JAI Press.
- Wiklund, J. & Shepherd, D. (2003). Knowledge-based resources, entrepreneurial orientation, and the performance of small and medium-sized businesses. *Strategic Management Journal*, 24, 1307–1314.
- Wiklund, J. & Shepherd, D. (2005). Entrepreneurial orientation and small business performance: A configurational approach. *Journal of Business Venturing*, 20(1), 71–91.
- Wiklund, J. (1999). The sustainability of the entrepreneurial orientation-performance relationship. *Entrepreneurship Theory and Practice*, 24(1), 37-48.
- Zhao, H., Seibert, S. E., & Hills, G. E. (2005). The mediating role of self-efficacy in the development of entrepreneurial intentions. *Journal of Applied Psychology*, 90, 1265–1272.
- Zhao, H. & Seibert, S.E. (2006). The Big Five personality dimensions and entrepreneurial status: A meta-analytical review. *Journal of Applied Psychology*, 91(2), 259-271.

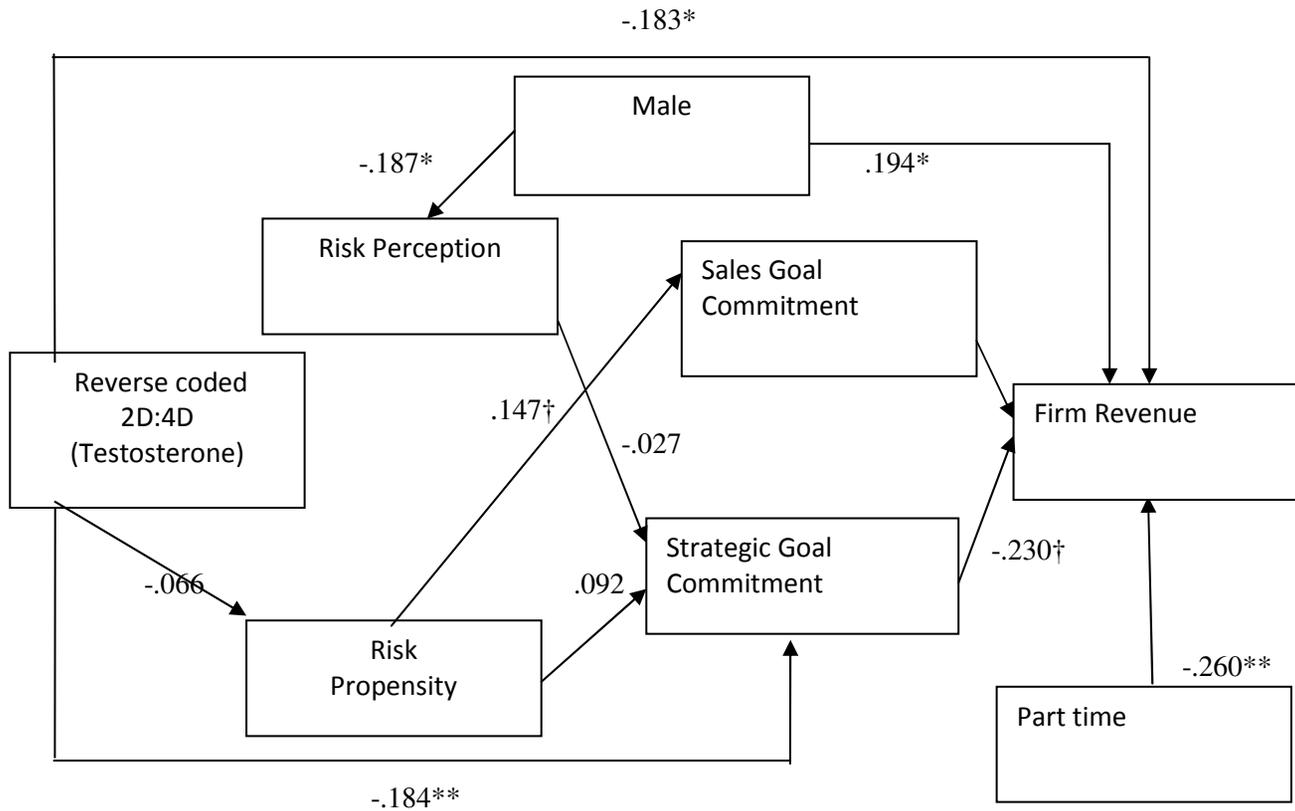
Table 1. Means, Standard Deviations, and Correlations

Variables	Mean	Std. Deviation	2D:4D	Risk Propensity	Risk Perception	Strategic Goal Commitment	Sales Goal Commitment	Male	Other Ventures
2D:4D	1.05	0.04	--						
Risk Propensity	2.75	0.60	-0.07	--					
Risk Perception	2.09	1.15	0.05	0.02	--				
Strategic Goal Commitment	3.93	0.82	-0.15	0.10	-0.08	--			
Sales Goal Commitment	3.91	0.72	0.04	0.15	-0.06	.778**	--		
Male	0.87	0.34	0.09	0.08	0.02	0.05	-0.03	--	
Other Ventures	0.40	0.49	0.03	0.02	-0.05	-0.04	-0.11	-0.08	--
Firm Revenue	43829.57	59913.00	-0.13	0.00	0.00	-0.02	0.04	0.18	-.294**

N=90

**p<0.01

Figure 1: Structural Equation Results: Entrepreneurial 2D:4D, Risk, Goal Commitment And Firm Revenue Model



Fit statistics: $X^2(16, N=90) = 10.0, p = .001$; goodness-of-fit index = .99; adjusted goodness-of-fit index = .99; root-mean-square error = .001; root-mean square error of approximation = .001; expected cross-validation index = .98. One tailed tests significance $^\dagger = 0.10$; $^* = 0.05$; $^{**} = 0.01$.

