

OPPORTUNITY RECOGNITION AND OPPORTUNITY EXPLOITATION: A  
BIVARIATE GENETICS PERSPECTIVE

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## OPPORTUNITY RECOGNITION AND OPPORTUNITY EXPLOITATION: A BIVARIATE GENETICS PERSPECTIVE

### ABSTRACT

We applied quantitative genetics techniques to a sample of 870 pairs of monozygotic and 857 pairs of same-sex dizygotic twins to examine the influence of genetic factors on the variation across people in opportunity recognition. We also examined the extent to which the same genetic factors contribute to both opportunity recognition and opportunity exploitation. The results indicate substantial heritability for opportunity recognition (0.45), with no influence of the shared environment. Moreover, we found that 54 percent of the phenotypic correlation between opportunity recognition and opportunity exploitation had a common genetic aetiology.

### INTRODUCTION

Whether it is to found an Internet search engine, an airline or a new restaurant, an important prerequisite to being an entrepreneur is identifying an opportunity for a new business. As a result, opportunity recognition is an important part of the entrepreneurship process. In the last decade, scholars have given increased attention to unravelling the antecedents of opportunity recognition (e.g. Shane, 2000; Gaglio and Katz, 2001; Baron and Ensley, 2006; Casson and Wadeson, 2007). One of the findings in this stream of research is that some people are better at noticing new business opportunities than other people, and that this superior ability makes them more likely than other people to start businesses (Baron and Ensley, 2006).

While researchers have identified some of the factors that account for the variation across people in opportunity recognition (Baron, 2007), to date researchers have not explored the question of whether some people are born with a greater genetic predisposition to identify entrepreneurial opportunities, and, if they are, whether the same genetic factors also account for the greater tendency of some people to start businesses. In this paper, we provide the first

empirical investigation of the genetic component of opportunity recognition and examine whether the covariance between opportunity recognition and opportunity exploitation is partly accounted for by genetic factors.

Investigating the genetic aetiology of opportunity recognition and exploitation is important for two reasons. First, an accurate understanding of entrepreneurship depends on the correctly ascribing the sources of variation between people in opportunity recognition. If the identification of new business opportunities is a necessary part of new business creation, then researchers must account for differences across people in their ability to recognize opportunities in order to explain new business formation. To date, researchers have explained only a small part of this variance (Shane, 2003; Butler, 2004). Understanding the role that genetics plays in opportunity recognition can help scholars build a more comprehensive and integrative understanding of this phenomenon.

Second, understanding the common genetic aetiology between opportunity recognition and exploitation is important to suggest what, if any, interventions can be undertaken to encourage people to create new businesses. If the entire correlation between opportunity recognition and exploitation is accounted for by genetic factors, this would suggest that we cannot influence the level of entrepreneurial exploitation that occurs in an economy by engaging in interventions that stimulate people to, or teach people to, recognize opportunities. On the other hand, if there are no shared genetic influences between opportunity recognition and exploitation, then we could significantly affect new business creation by stimulating opportunity recognition.

We examine the degree to which opportunity recognition has a genetic component and whether the same genetic component accounts for variation across people in both opportunity recognition and opportunity exploitation through behavioral genetics. Behavioral genetics involves the comparison of monozygotic (MZ) and dizygotic (DZ) twins to disentangle genetic from environmental influences in the variables of interest, in our case opportunity recognition and opportunity exploitation.

Because MZ twins share their entire genetic composition and DZ twins share, on average, 50 percent of their segregating genes, studies of twins can provide estimates in the heritability (or degree to which the source of variation is genetic) of a phenotype of interest (in this case, opportunity recognition). Assuming that MZ and DZ co-twins do not differ in the similarity of their environments, differences in the correlations between pairs of MZ and DZ co-twins is a function of genetic factors.

We use bivariate genetics techniques to identify whether the same genetic factors influence both opportunity recognition and opportunity exploitation. By comparing MZ and DZ twin correlations *across* both opportunity recognition and exploitation, (e.g., we compare one twin's opportunity recognition score with its co-twin's opportunity exploitation score) we can determine the extent to which the correlation between opportunity recognition and opportunity exploitation is a function of genetic factors. If the cross-trait-cross-twin correlations are greater for MZ twins than for DZ twins, then genetic factors contribute to the phenotypic correlation between these two variables, but if the cross-trait-cross-twin correlations are equal for MZ and DZ twins, or are greater for DZ twins than for MZ twins, then genetic factors do not contribute to the phenotypic correlation between these two variables.

## **THEORY DEVELOPMENT**

Understanding opportunity recognition, or the identification of a chance to combine resources in a way that might generate a profit, is an important question in the field of entrepreneurship (Shane and Venkataraman, 2000; Gaglio and Katz, 2001; Shane, 2003). Researchers have identified a number of differences between people that are correlated with opportunity recognition, including prior information (Shane, 2000), psychological "alertness" (Kirzner, 1979, Kaish and Gilad, 1991, Gaglio and Katz, 2001), pattern recognition skills (Baron and Ensley, 2006), and social network structure (Singh et al, 1999; Baron and Ozgen, 2007). However, the origin of these correlates of opportunity recognition has not been

identified. These differences might be randomly assigned or learned, or they might be the result of a person's genetic endowment.

We propose that a person's genetic endowment is an important source of the variation between people in their degree of opportunity recognition. Recent evidence indicates that genetic factors influence many aspects of human behaviour that are associated with opportunity recognition, including attitudes (e.g. Bouchard et al., 2004), intelligence (Plomin and Spinath, 2004), and openness to experience (Plomin et al., 2001).

We do not yet know how genetic factors could influence differences across people in opportunity recognition, but we have some plausible explanations. Genetic factors may affect the development of individual attributes that are associated with the recognition of entrepreneurial opportunities. For example, scholars have found that individuals who notice patterns between seemingly independent events or trends – they are better at “connecting the dots” – are more likely than others to identify entrepreneurial opportunities (Baron, 2004; Baron and Ensley, 2006). Genetic research has shown that this type of pattern recognition is heritable (Plomin et al., 2001). Therefore, genetic factors might affect opportunity recognition by influencing the distribution of pattern recognition skills across people.

Genetic factors may influence the recognition of entrepreneurial opportunities through gene-environment interactions. That is, a particular genetic endowment might moderate the influence of environmental stimuli on the likelihood of recognizing entrepreneurial opportunities (Rowe, 2003, Moffitt et al., 2005, 2006). For example, studies have shown that intelligence is associated with different allelic frequencies of the IGF2R gene (Chorney et al., 1998; Fischer et al., 1999). If identification of opportunities is associated with intelligence, as many researchers believe (Hebert and Link, 1998), then the IGF2R gene (or others with a similar function) may interact with environmental stimuli such as access to information, to increase the probability of opportunity recognition.

Genetic factors may influence opportunity recognition through gene-environment correlations (Jaffee and Price, 2007), or the tendency of people with certain genetic endowments to select into more favourable environments (Kendler and Eaves, 1986). Some

people select into environments that are more favourable to opportunity recognition. For example, people choose to develop skills and to obtain education that leads them to different jobs. Research shows that a person's job function influences his or her likelihood of opportunity recognition (Shane, 2003). The skills that people develop and the education that they obtain are at least partially heritable (Plomin et al., 2001). Thus, our genes might affect opportunity recognition through gene-environment correlations.

Recent research has shown that there is a genetic predisposition to engage in opportunity exploitation, with heritability estimates ranging from 0.37 to 0.42 depending on the operationalization of the construct (Nicolaou, Shane, Cherkas, Hunkin, Spector, 2008). Because recognizing opportunities is seen as a precursor to opportunity exploitation (Shane and Venkataraman, 2000; Shane, 2003), and much research shows that similar factors are associated with both phenomena (Baron, 2007; Stuart and Sorenson, 2007), the question arises as to whether the same genes increase the likelihood of opportunity recognition and opportunity exploitation.

An example of how common genetic factors could affect both recognition and exploitation is through cognitive abilities. Reasoning, processing speed, spatial ability, working memory and other cognitive abilities have been shown to be heritable (e.g. Nichols, 1978; Pedersen et al., 1992; Plomin et al., 2001). In turn, studies have shown the importance of cognitive factors to both opportunity recognition (e.g. Hebert and Link, 1988; Mitchell et al., 2000; Shane, 2003) and exploitation (e.g. De Wit, 1993; Sternberg, 2004).

Another way through which common genetic factors could affect both recognition and exploitation is through social networks. Social networks have been found to influence both the recognition (Hills et al., 1997; Singh et al., 1999; Sigrist, 1999; Ozgen and Baron, 2006) and exploitation of entrepreneurial opportunities (Aldrich et al., 1986; Nicolaou and Birley, 2003; Aldrich and Kim, 2007; Stuart and Sorenson, 2007). Behavioral genetics research has shown that there is a genetic predisposition to developing effective social networks. For example, studies have shown that people's choice of friends and members of their social networks has a genetic predisposition (Manke et al., 1995; Daniels and Plomin,

1985; Iervolino et al., 2002) as does the level of support that people obtain from their network (Bergeman et al., 1990). Moreover, social potency and social skills, which are important in the formation of effective networks (Baron and Markman, 2003), also are affected by genetic factors (Carey, 2003).

Based on these arguments, we hypothesize:

H1: Genetic factors influence the variation across people in opportunity recognition.

H2: The same genetic factors influence the variation across people in both opportunity recognition and opportunity exploitation.

## **METHODOLOGY**

The natural experiment of twins enables us to disentangle the portion of the variance in opportunity recognition that comes from genetic and environmental factors as well as the portion of the covariance between opportunity recognition and opportunity exploitation that is accounted for by genetic factors. Twin studies are based on a comparison of monozygotic (MZ) and dizygotic (DZ) twins. MZ twins are formed when a single sperm fertilizes a single egg; the egg subsequently splits into two, resulting into two individuals who are genetically identical (Kendler and Prescott, 2006). DZ twins are formed when two different eggs are fertilized by two different sperm, and hence share, on average, 50 percent of their segregating genes, just like all other full siblings.

Because MZ twins share 100 percent of their genes and DZ twins share, on average, 50 percent of their segregating genes, if pair resemblance for opportunity recognition among MZ twins exceeds that of DZ twins, we can infer that genetic factors contribute to the variance in opportunity recognition. In addition, genetic factors contribute to the phenotypic correlation between the two variables if cross-trait cross-twin correlations for opportunity recognition and opportunity exploitation are greater for MZ than for DZ twins.

The validity of twin studies rests on the assumption that the shared environment of DZ twins is similar to that of the MZ twins, so called the equal environments assumption

(EEA). For this assumption to be violated, environmental factors must treat MZ twins in a different way than DZ twins *and* this difference in treatment must influence the phenotype under study. Different methods have been used to evaluate the EEA, all of which confirm the robustness of the assumption (Kendler, 1983; Kendler and Prescott, 2006). First, studies have compared the phenotypic similarity in twin pairs using data on real and perceived zygosity, and have found that actual, and not perceived, twin zygosity is what influences twin similarity (Scarr, 1968, Scarr and Carter-Saltzman, 1979; Kendler and Prescott, 2006). Second, studies that have used different methods to assess the similarity of environmental exposure, such as (i) twin ratings of similarity at childhood, adolescence and adulthood, (ii) ratings of physical similarity from photographs, and (iii) ratings of similarity of parental treatment, have failed to find consistent violations of the EEA (Kendler et al., 1994; Hettema et al., 1995; Kendler and Prescott, 2006).

### Sample

Our sample consists of 3,454 twins, comprising 870 pairs of MZ and 857 pairs of same-sex DZ twins from the United Kingdom. We ascertained twin zygosity through a standardized validated questionnaire – which has an accuracy of 95% (Martin and Martin, 1995; Peeters et al., 1998) – and, in cases of uncertainty, through multiplex DNA fingerprinting using variable tandem repeats – which has an accuracy of around 99.7% (Singer et al., 2005).

The twins were initially recruited through a national media campaign designed to gather data for medical research (Spector et al., 1996; [www.twinsuk.ac.uk](http://www.twinsuk.ac.uk)). In 2006, each subject was sent a self-completion postal questionnaire, which focused mostly on gathering information on medical conditions (e.g. osteoporosis, response to pain etc.),<sup>1</sup> but which also gathered information relevant to the present study. Because the focus of the data collection

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<sup>1</sup> Over 90% of the sample was female; this is because the sample was initially recruited to study the heritability of osteoporosis and osteoarthritis, medical conditions that occur primarily in females.

was on medical issues, the subjects were unaware of the hypotheses of this study when completing the questionnaire.

### Measures of opportunity recognition and opportunity exploitation

The entrepreneurship literature does not agree on a definition of opportunity exploitation – the definitions used by researchers range from self-employment (Parker, 2004) to founding a new firm (Gartner, 1989) to being an owner-operator of a company (Hull et al., 1980). Rather than choose one definition over another, we sought to determine whether these different definitions measure the same underlying construct, and, if so, to create an overall measure of opportunity exploitation that is based on these different variables.

We asked the respondents about the following dimensions of opportunity exploitation:

- Self-employment, (Amit et al., 1995; Evans and Leighton, 1989; Taylor, 1996; Le, 1999, Burke et al, 2000; Van Praag and Cramer, 2001; Parker, 2004; Sorensen, 2007), which we operationalize with the question: “in your working life, how long have you been self employed?”
- Starting a new business (Gartner, 1989; Mesch and Czamanzki, 1997; Delmar and Davidsson, 2000), which we operationalize with the question: “in your working life, how many new businesses have you started?”
- Being an owner-operator of a company (Hull et al., 1980; Ahmed, 1985; Bitler et al., 2005), which we operationalize with the question: “in your working life, how many companies have you been an owner–operator of?”
- Engaging in the firm start-up process (Reynolds et al, 2004; Ruef et al, 2003; Delmar and Shane, 2003), which we operationalize with the question: “in your working life, for how many new business ideas have you taken any actions toward the creation of a new business?”

We factor analyzed the responses and found that they loaded on the same factor. We then combined these different items into a scale, which we found to be reliable; it had a Cronbach's alpha of 0.80.<sup>2</sup>

We measure opportunity recognition through the use of a five-item scale composed of the following questions drawn from the literature on opportunity recognition (Baron and Ozgen, 2007; Singh et al., 1999):

- I enjoy thinking about new ways of doing things;
- I frequently identify opportunities to start-up new businesses (even though I may not pursue them);
- How many ideas for new businesses did you think of in the past month?
- I frequently identify ideas that can be converted into new products or services (even though I may not pursue them);
- I generally lack ideas that may materialise into profitable enterprises (reverse scored).

This scale has a Cronbach's alpha of 0.72, indicating that it is reliable.

### Structural equation modeling

The relative contribution of genetic and environmental variation to opportunity recognition can be estimate quantitatively by using variance components analysis. In the basic twin design, variation can arise from three sources: additive genetic effects (A), shared (or common) environmental effects (C) (i.e. factors shared by family members), and non-shared environmental factors (E) (i.e., environmental effects that are unique to an individual) (Kendler and Prescott, 2006).

Diagrammatically the model that we estimate is shown in figure 1. The boxes represent the observed variables (i.e. opportunity recognition or opportunity exploitation), while the circles represent the latent factors that the model estimates (i.e., additive genetic

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<sup>2</sup> A factor analysis with Varimax rotation of the four opportunity exploitation and the five opportunity recognition questions yielded two distinct factors with eigenvalues were 3.63 and 1.63 respectively. The KMO measure of sampling adequacy was 0.83 and Bartlett's test of Sphericity was highly significant ( $p=0.0001$ ;  $\chi^2=9684$ ; 36 d.f.). There were no cross factor loadings and all loadings were higher than 0.50.

(A), common environmental (C) and non-shared environmental factors (E)). The correlation between the latent additive genetic factors is constrained at 1.00 for MZ and at 0.5 for DZ twins to reflect the degree of genetic relatedness. Because both MZ and DZ twin pairs were raised together, and so shared the same common environment, the correlation between latent common environmental factors is constrained at 1.00 for both types of twins. The non-shared environmental components are assumed to be uncorrelated across members of a twin pair.

INSERT FIGURE 1 ABOUT HERE

The univariate models are estimated through the following structural equations:  $P_{i\xi} = aA_{i\xi} + cC_{i\xi} + eE_{i\xi}$  and  $V_p = a^2 + c^2 + e^2 = 1$  where  $P$  is the phenotype of the  $i$ th individual in the  $\xi$ th pair ( $i=1,2$ ;  $\xi=1\dots n$ , with all variables scaled as deviations from zero), and  $V_p$  is the total phenotypic variance of the population.  $V_p$  corresponds to the sum of additive genetic variance ( $a^2$ ), shared environmental variance ( $c^2$ ) and non-shared environmental variance ( $e^2$ ).

The contribution of A, C, and E to the total variance is evaluated through a series of nested sub-model comparisons. The fit of each model is estimated using a chi-square goodness of fit test, with a perfect fit denoted by 1.00. A non-significant chi-square indicates a good model fit. We used the Akaike Information Criterion (AIC) (Akaike, 1987) and the Root Mean Square Error of Approximation (RMSEA) to select the best fitting model (Neale and Maes, 2002). (Lower values of the AIC and the RMSEA indicate a better model fit.)

#### *Bivariate genetic analysis*

The degree to which the same genetic factors affect both opportunity recognition and opportunity exploitation is measured through bivariate genetic analysis (the path diagram is illustrated in figure 2). Bivariate genetic analysis allows the *covariance* between opportunity recognition and opportunity exploitation be partitioned into that due to shared additive genetic, shared environmental, and unique environmental effects (Kuntsi et al., 2004; Rice et al., 2004; Singer et al., 2006). In such analysis, MZ and DZ twin correlations are compared

across variables. In our case, one twin's score on opportunity recognition is correlated with the co-twin's score on opportunity exploitation. If the cross-trait cross-twin correlations are greater for MZ twins than for DZ twins, this means that genetic factors contribute to the phenotypic correlation between the two variables. The bivariate model is based on a Cholesky parameterization (Loehlin, 1996; Kuntsi et al., 2004).

INSERT FIGURE 2 ABOUT HERE

In this figure  $r_A$ ,  $r_C$ , and  $r_E$  represent the genetic correlation, the shared environmental correlation and the unique environmental correlation, respectively. The genetic correlation,  $r_A$ , indicates the extent to which the genetic influences on recognition overlap with those on exploitation, irrespective of their individual heritabilities (Kuntsi et al, 2004). A genetic correlation of 1 would mean that all genetic influences on opportunity recognition also impact on opportunity exploitation (Plomin et al., 2001).

The variance covariance matrix that we estimate for the MZ twins is shown in Figure 3. ( $\Phi$  stands for opportunity recognition while  $\Omega$  symbolizes opportunity exploitation).

INSERT FIGURE 3 ABOUT HERE

The variance covariance matrix for the DZ twins is shown in Figure 4.

INSERT FIGURE 4 ABOUT HERE

## RESULTS

The descriptive statistics and correlations are shown in Table 1. There were no statistically significant differences between MZ and DZ twins on measures of opportunity recognition and opportunity exploitation.

INSERT TABLE 1 ABOUT HERE

Table 2 shows the results of model fitting for opportunity recognition. The chi-square test for goodness of fit for the model, the Akaike Information Criterion (Akaike, 1987) and the Root Mean Square Error of Approximation (RMSEA) showed that the best fitting model for opportunity recognition included additive genetic and non-shared environmental factors (AE model). The heritability of the opportunity recognition scale was 0.45 ( $p=0.18$ ;  $AIC= -1.78$ ;  $RMSEA= 0.02$ ) [95% CI 0.40-0.50%]. None of the variance could be attributed to shared environmental factors.

We also ran the analysis, adjusting for potential confounders – age, gender, children and religion. We found that the heritability estimate fell marginally to 0.41 once these confounders were included.

INSERT TABLE 2 ABOUT HERE

Table 3 shows the results of model fitting to opportunity exploitation. The AE was the best fitting model with 33% of the variance in opportunity exploitation explained by genetic factors ( $p=0.31$ ;  $AIC= -3.17$ ;  $RMSEA=0.02$ ) [95% CI 0.27-0.39%]. None of the variance in opportunity exploitation could be attributed to shared environmental factors.

INSERT TABLE 3 ABOUT HERE

Table 4 shows the cross-twin-cross-trait correlations for each variable. The values in bold are the MZ and DZ cross-twin correlations for each variable, while the values that are underlined are the cross-trait cross-twin correlations. The cross-trait cross-twin correlations for MZ twins were 0.19 and 0.24. Similarly, 0.11 and 0.08 are the cross-trait cross-twin correlations for DZ twins. The cross-trait cross-twin correlations are greater for MZ twins than for DZ twins suggesting that genetic factors are contributing to the phenotypic

correlation between opportunity recognition and opportunity exploitation. In fact, the bivariate genetic analysis indicates that 54 percent <sup>3</sup> of the phenotypic correlation between exploitation and recognition is accounted for by genetic influences that are common to exploitation and recognition (see Table 5).

#### INSERT TABLES 4 AND 5 ABOUT HERE

As a robustness check we also calculated bivariate models using the specific items that compose the opportunity exploitation scale – self-employment, starting a business, engaged in the firm start-up process, and being an owner-operator of a company – to ensure that the results reported in Table 5 are not an artefact of scale construction. The proportion of the phenotypic correlation accounted for by genetic factors is similar for the specific items composing the opportunity exploitation scale and the overall scale, indicating that the findings described in Table 5 are not an artefact.

### DISCUSSION

We applied quantitative genetics techniques to a sample of 870 pairs of MZ twins and 857 pairs of same-sex DZ twins to examine the magnitude of the genetic component of opportunity recognition and the extent to which the same genetic factors explain both opportunity recognition and opportunity exploitation. The results showed substantial heritability for opportunity recognition (0.45), with no influence of the shared environment. We found that 54 percent of the phenotypic correlation between opportunity recognition and opportunity exploitation had a common genetic aetiology.

#### Limitations

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<sup>3</sup> Table 5 shows that the genetic correlation ( $r_A$ ) is 0.52. Multiplying the genetic correlation by the square root of the univariate heritability estimates for recognition and exploitation yields the amount of the correlation between recognition and exploitation that is explained by genetic factors, i.e.  $0.52 \times \sqrt{0.45} \times \sqrt{0.33} = 0.20$ . This means that 54 % of the phenotypic correlation between exploitation and recognition (which is 0.37) is accounted for by genetic influences that are common to exploitation and recognition ( $0.20 / 0.37 = 0.54$ ).

Like all studies, this one is not without limitations. Our results have limited generalizability. Because our sample was initially recruited to study medical conditions that occur primarily in women, the sample is predominantly female, limiting our ability to generalize to men. While we have no a priori reason to believe that the effect of genetic factors on entrepreneurial behavior is gender specific, we cannot know for sure that the same patterns exist for men until a study confirming these findings in sample of men has been conducted.

Our results are only a first step toward explaining how our genes influence entrepreneurial behavior. Behavioral genetics studies, such as this one, cannot identify the specific genes that affect the likelihood of opportunity recognition and opportunity exploitation. Therefore, we know that some of the same genes affect both aspects of entrepreneurial behavior, given the relatively high genetic correlation between opportunity recognition and opportunity exploitation. However, we must await future research to identify what those genes are; how many are at work; how they interact; and the mechanisms through which they operate.

### Implications

Despite the limitations just mentioned, the results of our study have implications for both research on, and the practice of, entrepreneurship. On the research side, our study contributes to an emerging stream of research that integrates biological and sociological explanations for entrepreneurial activity (White et al, 2006; Nicolaou, Shane, Cherkas, Hunkin and Spector, 2008). While this school of thought does not negate the importance of environmental factors in explaining entrepreneurship, it suggests that we need to consider also the influence of biological factors if we are to develop accurate explanations for this important phenomenon.

Our study suggests the value of considering the role of genetics in the opportunity recognition process. To date, research has explained only a small part of the variance between people in the recognition of new business opportunities. Moreover, much of the research has

only identified proximal factors that are correlated with opportunity recognition, not the underlying causal factors. Whether the underlying causal factors that account for these correlations are either learned or innate (we believe that they are most likely a combination of both), has important ramifications for how we think about the answers to the questions of “why” and “how” people identify new business opportunities. At the most fundamental level, this is a nature-nurture question: Is everyone born with an equal likelihood of identifying opportunities, making learning the primary force behind the differences between people in the tendency to identify opportunities? Or are some people endowed by Nature with a greater predisposition or ability to identify opportunities, making learning only a secondary force behind the variance across people in opportunity recognition?

The research to date on opportunity recognition implicitly assumes the former and does not even test whether genetic factors matter. However, our results indicate that researchers should view opportunity recognition as an activity for which our genetic make-up plays a key role in explaining the variance across people in this activity. While future empirical work corroborating our findings would be necessary before firmly drawing any conclusions, this pattern suggests a different way of thinking about why and how people recognize entrepreneurial opportunities.

It is important to stress that our results do **not** imply that opportunity recognition is genetically determined, but only that genetic factors influence the propensity to recognize opportunities. In fact, our results show that a substantial part of opportunity recognition is accounted for by non-shared environmental factors (plus measurement error). Nevertheless, our finding that the variance across people in opportunity recognition is a function of both genetic and environmental factors suggests that the implicit “all environmental” approach in the literature is incomplete.

The influence of genetic factors on opportunity recognition also implies that the use of non-experimental data to investigate the impact of environmental factors can lead to confounded estimates because unobserved genetic endowments simultaneously influence both the environmental factors correlated with opportunity recognition and opportunity recognition

itself (Kohler et al., 2005). Therefore, our results indicate that scholars need to use fixed-effects models within MZ twins (co-twin control designs) to overcome the estimation problems caused by the effects of genetic factors on the environmental factors themselves (Kohler et al., 2005). Such approaches will enable entrepreneurship researchers to conduct more rigorous empirical analyses of the relationship between environmental variables and the likelihood of recognizing entrepreneurial opportunities.

Our finding that the “shared environment” did not influence opportunity recognition was quite surprising. Nevertheless, this is consistent with research in other areas of quantitative genetics that found no influence of the shared environment in many aspects of human behavior (e.g. Kendler and Prescott, 2006; Plomin et al., 2001; Singer et al., 2006). Our finding of no effect of the shared environment implies that “shared environmental” influences such as a person’s upbringing are not important in opportunity recognition.<sup>4</sup>

Our finding of a common genetic factor for both opportunity recognition and opportunity exploitation indicates that these two activities are fundamentally linked. This linkage suggests the value of viewing entrepreneurship as a process that begins with opportunity recognition and leads into opportunity exploitation through a series of decisions made, and actions taken, by entrepreneurs.

The bivariate genetic association that we found between opportunity recognition and exploitation has implications for molecular genetics research. It implies that if specific genes were found to account for some of the variance in opportunity recognition, these same genes would be good candidates to consider for explaining some of the variance in opportunity exploitation. However, half of the genetic variance in exploitation is not shared with recognition, suggesting that independent genetic effects on opportunity exploitation exist as well.

Our study also has important implications for business practice. Our finding that the entire *environmental influence* on opportunity recognition was accounted for by *unique*

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<sup>4</sup> It does not mean, however, that family influences are not important, but rather that each child has a unique and specific upbringing, and this is modelled through the “non-shared environmental factor” (Arvey et al., 2006).

environmental factors should hearten managers and policy makers. Given that a significant component of the unique environment comes from a person's work environment, our results suggest that companies and policy makers can influence the likelihood that people will recognize entrepreneurial opportunities. Thus, efforts to find the right environmental influences to enhance opportunity recognition – be those training, working conditions, or incentives – may prove to be quite fruitful.

However, our finding that 54 percent of the phenotypic correlation between opportunity recognition and opportunity exploitation is accounted for by the same genetic factor indicates that our ability to encourage entrepreneurial activity through interventions designed to influence their ability to recognize new business opportunities is much smaller than many observers currently believe. From a practical point of view, this constraint suggests a relatively smaller role for interventions to enhance opportunity recognition as a way to influence the level of opportunity exploitation that occurs.

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Figure 1: Path diagram for opportunity recognition

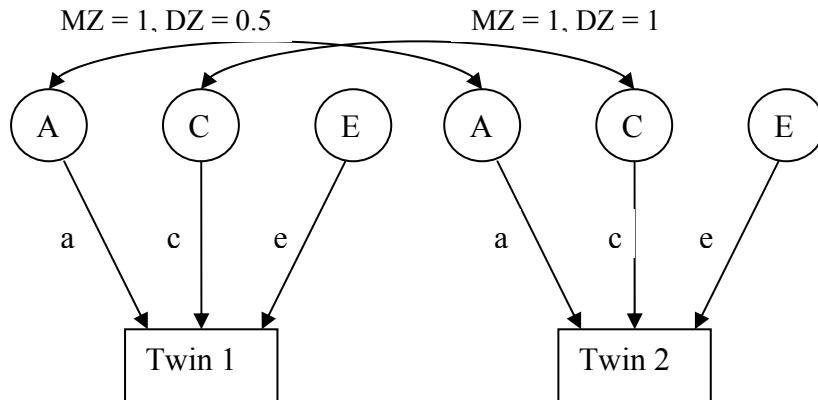
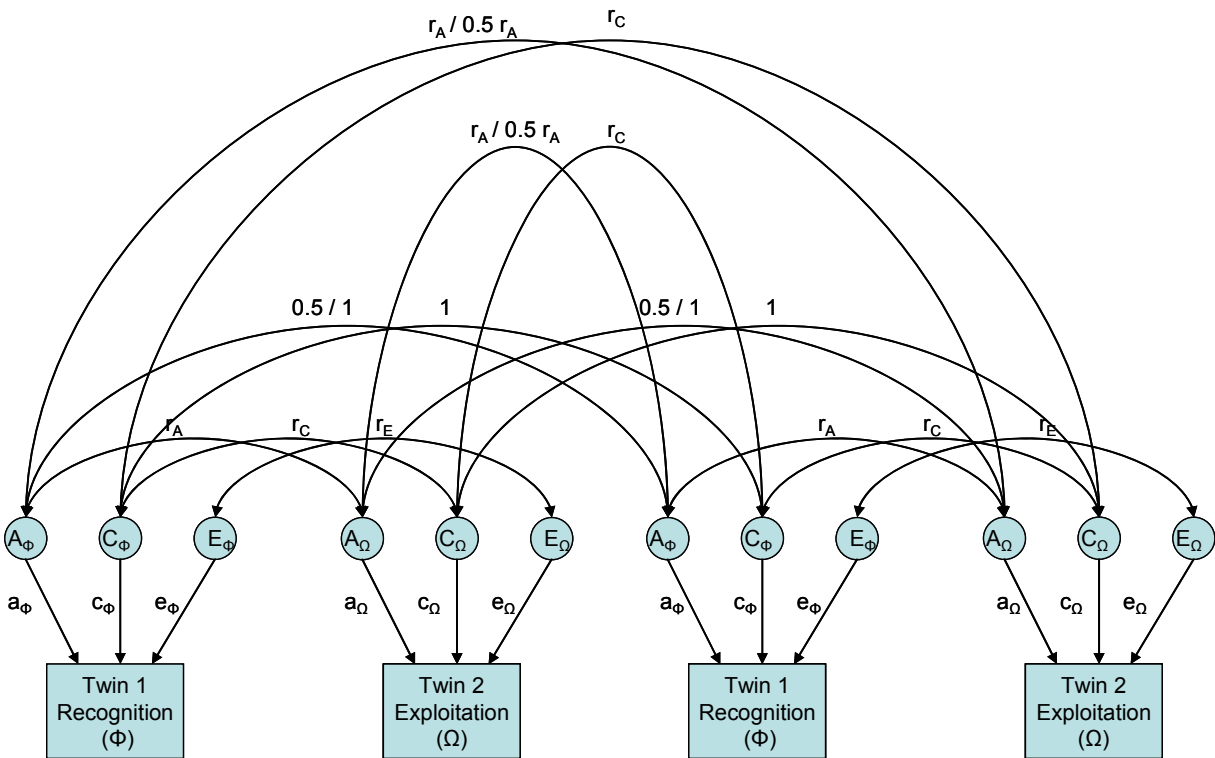


Figure 2: Path diagram for opportunity recognition and opportunity exploitation



(Adapted from Plomin et al., 2001)

Figure 3. The variance covariance matrix for the MZ twins.

	Twin 1	Twin 2	Twin 1	Twin 2
	Recognition ( $\Phi$ )	Recognition ( $\Phi$ )	Exploitation ( $\Omega$ )	Exploitation ( $\Omega$ )
Twin 1 Recognition ( $\Phi$ )	$a_{\Phi}^2 + c_{\Phi}^2 + e_{\Phi}^2$			
Twin 2 Recognition ( $\Phi$ )	$a_{\Phi}^2 + c_{\Phi}^2$	$a_{\Phi}^2 + c_{\Phi}^2 + e_{\Phi}^2$		
Twin 1 Exploitation ( $\Omega$ )	$r_A a_{\Phi} a_{\Omega} + r_C c_{\Phi} c_{\Omega} + r_E e_{\Phi} e_{\Omega}$	$r_A a_{\Phi} a_{\Omega} + r_C c_{\Phi} c_{\Omega}$	$a_{\Omega}^2 + c_{\Omega}^2 + e_{\Omega}^2$	
Twin 2 Exploitation ( $\Omega$ )	$r_A a_{\Phi} a_{\Omega} + r_C c_{\Phi} c_{\Omega}$	$r_A a_{\Phi} a_{\Omega} + r_C c_{\Phi} c_{\Omega} + r_E e_{\Phi} e_{\Omega}$	$a_{\Omega}^2 + c_{\Omega}^2$	$a_{\Omega}^2 + c_{\Omega}^2 + e_{\Omega}^2$

Figure 4. The variance covariance matrix for the DZ twins.

	Twin 1	Twin 2	Twin 1	Twin 2
	Recognition ( $\Phi$ )	Recognition ( $\Phi$ )	Exploitation ( $\Omega$ )	Exploitation ( $\Omega$ )
Twin 1 Recognition ( $\Phi$ )	$a_{\Phi}^2 + c_{\Phi}^2 + e_{\Phi}^2$			
Twin 2 Recognition ( $\Phi$ )	$0.5a_{\Phi}^2 + c_{\Phi}^2$	$a_{\Phi}^2 + c_{\Phi}^2 + e_{\Phi}^2$		
Twin 1 Exploitation ( $\Omega$ )	$r_A a_{\Phi} a_{\Omega} + r_C c_{\Phi} c_{\Omega} + r_E e_{\Phi} e_{\Omega}$	$0.5r_A a_{\Phi} a_{\Omega} + r_C c_{\Phi} c_{\Omega}$	$a_{\Omega}^2 + c_{\Omega}^2 + e_{\Omega}^2$	
Twin 2 Exploitation ( $\Omega$ )	$0.5r_A a_{\Phi} a_{\Omega} + r_C c_{\Phi} c_{\Omega}$	$r_A a_{\Phi} a_{\Omega} + r_C c_{\Phi} c_{\Omega} + r_E e_{\Phi} e_{\Omega}$	$0.5a_{\Omega}^2 + c_{\Omega}^2$	$a_{\Omega}^2 + c_{\Omega}^2 + e_{\Omega}^2$

Table 1: Descriptive statistics and correlations

<i>Variable</i>	$\mu$	$\sigma$	1	2	3	4	5	6	7	8	9
1. <i>Opportunity recognition scale</i>	1.39	0.83									
2. <i>Age</i>	55.6	13.2	-.17								
3. <i>Sex</i>	0.91	.29	.09	-.01							
4. <i>Religion</i>	.10	.31	.05	-.08	-.03						
5. <i>Children</i>	.73	.44	-.03	.30	.02	-.04					
6 <i>Businesses started</i>	.36	.78	.36	.05	-.09	.06	.05				
7 <i>Companies owned &amp; operated</i>	.25	.68	.23	.03	-.09	.04	.04	.64			
8 <i>Years self-employed</i>	.68	1.33	.23	.09	-.06	.05	.07	.60	.51		
9 <i>Start-up efforts</i>	.48	.96	.42	.02	-.01	.03	.05	.70	.50	.45	
10. <i>Opportunity exploitation scale</i>	.44	.77	.37	.06	-.10	.05	.07	.88	.77	.84	.79

Table 2: Heritability estimates for the opportunity recognition scale

<b>Model</b>	<b>A (95% CI)</b>	<b>C (95% CI)</b>	<b>E (95% CI)</b>	$\chi^2$	<b>df</b>	<b>p Value</b>	<b>AIC</b>	<b>RMSEA</b>
ACE	0.45 (0.37 to 0.50)	0 (0 to 0.07)	0.55 (0.50 to 0.60)	6.22	3	0.10	0.22	0.034
CE	–	0.33 (0.28 to 0.37)	0.67 (0.63 to 0.72)	50.12	4	0.001	42.12	0.123
AE	0.45 (0.40 to 0.50)	–	0.55 (0.50 to 0.60)	6.22	4	0.18	-1.78	0.020

A, additive genetic; C, common environment; E, unique environment. The table shows the results for the best fitting model for each variable.

Table 3: Heritability estimates for the opportunity exploitation scale

<b>Model</b>	<b>A (95% CI)</b>	<b>C (95% CI)</b>	<b>E (95% CI)</b>	$\chi^2$	<b>df</b>	<b>p Value</b>	<b>AIC</b>	<b>RMSEA</b>
ACE	0.33 (0.20 to 0.39)	0 (0 to 0.11)	0.67 (0.61 to 0.73)	4.83	3	0.19	-1.17	0.022
CE	–	0.25 (0.20 to 0.30)	0.75 (0.71 to 0.80)	22.2 4	4	0.001	14.24	0.077
<i>AE</i>	<i>0.33 (0.27 to 0.39)</i>	–	<i>0.67 (0.61 to 0.73)</i>	<i>4.83</i>	<i>4</i>	<i>0.31</i>	<i>-3.17</i>	<i>0.017</i>

A, additive genetic; C, common environment; E, unique environment. The table shows the results for the best fitting model for each variable.

Table 4: Cross-trait cross-twin correlations for the opportunity recognition and opportunity exploitation scales

	Twin Opportunity recognition 1	Twin Opportunity exploitation 1	Twin Opportunity recognition 2	Twin Opportunity exploitation 2
<b>MZ twins</b>				
Twin Opportunity recognition 1	1			
Twin Opportunity exploitation 1	<i>.37</i>	1		
Twin Opportunity recognition 2	<i>.47</i>	<i>.24</i>	1	
Twin Opportunity exploitation 2	<i>.19</i>	<i>.34</i>	<i>.37</i>	1
<b>DZ twins</b>				
Twin Opportunity recognition 1	1			
Twin Opportunity exploitation 1	<i>.32</i>	1		
Twin Opportunity recognition 2	<i>.17</i>	<i>.08</i>	1	
Twin Opportunity exploitation 2	<i>.11</i>	<i>.14</i>	<i>.41</i>	1

Table 5: Bivariate genetic analysis

<b>AE Model</b>	<b><math>r_A</math></b>	<b><math>r_E</math></b>	<b><math>r_C</math></b>	<b>Phenotypic correlation</b>	<b>% of phenotypic r attributable to genetic influence</b>
<i>RECOGNITION-EXPLOITATION</i>	<i>0.52</i>	<i>0.28</i>	<i>0</i>	<i>0.37</i>	<i>0.54</i>