

OPENNESS TO EXPERIENCE AND OPPORTUNITY RECOGNITION: EVIDENCE OF A  
COMMON GENETIC ETIOLOGY

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ABSTRACT

Recognizing opportunities for new businesses is an important part of the entrepreneurial process, and one that researchers are seeking to explain. Because opportunity recognition is at least partially a cognitive process, openness to experience may influence opportunity recognition by facilitating access to information useful in the opportunity recognition process. In this study, we sought to determine whether genetic factors influence opportunity recognition by affecting the tendency of people to be open to experience. We applied bivariate genetics techniques to a sample of 1740 monozygotic and 1714 same-sex dizygotic twins and found that a substantial part of the heritability of opportunity recognition is mediated through genetic influences on openness to experience.

## INTRODUCTION

Opportunity recognition is of central importance to the field of entrepreneurship (Shane and Venkataraman, 2000; Shane, 2003; Baron, 2006, 2007). The decision to found a new venture often arises from a person's belief that he or she has recognized an opportunity with profit potential, suggesting that variance in the tendency of people to start businesses can be explained by differences between them in their tendency to recognize entrepreneurial opportunities (Gaglio and Katz, 2001; Baron, 2007).

Because opportunity recognition is at least partially a cognitive process, the psychological trait of openness to experience may influence it, perhaps by facilitating access to information useful in the opportunity recognition process. For instance, Heinstrom (2003) showed that openness to experience is associated with broad information gathering, critical judgment, and preference for gathering non-confirming information. Opportunity recognition might be facilitated by broad information acquisition, critical analysis and a willingness to examine disconfirming data.

If entrepreneurship is desired, and opportunity recognition, a facilitator of that activity, is enhanced by openness to experience, why don't all people open to experience engage in entrepreneurship? The answer must be that openness to experience varies across people for reasons at least partially beyond their control. But what are the causes of that variation? Is it the environment in which they live or a genetic predisposition, or both?

For instance, studies show that between 45 percent and 61 percent of the differences across people in the openness to experience is explained by our genes (Loehlin, 1992). In fact, a recent study by Comings et al (1999) even identified specific genes associated with this personality trait, most notably the DRD4 gene. Other scholars have shown that genetic endowments partly contribute to the variance between individuals in opportunity recognition (Nicolaou, Shane, Cherkas and Spector, 2008). It is plausible that openness to experience is associated with opportunity recognition because openness to experience influences how people

gather and process information, an important aspect of opportunity recognition. Moreover, because both opportunity recognition and openness to experience are influenced by genetic factors, this raises the question: "Are the same genetic factors influencing opportunity recognition and the tendency of people to be open to experience?" This paper seeks to answer that question.

We believe that investigating the genetic covariance between openness to experience and opportunity recognition is important for two reasons: one theoretical and the other normative. On the theoretical side, seeking to explain why people become entrepreneurs is an important part of a scholarly exploration of this phenomenon. In recent years, scholars have begun to develop a biosocial foundation for explaining entrepreneurship (White et al., 2007; Nicolaou, Shane, Cherkas, Hunkin, Spector, 2008b). This paper contributes to that endeavour by identifying one of the many pathways through which an important biological factor – genes – influence one important aspect of entrepreneurship – opportunity recognition.

Second, identifying the proportion of the covariance between openness to experience and opportunity recognition that is accounted for by genetic factors will help us to evaluate to what degree we can use teaching, public policy, and other interventions to increase entrepreneurship. For instance, can we make people more likely to recognize entrepreneurial opportunities by training them to be more open to experience? If we can, then a good approach for entrepreneurship educators would be to train students in ways that make them more open to experience. If, however, the entire covariance between openness to experience and opportunity recognition was accounted for by genetic factors then such endeavours would be futile as we would not be able to influence opportunity recognition by encouraging people to be more open to experience.

We use bivariate genetic techniques to determine the proportion of the covariance between openness and recognition that is accounted for by genetic factors using a sample of 1740 monozygotic (MZ) and 1714 same-sex dizygotic (DZ) twins.

## THEORY DEVELOPMENT

Recognizing the opportunity for a new business is an important dimension of the entrepreneurial process (Venkataraman, 1997; Shane and Venkataraman, 2000; Shane, 2003; Baron and Ensley, 2006; Casson and Wadeson, 2007; Alvarez and Barney, 2007). The decision to found a new venture often arises from a person's belief that he or she has recognized an opportunity with profit potential (Gaglio and Katz, 2001; Baron, 2007).

As a result, scholars have given a lot of attention to unraveling the antecedents of opportunity recognition. Factors that have been found to influence opportunity recognition include social networks (Singh et al., 1999; Baron and Ozgen, 2007), prior information (Shane, 2000; McKelvie and Wiklund, 2004), pattern recognition (Baron, 2006; Baron and Ensley, 2006) and alertness (Kirzner, 1979; Gaglio and Katz, 2001). Psychological traits might also influence opportunity recognition.

Openness to experience is one of the dimensions of the Five Factor Model of personality and describes the extent to which an individual is broad minded, imaginative, curious, and original (Barrick and Mount, 1991). People who score high on openness to experience are more amenable to new ideas, thoughts and unconventional perspectives than people who score low on this trait (Costa and McCrae, 1992; George and Zhou, 2001). They are also more adaptable to changing circumstances and more likely to explore novel ideas. Moreover, the openness dimension reflects individual tendencies to consider external information (McCrae, 1987) and adjust one's beliefs (John, 1990).

Because opportunity recognition is at least partially a cognitive process, the personality trait of openness to experience may influence it, perhaps by facilitating access to information useful in the opportunity recognition process. For instance, Heinström (2003) showed that openness to experience is associated with broad information gathering, critical judgment, and preference for gathering non-confirming information. Opportunity recognition might be

facilitated by broad information acquisition, critical analysis and a willingness to examine disconfirming data.

Moreover, research has shown that individuals who are open to experience are more creative (Feist, 1998, 1999; Scratchley and Hakstian, 2000) and as a result more likely to identify and structure new solutions to existing problems (Harper, 1996; Shane, 2003). Also, openness is related to cognitive aspects of creativity such as divergent thinking (McCrae, 1987). Divergent thinkers are more likely to connect the dots between unrelated pieces of information and hence more likely to recognize entrepreneurial opportunities (Baron, 2006). As a result, it is not surprising that a recent meta-analysis showed that entrepreneurs scored higher than managers on openness to experience (Zhao and Siebert 2006).

People might differ in openness to experience for a variety of reasons, including a host of unique life experiences of the individual, but they may also differ in openness to experience because of different genetic predispositions. Studies show that between 45 percent and 61 percent of the differences across people in their openness to experience is explained by difference in our genetic makeup (Loehlin, 1992; Comings et al, 1999), involving many genes of small effect, rather than a single gene.

Recent research has also found that additive genetic factors account for 45 percent of the variance between people in opportunity recognition (Nicolaou, Shane, Cherkas and Spector, 2008). The genetic component of opportunity recognition and openness to experience, coupled with the correlation between openness to experience and entrepreneurship, suggest that genetic factors might increase the likelihood of opportunity recognition through the personality trait of openness to experience. Hence, we hypothesize: *Genetic factors account for part of the covariance between openness to experience and opportunity recognition.*

## METHODOLOGY

Quantitative genetics studies are based on a comparison between monozygotic (MZ, identical) and dizygotic (DZ, non-identical) twins. MZ twins derive from a single fertilized egg that splits producing two genetically identical individuals. DZ twins derive from separately fertilized eggs and on average share 50 percent of their non segregating genes, like other siblings. If genetic factors exert a significant influence on a variable, then MZ twins must be more similar to each other than DZ twins on that variable (Plomin et al., 2008).<sup>1</sup> Therefore, if MZ twins are more similar than same-sex DZ twins for opportunity recognition or openness to experience this would imply that genetic factors contribute to the variance of the variable in question.

Quantitative genetics studies can also be used to see if the same genetic factors influence two variables of interest, in our case openness to experience and opportunity recognition. If the same genetic factors did not influence the two variables, then there would be no difference in the cross-trait-cross-twin correlations between openness and opportunity recognition of MZ and DZ twins. As long as MZ and DZ twins face similar environments to their co-twins, greater cross-trait-cross-twin correlations between openness to experience and opportunity recognition of MZ twins than DZ twins, would mean that genetic factors contribute to the phenotypic correlation between the two variables.

A number of studies, using different methodologies, have generally confirmed the robustness of the equal environments assumption (Scarr, 1968; Kendler, 1983; Kendler et al., 1994; Hettema et al., 1995; Kendler and Prescott, 2006). Therefore, we can test whether the same genetic factors influence openness to experience and opportunity recognition by looking at the cross-trait-cross-twin correlations between openness to experience and opportunity recognition of MZ twins and DZ twins.

### Sample

We examined a sample of 870 pairs of MZ and 857 pairs of same-sex DZ twins from the UK (for more information about the sample, please see Spector et al., 2006 and [www.twinsuk.ac.uk](http://www.twinsuk.ac.uk)). Twin zygosity was established using a standardized twin questionnaire (Peeters et al., 1998) and, in cases of uncertainty, through multiplex DNA fingerprinting using variable tandem repeats. To gather information about opportunity recognition and openness to experience each twin was sent a self-completion questionnaire in 2006 that included questions about these two variables. Because the relevant questions were included in different sections of the survey, and much of the survey concerned health related activities, the respondents were unaware of the hypothesis of this study when completing the questionnaire.

#### Opportunity recognition

We measure opportunity recognition using 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, and a factor analysis showed that the five questions all loaded on the same factor.<sup>2</sup>

#### Openness to Experience

We measure openness to experience using the Ten Item Personality Inventory (TIPI) scale (Gosling, Pentfrow and Swann, 2003). As Gosling et al. (2003) argue, the instrument

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<sup>1</sup> Behavioral genetics studies usually compare *same-sex* dizygotic twins to MZ twins (who are always of the same sex) because such a comparison removes the potentially confounding effect of gender differences (Plomin et al., 2008).

reaches “adequate levels in terms of: (a) convergence with widely used Big-Five measures in self-observer, and peer reports, (b) test-retest reliability, (c) patterns of predicted external correlates, and (d) convergence between self and observer ratings” (Gosling et al., 2003, p. 504). The TIPI scale also achieves slightly better validity than other brief five factor personality scales (Furnham, 2008), and has been used with success in a large number of countries, having been translated into 9 languages (Muck et al., 2007).

### Bivariate Genetic Analysis

We use bivariate genetic analysis in order to partition the covariance between two traits - openness to experience and opportunity recognition - into that due to additive genetic factors, common environmental factors and unique environmental factors (Rice et al. 2004). Thus, in this analysis, we correlate one twin’s openness to experience score with the co-twin’s opportunity recognition score and – as we mentioned earlier – if the cross-trait-cross-twin correlation for MZ twins is greater than the cross trait cross twin correlation for DZ twins, this would imply that genetic factors account for part of the correlation between the two phenotypes (Kuntsi, Eley, Hughes, Asherson, Caspi, Moffitt, 2004).

INSERT FIGURE 1 ABOUT HERE

The path diagram underlying the analysis is shown in Figure 1. The boxes represent the observed variables – openness to experience and opportunity recognition – while the circles represent the latent variables that the model aims to estimate. **A** represents additive genetic effects, **C** represents shared environmental effects (i.e. those factors that are shared by with family members), and **E** represents non-shared environmental factors (i.e. environmental factors that are unique to an individual and includes measurement error). The correlation between the latent additive genetic factors is constrained at 1.00 for MZ twins and 0.5 for DZ twins to reflect

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<sup>2</sup> The factor had an eigenvalue of 2.4, the KMO measure of sampling adequacy was 0.76, Bartlett’s test of Sphericity was highly significant ( $p=.001$ ;  $\chi^2 = 3266$ ,  $df=10$ ) and all loadings were higher than 0.60.

the degree of genetic relatedness. The correlation between the latent shared environmental factors is constrained at 1.00 for both types of twins because all of the twin pairs were raised in the same family and therefore share the same common environment.  $r_A$ ,  $r_C$  and  $r_E$  represent the genetic, shared environmental and non-shared environmental correlations respectively. A genetic correlation of 1.00 would indicate that all genetic influences on openness to experience also influence opportunity recognition. A shared environmental correlation of 0 would indicate that the environmental influences that make the twins more similar on opportunity recognition would be entirely independent of the environmental influences that make the twins more similar on opportunity recognition (Plomin et al., 2008).

It is important to note that  $r_A$ ,  $r_C$  and  $r_E$  are independent of the individual heritabilities of each phenotype (Plomin et al. 2008). It is possible that openness and opportunity recognition are each affected by genetic factors but none of those genetic factors are the same. It is also possible that genetic factors have little influence on openness to experience and opportunity recognition, but that the same genetic factors influence both openness to experience and opportunity recognition.

Figure 2 represents the variance-covariance matrix for the bivariate model.  $\Phi$  and  $\Omega$  symbolize openness to experience and opportunity recognition respectively.  $\Psi$  is the coefficient of genetic relatedness: 1.00 for MZ and 0.5 for DZ twins.

INSERT FIGURE 2 ABOUT HERE

## RESULTS

The correlation matrix and the descriptive statistics are shown in Table 1. We did not find any statistical significant differences between the scores of MZ and DZ twins on openness to experience ( $p=0.40$ ) and opportunity recognition ( $p=0.39$ ). Therefore, the MZ and DZ twins are equally representative of the sample's openness to experience and opportunity recognition scores.

INSERT TABLE 1 ABOUT HERE

Table 2 shows the univariate heritability estimates for the two variables. For both variables, the best fitting model according to the chi square statistic and the Akaike's Information Criterion (AIC) (Akaike, 1987), was the one that included additive genetic and unique environmental effects (AE model). The heritability estimate for openness to experience was 0.40 (95% CI 0.33-0.46) while the heritability estimate for opportunity recognition was 0.45 (95% CI 0.40-0.50).

We also adjusted for potential confounders that could bias the results – age, gender, marital status and religion (Hakim et al., 2004). After adjustment, the heritability of openness to experience fell marginally to 0.38 (95% CI 0.31-0.44) and the heritability of opportunity recognition dropped marginally to 0.41 (95% CI 0.34-0.47).

INSERT TABLE 2 ABOUT HERE

Table 3 shows the cross-trait-cross-twin correlations for both MZ and DZ twins for the two variables. Specifically, the cross-trait-cross-twin correlations for MZ twins are 0.26 and 0.28, while the cross-trait-cross-twin correlations for DZ twins are 0.08 and 0.03. In other words, the correlation between the opportunity recognition score for twin 1 and the openness to experience score for twin 2 is 0.26 for MZ twins and 0.08 for DZ twins, indicating that genetic factors contribute to the covariance between openness to experience and opportunity recognition.

INSERT TABLE 3 ABOUT HERE

The overall (phenotypic) correlation between openness to experience and opportunity recognition was 0.37. The bivariate genetic analysis yielded a genetic correlation ( $r_A$ ) of 0.57 and a non-shared environmental correlation ( $r_E$ ) of 0.23. Therefore, the correlation solely due to genetic factors was 0.23,<sup>3</sup> indicating that more than half, 62%, of the overall (phenotypic)

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<sup>3</sup> This estimate is obtained by multiplying the square root of the heritability estimate for opportunity recognition by the square root of the heritability estimate for openness to experience and by the genetic correlation (i.e.  $\sqrt{0.41} \times 0.57 \times \sqrt{0.40}$ ).

correlation between openness to experience and opportunity recognition was accounted for by genetic factors (see Table 4).<sup>4</sup> (The rest was due to non-shared environmental factors.)

INSERT TABLE 4 ABOUT HERE

## DISCUSSION

We have shown that genetic factors account for a large part of the variance in opportunity recognition by influencing the probability that people will be open to experience. Our empirical investigation showed the heritabilities of opportunity recognition and openness to experience to be 0.45 and 0.40 respectively. We also found that the phenotypic correlation between openness to experience and opportunity recognition was 0.37. Our bivariate genetics models showed that genetic factors account for 62 percent of this overall (phenotypic) correlation between openness to experience and opportunity recognition.

### Limitations

Our study has a number of limitations. First, over 90% of our sample is female. While we controlled for the influence of gender in our models, the overwhelmingly female sample makes it difficult for us to generalize the results to males. Second, the Ten Item Personality Inventory (TIPI) that we used to measure openness to experience is less reliable than longer big five personality scales (Gorsing et al., 2003) (even though TIPI does very well compared to other brief big five measures [Furnham, 2008]). Third, our measure of opportunity recognition relies on respondents to evaluate their own behavior. Self-reports of past approaches to opportunity recognition may not correlate well with actual opportunity recognition activity.

### Implications

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<sup>4</sup> 0.23 divided by 0.37.

Despite the limitations mentioned above, our study has both research and normative implications. On the research side, our study provides guidance for molecular genetics research. The genetic correlation between openness and opportunity recognition indicates that many of the same genetic factors influence both. Prior research (Comings et al, 1999) shows that a variant of the DRD4 gene is associated with openness to experience. Our research suggests that the same gene would be a good candidate to consider when seeking to identify specific genes that influence the variance between people in opportunity recognition.

On the normative side, our results show that one can significantly influence the likelihood that a person will recognize entrepreneurial opportunities by increasing his or her openness to experience (because a part of the covariance between openness and opportunity recognition was accounted for by environmental factors.) This result has useful implications teaching entrepreneurship as well as for corporations interested in increasing the level of entrepreneurial activity among their employees. Efforts to encourage/educate/train people to be more open to experience will increase their tendency to identify entrepreneurial opportunities. Therefore, figuring out how to make people more open to experience is a good use of resources for those interested in enhancing opportunity recognition.

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Figure 1: Path diagram

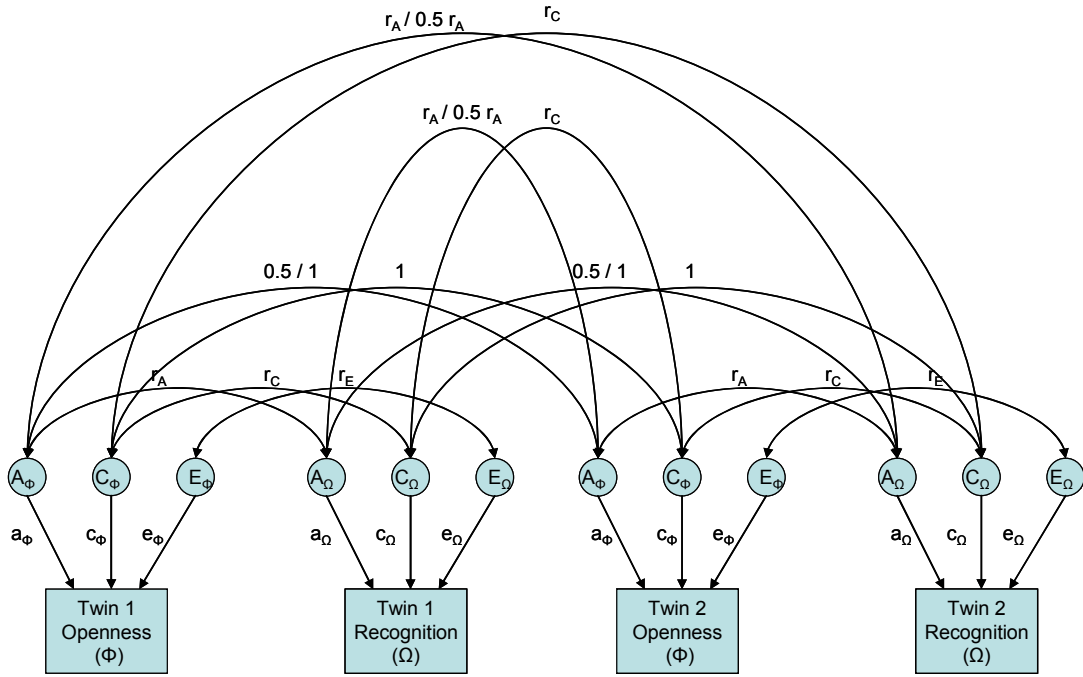


Figure 2: Variance-covariance matrix

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

Table 1: Descriptive statistics and correlations

<i>Variable</i>	$\mu$	$\sigma$	1	2	3	4	5	6
1. <i>Opportunity recognition</i>	1.39	0.83	1					
2. <i>Openness to experience</i>	3.24	1.27	.37	1				
3. <i>Sex</i>	0.91	0.29	.06	-.02	1			
4. <i>Age</i>	55.6	13.2	-.17	.09	-.01	1		
5. <i>Religious</i>	.10	.31	-.05	-.05	-.03	-.08	1	
6. <i>Marital status</i>	.69	.46	.02	.02	.01	.20	-.11	1

Table 2: Univariate heritability estimates for opportunity recognition and openness to experience

Model	A (95% CI)	C (95% CI)	E (95% CI)	$\Delta\chi^2$	$\Delta df$	$\Delta AIC$
<b>OPPORTUNITY RECOGNITION</b>						
ACE	0.45 (0.37 to 0.50)	0.00 (0.00 to 0.07)	0.55 (0.50 to 0.60)			
CE	–	0.33 (0.28 to 0.37)	0.67 (0.63 to 0.72)	43.9	1	41.9
<i>AE</i>	<i>0.45 (0.40 to 0.50)</i>	–	0.55 (0.50 to 0.60)	0	1	-2.00
<b>OPENNESS TO EXPERIENCE</b>						
ACE	0.40 (0.33 to 0.46)	0.00 (0.00 to 0.04)	0.60 (0.54 to 0.67)			
CE	–	0.25 (0.20 to 0.30)	0.75 (0.70 to 0.80)	40.6	1	38.6
<i>AE</i>	<i>0.40 (0.33 to 0.46)</i>	–	<i>0.60 (0.54 to 0.67)</i>	0	1	-2.00

A, additive genetic; C, common environment; E, unique environment.

Table 3: Cross trait cross twin correlations between openness to experience and opportunity recognition

	<b>Twin 1 Openness to Experience</b>	<b>Twin 1 Opportunity Recognition</b>	<b>Twin 2 Openness to Experience</b>	<b>Twin 2 Opportunity Recognition</b>
<b>MZ twins</b>				
<b>Twin 1 Openness to Experience</b>	1			
<b>Twin 1 Opportunity Recognition</b>	.34	1		
<b>Twin 2 Openness to Experience</b>	<b>.44</b>	<u>.26</u>	1	
<b>Twin 2 Opportunity Recognition</b>	<u>.28</u>	<b>.47</b>	.41	1
<b>DZ twins</b>				
<b>Twin 1 Openness to Experience</b>	1			
<b>Twin 1 Opportunity Recognition</b>	.37	1		
<b>Twin 2 Openness to Experience</b>	<b>.08</b>	<u>.08</u>	1	
<b>Twin 2 Opportunity Recognition</b>	<u>.03</u>	<b>.17</b>	.40	1

Table 4: Bivariate genetic analysis

AE Model	
<i>OPENNESS TO EXPERIENCE - OPPORTUNITY RECOGNITION</i>	
<b>r<sub>A</sub></b>	<i>0.57</i>
<b>r<sub>C</sub></b>	<i>0</i>
<b>r<sub>E</sub></b>	<i>0.23</i>
<b>Correlation due to genetic factors</b>	<i>0.23</i>
<b>% of phenotypic r attributable to genetic influence</b>	<i>0.62</i>