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# Creative personality, opportunity recognition and the tendency to start businesses: A study of their genetic predispositions

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ABSTRACT

We explored the effect of having a creative personality on the identification of business opportunities and the tendency to start businesses. Examining a sample of 3242 twins from the United Kingdom, which we surveyed in 2011, we confirmed that people with creative personalities are more likely than others to identify business opportunities and start businesses. We investigated how much of these associations are accounted for by a shared genetic etiology and found that common genetic influences account for a significant fraction of them. We discuss the implications of our findings for research on creative personality, opportunity recognition and entrepreneurship.



## 1. Executive summary

People have stable personal characteristics that affect how creatively they behave in a variety of domains — a pattern that researchers have labeled creative personality. Extant research has not yet examined whether people with creative personalities are more likely than others to identify entrepreneurial opportunities or be entrepreneurs. While research has shown some evidence of an association between creativity and both the tendency to identify opportunities and the tendency to start businesses, this pattern does not mean that creative personality is associated with entrepreneurship, as the association might exist because of the context in which entrepreneurship occurs.

In this paper we examine whether people with creative personalities are more likely than others to recognize entrepreneurial opportunities and to start businesses. We also examine whether part of the association between creative personality and opportunity recognition and between creative personality and the tendency to start businesses is accounted for by a shared genetic etiology.

Twin studies are an experiment of nature that allows us to separate both the variance in a variable and the covariance between two variables into genetic and environmental factors. Therefore, we utilize a sample of identical and non-identical twins, which

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we surveyed in 2011, to disentangle the association between creativity personality and both opportunity recognition and the tendency to start businesses into genetic and environmental influences.

This study found that people with creative personalities are more likely than others to both identify new business opportunities and to start businesses. It also found that genetic factors account for part of the correlation between creative personality and entrepreneurial behavior.

The study has implications for both research on and the practice of entrepreneurship. Our results show that creative personality is related to the tendency to be an entrepreneur at a magnitude similar to that found for other dimensions of personality, and to the recognition of opportunities at double this estimate. The significant correlation suggests that employers might want to use creative personality scales to identify employees for jobs where recognizing opportunities or being an entrepreneur is important, such as product development and corporate entrepreneurship.

Our results do *not* indicate that either genes or the environment *determine* creative personality and entrepreneurship. They only indicate the value of considering the complementary roles that biology and environment play in accounting for entrepreneurial behavior. As Plomin et al. (2013: 104) argue, "genetic influence on behavior is just that — an influence or contributing factor, not something that is preprogrammed and deterministic." In fact, the experimental nature of a twin design provides robust evidence of the importance of environmental factors in entrepreneurship.

Readers are cautioned not to draw implications about creative behavior from our study. Our research did not examine creative behavior, but only creative personality. Moreover, much research shows that creativity is influenced by situational, contextual and cognitive factors as well as individual factors related to personality. Therefore, our results are *complementary* to other approaches to analyzing the role of creativity in entrepreneurship, including those that show that learning and cognitive structures affect creativity or opportunity recognition.

## 2. Introduction

Is creative personality associated with opportunity recognition and the tendency to start new businesses? Scientific evidence on this question is lacking.

While studies show some limited evidence of a statistical association between creativity – or "the tendency to generate or recognize ideas, alternatives, or possibilities that may be useful in solving problems, communicating with others, and entertaining ourselves and others" – (Franken, 1994: 396), and both opportunity recognition and the tendency to start businesses (Cliff et al., 2006; Lee et al., 2004; Shane, 2003), this evidence does not necessarily mean that people with creative personalities are more likely to be entrepreneurs. Any observed statistical association between creativity and entrepreneurship may result from situational, contextual and cognitive factors, rather than individual factors related to personality.

Moreover, even if studies were to show an association between creative personality and entrepreneurship, we do not know whether most of this association results from environmental factors or from genetic factors. The association could occur primarily because common genetic factors account for both the tendency to have a creative personality and the tendency to be an entrepreneur, or it could occur primarily because situational factors account for the tendency of people to have creative personalities and to be entrepreneurs, or the association could be accounted for by both environmental and genetic factors.

This study examines whether people with a creative personality are more likely than others to identify business opportunities and become entrepreneurs, and the extent to which common genetic factors account for the association between a creative personality and the tendency to identify opportunities and become an entrepreneur. Specifically, we explore this question using data from 1898 monozygotic (MZ) and 1344 same-sex dizygotic (DZ) twins from the United Kingdom, who we surveyed in 2011.

We find that people with a creative personality are significantly more likely than others to both identify entrepreneurial opportunities and start new businesses. Moreover, genetic factors account for 66% of the correlation between creative personality and opportunity recognition and 82% of the correlation between creative personality and the tendency to start businesses.

Our findings have implications for both research and practice. From a research perspective, our results are the first to suggest that people with creative personalities are more likely to recognize entrepreneurial opportunities and to start new businesses. They also indicate that some people have an innate predisposition to both develop creative personalities and to become entrepreneurs. From a practical perspective, our results suggest that employers investigate the use of creative personality scales to identify employees for jobs where recognizing opportunities is important, such as product development, and corporate entrepreneurship.

Of course, these results do *not* indicate that genes *determine* creative personality and entrepreneurship – the relationships that we find are nothing more than predispositions – but they show the value of considering the role of biology in accounting for entrepreneurial behavior. Thus, our study follows in the spirit of Freese et al. (2003), who emphasized that biology and sociology are *not* locked in a zero-sum game where any reference to the biology lessens the value of sociology (Freese, 2008; Freese et al., 2003), psychology, economics, or any other social science, in explaining entrepreneurial behavior.

Our study is also *complementary* to other approaches to analyzing the role of creativity in entrepreneurship. Previous studies have shown that both cognitive structures and processes (Gielnik et al., 2012; Ward, 2004), and learning, play a role in both creativity (Scott et al., 2004) and opportunity recognition (Corbett, 2005; DeTienne and Chandler, 2004). Our study does *not* challenge the importance of either learning or cognitive structures for creativity or opportunity recognition. It merely follows the approach of Kozbelt et al. (2010) who argue that to truly explain creativity one must also delve more deeply into understanding people, particularly their personalities.

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## 3. Theoretical development

Some people have stable personal characteristics and dispositions that lead them to consistently behave in a more creative manner across various domains (Barron and Harrington, 1981; Hoff et al., 2011; Martindale, 1989; Runco, 2007). As Feist (1998, p. 304) argues, "empirical research over the past 45 years makes a rather convincing case that creative people behave consistently over time and situation and in ways that distinguish them from others. It is safe to say that in general a 'creative personality' does exist and personality dispositions do regularly and predictably relate to creative achievement."

Is entrepreneurship one of the domains in which people with creative personalities is more likely to exercise their creative nature? One might think that it is. Creativity is important in this setting (Gilad, 1984; Whiting, 1988), with some even arguing that "for entrepreneurs in particular, creativity is central" (Shalley and Perry-Smith, 2008, p. 23). Coming up with novel and useful ideas is valuable in identifying opportunities for, and starting, new businesses (Fillis and Rentschler, 2010). Identifying novel solutions to competitive and sales challenges is also valuable to those creating new enterprises and altering the way in which one approaches management and supply problems that plague new businesses often helps to identify solutions to them.

Moreover, some evidence suggests that creativity and entrepreneurship are correlated. For example, Hull et al. (1980) surveyed university alumni and found that business owners scored higher than non-owners on creativity. In addition, Caird (1991) found that owner managers scored higher on creative tendency than nurses, civil servants and clerical trainees. Lee et al. (2004) found that regional creativity was associated with new firm formation. Furthermore, more creative individuals have been found to be more likely to recognize entrepreneurial opportunities (Ardichvili et al., 2003; Dimov, 2007; Heinonen et al., 2011; Kirzner, 2009), develop business ideas (Puhakka, 2007), and exhibit entrepreneurial intentions (Yar Hamidi et al., 2008).

However, extant research does not yet show conclusively that people with more creative personalities are more likely to identify business opportunities or be entrepreneurs. In addition, any observed association between creativity and entrepreneurship would not necessarily mean that people with more creative personalities are more likely to become entrepreneurs. Creativity is influenced by situational factors (Amabile, 1996). Therefore, an association between entrepreneurship and creativity might exist because the context in which entrepreneurship occurs – the task environment – may induce all types of people to behave more creatively than they would in other contexts. That is, people can be creative without having a creative personality and an association between creativity and entrepreneurship may emanate from situational, contextual and cognitive factors, rather than individual factors related to personality.

### *3.1. The genetic origin of creative personality, opportunity recognition and starting businesses*

If empirical analysis were to show that people with creative personalities are more likely than others to be entrepreneurs, an important question is why. The association between creative personality and entrepreneurship could result from genetic factors, environmental factors, or both. Environmental factors, such as life experiences, could lead some people to develop creative personalities. Having developed those personalities, those people might then become more likely to engage in entrepreneurship. Alternatively, genetic factors could lead some people to develop creative personalities. Having developed those personalities, those people might then become more likely to engage in entrepreneurship. Finally, the development of creative personalities that increase the probability that people become entrepreneurs could be the result of both genetic and environmental influences.

Identifying the source of any correlation between creative personality and entrepreneurship is important because it affects the ability of entrepreneurship scholars to be normative. For instance, if creative personality and entrepreneurship have high environmental correlations, and work conditions affect the development of creative personalities, then policy makers might seek to boost entrepreneurship levels through interventions to change work conditions. Because genetic correlation reflects effects of selection (Johnson et al., 2009), if the correlation between creative personality and entrepreneurship is largely genetic, then policy makers could provide people that have creative personalities with environments that help them fully realize their creative, opportunity recognition and entrepreneurship potential.

Before researchers can consider whether any correlation between creative personality and entrepreneurship has a genetic component, they first need evidence that both creative personality and entrepreneurial behavior have a genetic component. Prior research has established this precondition. The tendency to identify entrepreneurial opportunities (Nicolaou et al., 2009) and the tendency to be an entrepreneur (Nicolaou et al., 2008; Shane et al., 2010) are heritable. Examining a variety of different measures of entrepreneurship, Nicolaou et al. (2008) found heritability estimates ranging from 0.37 to 0.48 depending on whether the measure was starting a business, number of businesses started, being an owner operator, the number of companies owned and operated, being self-employed, years self-employed, having engaged in a start-up effort and the number of start-up efforts undertaken. In a study of Swedish twins, Zhang et al. (2009) found a heritability estimate of 0.60 for entrepreneurship among females while, in a study of US twins, Shane et al. (2010) found a heritability estimate of 0.48 for self-employment. Nicolaou et al. (2009) measured opportunity recognition using a five item scale and found heritability of 0.45.

Recent research using molecular genetics has yielded some supportive findings as well. Although genome-wide association studies have not identified any genes that reach a genome-wide level of significance (Quaye et al., 2012a), Wernerfelt et al. (2012) showed that people with a particular version of the AVPR1a gene were more likely to be serial entrepreneurs than others. A study by Nicolaou et al. (2011) showed that a version of the DRD3 is associated with the tendency to start businesses. Studies also have shown that genetically influenced hormone levels increase the likelihood that people engage in entrepreneurial activity. For example, White et al. (2006) found that testosterone levels were higher among people with start-up experience than among people with no start-up experience.

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Studies have shown evidence of genetic predisposition to having a creative personality. Bouchard et al. (1998) found that a measure of creative temperament, which is an aspect of personality, had intra-class correlations of 0.50 between MZ twins reared apart and correlations of only 0.12 between DZ twins reared together. In a study of 157 twins reared apart, Waller et al. (1993) found an intra-class correlation of 0.54 for Gough's creative personality scale (CPS) between monozygotic twins reared apart, but a low and insignificant correlation between dizygotic twins reared apart. This finding indicates that identical twins tend to have similar scores on creative personality scales, while fraternal twins do not, even if the identical twins grow up separately and do not know each other. The difference between the patterns for identical and fraternal twins indicates a genetic component to scores on the creative personality scale.

### 3.2. Genetic covariation of creative personality and entrepreneurship

Genetic variation might affect organizational behavior in four interwoven ways. First, genetic differences might lead to variation in physiological attributes, such as brain structure, neurotransmitter system function, hormone levels, physical strength, physical attractiveness, and so on (Plomin et al., 2013), in ways that influence behavior. Second, genetic variation might influence the tendency of people to develop psychological characteristics that affect the probability of engaging in certain behaviors (Shane et al., 2010). Third, genetic endowment might interact with environmental stimuli to influence behavior, a concept referred to as gene–environment interaction (Plomin et al., 1977). Fourth, genetic variation might affect the probability that people select into environments that favor their genetic propensities, a concept referred to as gene–environment correlation (Plomin et al., 1977; Scarr and McCartney, 1983).[2]

This article focuses on the second of these mechanisms.[3] Genes influence behavior by influencing the probability that people develop the psychological characteristics associated with that behavior. While no work has yet identified a genetic correlation between creative personality and entrepreneurship, previous research has identified genetic correlations between other aspects of personality and entrepreneurship. Nicolaou et al. (2008) found evidence for a genetic correlation between sensation seeking (Stephenson et al., 2003; Zuckerman, 1994) and starting businesses. Shane et al. (2010) found evidence of a genetic correlation between openness to experience and extraversion and self-employment.

In this paper we examine whether creative personality and the tendency to recognize entrepreneurial opportunities have a common genetic source. That is, the same genetic factors influence the predisposition to develop a creative personality and the predisposition to identify entrepreneurial opportunities. We also examine how much of the correlation between creative personality and the tendency to start businesses is accounted for by common genetic factors. Specifically we hypothesize:

**Hypothesis 1.** Creative personality and the tendency to recognize entrepreneurial opportunities have a shared genetic etiology.

**Hypothesis 2.** Creative personality and the tendency to start businesses have a shared genetic etiology.

## 4. Methodology

### 4.1. Sample

Our sample is comprised of 3242 twins, consisting of 949 pairs of monozygotic (MZ) and 672 pairs of same-sex dizygotic (DZ) twins from the UK who were reared together. The sample is drawn from the TwinsUK registry, which is one of the largest twin registries in the world (Spector and Williams, 2006). The twins in the registry are healthy individuals that are comparable on a number of dimensions to age-matched singletons (Andrew et al., 2001). Data for the study were collected from a self-completed questionnaire between December 2010 and May 2011. Twin zygosity was established through standard validated questions and through collection of DNA (Peeters et al., 1998; Singer et al., 2005). The sample is primarily female because it was originally designed to examine genetic effects on medical conditions that primarily affect women (e.g., osteoporosis).

### 4.2. Analyses

We used behavioral genetics techniques to examine the extent to which genetic factors account for the association between creative personality and the tendency to recognize opportunities and start businesses. For genetics to account for part of this covariance, three conditions must hold. First, creative personality must be associated with the tendency to recognize opportunities

[2] There are three types of gene–environment correlations: active, reactive and passive. Active g–e correlations occur when individuals actively seek or create environments correlated with their genetic propensities. Reactive g–e correlations occur when different genetic propensities evoke different reactions from the environment. Passive g–e correlations occur when genetically-related parents provide their children with an environment that is correlated with the genetic propensities of their children (Plomin et al., 1977; Scarr and McCartney, 1983).

[3] In practice, these mechanisms are not mutually exclusive and are likely to all be present. The literature suggests that there are multiple interwoven mechanisms lying between genetics and organizational behavior (Song et al., 2014). As Freese (2008) explains, physical processes, psychological factors and environmental factors all influence the pathway from genetics to human behavior. Although we focus on the main effects of genetics on psychological characteristics, environmental factors also affect the way in which genetics influences opportunity recognition and the tendency to be an entrepreneur.

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| | Twin 1 Creative Personality (Φ) | Twin 2 Creative Personality (Φ) | Twin 1 Recognition / Start business (Ω) | Twin 2 Recognition / Start business (Ω) |
|---|---|---|---|---|
| Twin 1 Creative Personality (Φ) | $a_\Phi^2 + c_\Phi^2 + e_\Phi^2$ | | | |
| Twin 2 Creative Personality (Φ) | $a_\Phi^2 + c_\Phi^2$ | $a_\Phi^2 + c_\Phi^2 + e_\Phi^2$ | | |
| Twin 1 Recognition / Start business (Ω) | $r_A a_\Phi a_\Omega + r_C c_\Phi c_\Omega + r_E e_\Phi e_\Omega$ | $r_A a_\Phi a_\Omega + r_C c_\Phi c_\Omega$ | $a_\Omega^2 + c_\Omega^2 + e_\Omega^2$ | |
| Twin 2 Recognition / Start business (Ω) | $r_A a_\Phi a_\Omega + r_C c_\Phi c_\Omega$ | $r_A a_\Phi a_\Omega + r_C c_\Phi c_\Omega + r_E e_\Phi e_\Omega$ | $a_\Omega^2 + c_\Omega^2$ | $a_\Omega^2 + c_\Omega^2 + e_\Omega^2$ |

Note: The ordering of this matrix follows Plomin et al. (2013: 395) for ease of interpretation. The actual ordering of the variables in Mx is different to the matrix above.

**Fig. 1.** The variance covariance matrix for the MZ twins. Note: The ordering of this matrix follows Plomin et al. (2013: 395) for ease of interpretation. The actual ordering of the variables in Mx is different from the matrix above.

and start businesses. Second, creative personality, the tendency to recognize opportunities, and the tendency to start businesses, must all be heritable. Third, the genetic correlations between creative personality and the tendency to recognize opportunities and start businesses must be sizeable.

To estimate the heritability of creative personality, the tendency to recognize opportunities and the tendency to start businesses, and to examine the share of the correlation between creative personality and these dimensions of entrepreneurial behavior, we rely on the natural experiment of twins. Because MZ twins share their entire genetic composition and DZ twins share, on average, half of their segregating genes, samples of MZ and DZ twins can be used to separate both the variance in creative personality and the covariance between creative personality and the tendency to recognize opportunities and the tendency to become an entrepreneur into genetic and environmental factors (Plomin et al., 2013).

Following the standard approach in quantitative genetics (Kuntsi et al., 2004; Plomin et al., 2013; Rice et al., 2004; Singer et al., 2005), we compare a twin's creative personality score with his or her co-twin's score on the tendency to recognize opportunities and to start businesses to see if these cross-characteristic cross-twin correlations are greater for MZ than for DZ twins. If they are, then genetic factors account for part of the correlation between creative personality and the tendency to recognize opportunities and start businesses (Kuntsi et al., 2004; Rijsdijk and Sham, 2002).

Behavioral genetics studies using twins depend on the assumption that MZ and DZ twins have a similar shared environment. The equal environments assumption is violated if environmental factors treat MZ twins more similarly than they treat DZ twins and this difference in treatment influences the phenotype under examination (in our case, creative personality and the tendency to recognize opportunities and start businesses.) A wide variety of studies utilizing different methodologies have been used to investigate this assumption and have generally confirmed its robustness (Conley and Rauscher, 2011; Hettema et al., 1995; Kendler and Prescott, 2006; Kendler et al., 1993; Scarr and Carter-Saltzman, 1979). For example, studies of MZ twins raised apart have generated heritability estimates that are similar to those of MZ twins raised in the same family (Bouchard, 1998). In addition, studies of correctly and incorrectly classified MZ and DZ twins that tested the equal environments assumptions have found that "traditional heritability estimates are not overestimated, and may in fact be underestimated for behavioral phenotypes" (Conley and Rauscher, 2011, p. 17). Because the validity of this assumption can only be tested on samples of twins reared apart, which are extremely rare and do not

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| | Twin 1 Creative Personality (Φ) | Twin 2 Creative Personality (Φ) | Twin 1 Recognition / Start business (Ω) | Twin 2 Recognition / Start business (Ω) |
|---|---|---|---|---|
| Twin 1 Creative Personality (Φ) | $a_\Phi^2 + c_\Phi^2 + e_\Phi^2$ | | | |
| Twin 2 Creative Personality (Φ) | $0.5\,a_\Phi^2 + c_\Phi^2$ | $a_\Phi^2 + c_\Phi^2 + e_\Phi^2$ | | |
| Twin 1 Recognition / Start business (Ω) | $r_A a_\Phi a_\Omega + r_C c_\Phi c_\Omega + r_E e_\Phi e_\Omega$ | $0.5\,r_A a_\Phi a_\Omega + r_C c_\Phi c_\Omega$ | $a_\Omega^2 + c_\Omega^2 + e_\Omega^2$ | |
| Twin 2 Recognition / Start business (Ω) | $0.5\,r_A a_\Phi a_\Omega + r_C c_\Phi c_\Omega$ | $r_A a_\Phi a_\Omega + r_C c_\Phi c_\Omega + r_E e_\Phi e_\Omega$ | $0.5\,a_\Omega^2 + c_\Omega^2$ | $a_\Omega^2 + c_\Omega^2 + e_\Omega^2$ |

Note: The ordering of this matrix follows Plomin et al. (2013: 395) for ease of interpretation. The actual ordering of the variables in Mx is different to the matrix above.

**Fig. 2.** The variance covariance matrix for the DZ twins. Note: The ordering of this matrix follows Plomin et al. (2013: 395) for ease of interpretation. The actual ordering of the variables in Mx is different from the matrix above.

contain data on entrepreneurial behavior, we cannot test the assumption directly. Instead we rely on evidence that the assumption has been found to be valid in numerous studies.

### 4.3. Measure of creative personality

We measure creative personality by using Gough's creative personality scale (CPS; Gough, 1979). Numerous studies show that the CPS is a reliable and valid measure of creative personality, and that it captures an individual's overall creative potential (Batey and Furnham, 2008; Dul et al., 2011; Oldham and Cummings, 1996; Shalley et al., 2004). Comprised of 30 items that were empirically derived from the Adjective Check List (Gough and Helibrun, 1965), the CPS has been validated in subsequent research (Kaduson and Schaefer, 1991). The measure has been used in human resource practice to select employees for creative potential (Malakate et al., 2007), and has been correlated with several other measures of creative behavior and creative cognitive style (Gino and Ariely, 2012).

Of the 30 adjectives in the CPS, 18 describe highly creative individuals (e.g. insightful, interests wide, inventive, reflective etc.) and 12 describe less creative individuals (e.g. commonplace, conventional, interests narrow, conservative etc.). An individual was given a value of +1 for each high creativity item and a value of −1 for each low creativity item used to describe them. The items are summed to form the creative personality scale.

Following previous research (e.g. Oldham and Cummings, 1996; Zhou, 2003; Zhou and Oldham, 2001), we calculated the reliability of this scale for our sample using a weighted composite technique (Lord and Novik, 1968; Oldham and Cummings, 1996).[4] The alpha coefficient was 0.70.

[4] The following formula was used to calculate the reliability of the creative personality scale, $\alpha = \frac{(v^+/v)\alpha^+ + (v^-/v)\alpha^- + 2\rho(v^+/v)(v^-/v)}{(v^+/v)+(v^-/v)+2\rho(v^+/v)(v^-/v)}$, where $v$ = the total number of items, $v^+$ = the total number of high creativity items, $v^-$ = the total number of low creativity items, $\alpha^+$ = Cronbach's alpha for the scale comprised of high creativity items, $\alpha^-$ = Cronbach's alpha for the scale comprised of low creativity items, and $\rho$ = the correlation between the high and low creativity scales.

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**Table 1**
Descriptive statistics and correlations.

| Variable | μ | σ | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| 1. Age | 59.3 | 13.5 | | | | | |
| 2. Sex | 0.92 | 0.28 | −.01 | | | | |
| 3. Creative personality scale | 4.57 | 4.02 | −.06** | −.06** | | | |
| 4. Tendency to recognize opportunities | 2.17 | 0.79 | −.08*** | −.04 | .43*** | | |
| 5. Tendency to start businesses | 0.36 | 0.74 | .03 | −.13*** | .20*** | .38*** | |

*** $p < .001$.
** $p < .01$.

### 4.4. Measure of the tendency to recognize entrepreneurial opportunities

We measure the tendency to recognize opportunities through the use of a five-item scale comprised of questions that are derived from the literature on opportunity recognition (Baron and Ozgen, 2007; Nicolaou et al., 2009; Singh et al., 1999). Typical questions include "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 materialize into profitable enterprises" (reverse scored); "I frequently identify opportunities to start-up new businesses (even though I may not pursue them)". The alpha for this scale was 0.78.

### 4.5. Measure of the tendency to start businesses

We measure the tendency to start businesses through a question commonly used in the entrepreneurship literature (Choi and Shepherd, 2004; Delmar and Davidsson, 2000; Gartner, 1988). "In your working life, how many new businesses, if any, have you started?"

### 4.6. Common method variance

A potential problem in survey data is common method variance, which results from the tendency of people to provide responses to the independent and dependent variables that are correlated as a result of the way that they respond to questions (Podsakoff and Organ, 1986; Podsakoff et al., 2003, 2012). Because our study is based on a natural experiment that examines differences in the cross-twin and cross-characteristic cross-twin correlations between identical and fraternal twins, common method variance is unlikely to bias our heritability estimates. For example, in testing Hypothesis 1 we examine the correlations between the creative personality of twin 1 and the tendency to recognize opportunities of twin 2. Greater cross-characteristic cross-twin correlations for identical than for fraternal twins would indicate that genetic factors account for part of the covariance between these two variables. For common method variance to bias our heritability estimates, the way that identical twins respond to survey questions would have to be different from the way that fraternal twins respond to the same questions; we see no reason why this would be the case.

We also followed data collection methods that adhere to the recommendations of Podsakoff et al. (2003) to reduce the potential for such bias. We used different scale formats and anchors for the different measures in our study to reduce the potential for artifactual covariation by similar scale endpoints and formats (Podsakoff et al., 2003: 882, 884). We also placed the predictor and criterion variables at different places in the questionnaire to eliminate any item priming effects that could make a variable more salient to a respondent and suggest a causal relationship with the other variable (Podsakoff et al., 2003: 882).

### 4.7. Statistical techniques

We used structural equation modeling techniques to examine whether creative personality, opportunity recognition, and the tendency to start businesses are heritable and to examine the extent to which the covariance between creative personality and the tendency to recognize opportunities and start business is genetic. The variance of any variable can be disentangled into three (potential) components: a genetic component (A), a shared environmental component (C), and a unique environmental component (E). Because MZ and DZ twins share different degrees of genetic relatedness, but similar degrees of shared and unshared environment, the correlations between these different pairs of twins can be used to estimate genetic influence on a variable and the co-variation between multiple variables.

Because MZ twins share 100% of their genes and DZ twins share, on average, 50% of their segregating genes, the correlation between the latent additive genetic factors is constrained at 1 for MZ twins and at 0.5 for DZ twins. The correlation between the latent shared environmental factors is held at 1 for both sets of twins because all the twins were raised in the same family.

For each characteristic, we develop a heritability estimate, defined as the proportion of total variation that can be explained by genetic variation. The univariate models are estimated through the following structural equations: $\Phi_{i\xi} = aA_{i\xi} + cC_{i\xi} + eE_{i\xi}$ and $V_\Phi = a^2 + c^2 + e^2 = 1$ where $\Phi$ is the phenotype of the $i$th individual in the $\xi$th twin pair ($i = 1,2$; $\xi = 1 \ldots n$, with all variables scaled as deviations from zero), and $V_\Phi$ is the total phenotypic variance of the population. $V_\Phi$ corresponds to the sum of additive genetic variance ($a^2$), shared environmental variance ($c^2$) and non-shared environmental variance ($e^2$).

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**Table 2**
Heritability estimates for the creative personality scale.

| Model | A (95% CI) | C (95% CI) | E (95% CI) | AIC | RMSEA | $X^2$ | df | p-Value |
|---|---|---|---|---|---|---|---|---|
| ACE | 0.48 (0.41 to 0.53) | 0 (0 to 0.05) | 0.52 (0.47 to 0.57) | 0.56 | 0.04 | 6.56 | 3 | 0.09 |
| CE | – | 0.36 (0.31 to 0.40) | 0.64 (0.60 to 0.69) | 50.40 | 0.15 | 58.40 | 4 | 0.00 |
| *AE* | *0.48 (0.43 to 0.53)* | – | *0.52 (0.47 to 0.57)* | *−1.44* | *0.03* | *6.56* | *4* | *0.16* |

Note: A, additive genetic; C, common environment; E, unique environment.
The best-fitting model is shown in italics.

Adjusting for age and sex in all the analyses, we compared a series of nested models to the best fitting model to assess the contribution of A, C and E to the total variance. In order to select the best fitting model, we used the chi-square test (with a non-significant chi-square showing a good fit to the data (Betsworth et al., 1994)), Akaike's Information Criterion (AIC) (where "the one that gives the minimum of AIC represents the best fit"; Akaike, 1987: 320), and the root mean square error of approximation (RMSEA) (Neale and Maes, 2002).

We apply bivariate genetics techniques to examine the cross-characteristic-cross-twin correlations between the creative personality scale and the tendency to recognize opportunities and start businesses. As long as the MZ and DZ twins experience similar environments to their co-twins, greater cross-characteristic-cross-twin correlations between a creative personality and the tendency to recognize opportunities or the tendency to start businesses for MZ twins would imply that genetic factors contribute to the phenotypic correlation between the two variables. Conversely, if the cross-characteristic, cross-twin correlations are significant, but of similar magnitude in both MZ and DZ twin pairs, then a shared environmental influence would be indicated. A unique environmental influence would be indicated if there are no cross-characteristic, cross-twin correlations.[5]

The analysis yields the genetic ($r_A$), shared environmental ($r_C$) and non-shared environmental ($r_E$) correlations respectively. The genetic correlation ($r_A$) represents the degree to which the genetic influences on an individual's score for creative personality overlap with those on the tendency to recognize opportunities (start businesses), irrespective of the individual heritabilities of the two variables. The shared environmental correlation ($r_C$) measures the extent to which the environmental influences that make the twins more similar on the score for creative personality are correlated with the environmental influences that make the twins more similar on the tendency to recognize opportunities (start businesses) (Plomin et al., 2008). The non-shared environmental correlation ($r_E$) captures the environmental factors that twin pairs do not have in common and that influence both the score on creative personality and the tendency to recognize opportunities (start businesses) (Plomin et al., 2008). The structural equation model fitting was performed using the statistical package Mx (Neale et al., 2003). The variance–covariance matrices that we estimate (for both MZ and DZ twins) are shown in Figs. 1 and 2 respectively. (See Neale and Maes (2002) and Nicolaou and Shane (2009) for additional information.)

## 5. Results

Descriptive statistics and correlations are presented in Table 1. There were no statistically significant differences between MZ and DZ twins for creative personality ($p = 0.32$), tendency to recognize opportunities ($p = 0.11$), the tendency to start businesses ($p = 0.96$), age ($p = 0.14$), or sex ($p = 0.10$). Thus, the sample appears unbiased with respect to the distribution of entrepreneurial activities and creativity personality across MZ and DZ twins.

Table 1 also reveals that creative personality is significantly correlated with both the tendency to identify entrepreneurial opportunities ($r = 0.43$; $p < 0.001$) and the tendency to start businesses ($r = 0.20$; $p < 0.001$). The presence of these correlations indicates the value of identifying the degree to which they are the result of genetic and environmental factors.

Tables 2, 3 and 4 show the heritability estimates for creative personality, the tendency to recognize opportunities and the tendency to start businesses respectively. (As stated earlier, the heritability of these three dimensions is a necessary condition for genetic factors to account for some of the correlation between them.)

Table 2 shows the results of fitting univariate genetics models for creative personality. We used the chi-square test, Akaike's information criterion (AIC) and the root mean square error of approximation (RMSEA) to select between the ACE (additive genetic, common environmental and unique environmental), AE (additive genetic and unique environmental) and CE (common environmental and unique environmental) models. The best fitting model for creative personality involved both additive genetic and unique environmental effects (AE model). The heritability of the creative personality scale was 0.48 (95% CI: 0.43–0.53). Shared environmental factors did not account for any of the variance in creative personality.

Table 3 shows the results of fitting univariate genetics models for the tendency to recognize opportunities. The chi-square test, Akaike's information criterion (AIC) and the root mean square error of approximation (RMSEA) showed that the best fitting

[5] The bivariate genetics model that we use captures the genetic correlation or extent to which common genes account for both creative personality and the tendency to recognize opportunities (tendency to start businesses). This notion of common genetic factors underlying two variables is similar to a mediation model in which personality mediates the genetic influences on entrepreneurship. As Olson et al. (2001: 853) argue, "one way of exploring possible mediators of the heritability of a variable is to calculate the extent to which genetic variation is shared with another variable …. Such a pattern is consistent with the idea that the heritability of one variable mediates or is responsible for some or all of the heritability of the other (although which variable is doing the mediating is not indicated)." Mathieu and Taylor (2007) have identified three important requirements for testing mediation that include experimental design, temporal precedence and theoretical rationale. Twin models approximate these three conditions as twins are a natural experiment, genes are exogenous to the variables analyzed, and personality is understood to temporally precede entrepreneurship (Zhang et al., 2009).

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**Table 3**
Heritability estimates for the tendency to recognize opportunities.

| Model | A (95% CI) | C (95% CI) | E (95% CI) | AIC | RMSEA | $X^2$ | df | p-Value |
|---|---|---|---|---|---|---|---|---|
| ACE | 0.36 (0.19 to 0.41) | 0 (0 to 0.14) | 0.64 (0.59 to 0.70) | −5.96 | 0.01 | 0.43 | 3 | 0.93 |
| CE | – | 0.28 (0.23 to 0.33) | 0.72 (0.67 to 0.77) | 7.63 | 0.06 | 15.63 | 4 | 0.00 |
| *AE* | *0.36 (0.30 to 0.41)* | – | *0.64 (0.59 to 0.70)* | *−7.96* | *0.01* | *0.43* | *4* | *0.98* |

Note: A, additive genetic; C, common environment; E, unique environment.
The best-fitting model is shown in italics.

model for the tendency to recognize opportunities involved additive genetic and unique environmental effects (AE model). The heritability of the tendency to recognize opportunities was 0.36 (95% CI: 0.30–0.41). Shared environmental factors did not account for any of the variance in the tendency to recognize opportunities.

Table 4 shows the results of fitting univariate genetics models for the tendency to start businesses.[6] The chi-square test, Akaike's information criterion (AIC) and the root mean square error of approximation (RMSEA) showed that the best fitting model for the tendency to start businesses was the AE model. The heritability of this tendency was 0.32 (95% CI: 0.27–0.38). Shared environmental factors did not account for any of the variance in the tendency to start businesses.

To assess whether genetic factors account for part of the covariance between creative personality and the tendency to recognize entrepreneurial opportunities we then fitted bivariate genetics models. Table 5 shows the results of this test.

We focus our attention on the genetic correlation between the two variables ($r_A$), which is 0.68. This correlation indicates that two-thirds of the phenotypic correlation between creative personality and the tendency to recognize opportunities is explained by genetic factors that are common to the two variables.[7]

Table 5 also shows the results of the test to assess the extent to which genetic factors account for part of the covariance between creative personality and the tendency to start businesses. The analysis reveals a genetic correlation ($r_A$) of 0.42, indicating that 82% of the phenotypic correlation between the creative personality scale and the tendency to start businesses is explained by genetic factors that are common to these two variables.[8]

We reran our bivariate analyses between creative personality and the tendency to start businesses and between creative personality and the tendency to recognize entrepreneurial opportunities, controlling for the effects of extraversion, openness to experience, agreeableness, conscientiousness, emotional stability and sensation seeking. We used a sample of 2124 twins (comprised of 547 pairs of MZ and 515 pairs of DZ twins) for which new data from the 2011 survey on creative personality, tendency to start businesses, and tendency to recognize opportunities were linked with old data from previous twin surveys (on the Big Five personality characteristics and sensation seeking).[9] Following previous research, we regressed out the confounding variables and estimated genetic correlations on the adjusted results (Hakim et al., 2004; Mohammed et al., 2003; Neale, 1998).

Table 6 shows the results of this analysis. The analysis yielded a genetic correlation ($r_A$) of 0.46 between creative personality and the tendency to recognize entrepreneurial opportunities (indicating that 60% of the phenotypic correlation was due to genetic factors) and a genetic correlation ($r_A$) of 0.25 between creative personality and the tendency to start businesses (indicating that 71% of the phenotypic correlation was due to genetic factors).

In summary, we found that the best fitting model in all univariate and bivariate genetic analyses included additive genetic and unique environmental effects (the AE model, where A refers to genetic influences and E to environmental influences that are independent, or uncorrelated, among the twins). The bivariate models showed that part of the covariance between creative personality and the tendency to recognize opportunities and the tendency to start businesses was accounted for by common genetic factors.

## 6. Discussion

No prior research has shown a correlation between creative personality and entrepreneurship despite the plausible hypothesis that people with creative personalities would be more likely to start businesses. This study showed that people with creative personalities were more likely to identify business opportunities and to start businesses and that the correlations between creative personality and the two measures of entrepreneurship were *partly* accounted for by common genetic factors.

[6] To estimate this ordinal measure we estimated polychoric models using asymptotically distribution free weighted least squares (Browne, 1982, 1984; Joreskog, 1990; Neale et al., 2003). We obtained a similar result when we estimated the heritability using standard fit function (Neale et al., 2003) with a logarithmic transformation of the tendency to start businesses (heritability = 0.31 [95% CI: 026–0.37] for the best-fitting AE model).

[7] This estimate is obtained by multiplying the genetic correlation by the square root of the heritabilities of creativity personality and the tendency to recognize opportunities and dividing this number by the phenotypic correlation between the two variables, i.e. $\left[0.68 \times \sqrt{0.48} \times \sqrt{0.36}\right] / 0.43 = 0.66$.

[8] The total phenotypic correlation between creative personality and the tendency to start businesses is obtained by: (a) multiplying the genetic correlation ($r_A$) by the square root of the heritabilities of creative personality and the tendency to start businesses, and (b) adding to this the product of the unique environmental correlation ($r_E$), the square root of the unique environmental factors for creative personality, and the square root of the unique environmental factors for the tendency to start businesses, i.e. $\left[0.42 \times \sqrt{0.48} \times \sqrt{0.32}\right] + \left[0.07 \times \sqrt{0.52} \times \sqrt{0.68}\right] = 0.20$.

[9] In particular, openness to experience and extraversion, which have been shown to be associated with the tendency to start businesses (Zhao and Seibert, 2006), are likely to be associated with creative personality. The correlations between creative personality and openness to experience and extraversion in our study were 0.38 and 0.31 respectively.

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**Table 4**
Heritability estimates for the tendency to start businesses.

| Model | A (95% CI) | C (95% CI) | E (95% CI) | AIC | RMSEA | $X^2$ | df | p-Value |
|---|---|---|---|---|---|---|---|---|
| ACE | 0.28 (0.09 to 0.38) | 0.04 (0 to 0.20) | 0.68 (0.62 to 0.74) | −5.76 | 0.01 | 0.24 | 3 | 0.97 |
| CE | – | 0.26 (0.21 to 0.31) | 0.74 (0.69 to 0.79) | 0.76 | 0.04 | 8.76 | 4 | 0.00 |
| *AE* | *0.32 (0.27 to 0.38)* | – | *0.68 (0.62 to 0.73)* | *−7.76* | *0.01* | *0.24* | *4* | *0.99* |

Note: A, additive genetic; C, common environment; E, unique environment.
The best-fitting model is shown in italics.

Our study contributes to a biosocial perspective on entrepreneurship. Prior research has indicated that both genetic and environmental factors influence the tendency of people to recognize opportunities and to be entrepreneurs. Moreover, this research has suggested that one way through which genetic factors influence entrepreneurship is by influencing people's attributes and personality characteristics (Nicolaou and Shane, 2009; Zhang et al., 2009). Our study contributes to this work by showing that part of the genetic influence in entrepreneurship is mediated through an individual attribute not previously looked at: creative personality.

It is imperative to emphasize that our study does *not* argue that genes *determine* creative personality and entrepreneurship, any more than it argues that the environment *determines* them. The relationships that we find are nothing more than predispositions. As Bearman (2008, p. vi) has explained, studying the genetics of behavior is not "a eugenicist project in disguise." Rather, it is an effort to understand the role that genetics plays *in concert* with contextual and environmental factors. Moreover, as Johnson et al. (2009: 218) eloquently argue, "even highly heritable traits can be strongly manipulated by the environment, so heritability has little if anything to do with controllability."

Considering the complementary role that biology plays in accounting for entrepreneurship is important lest we limit our ability to explain this important phenomenon. While most entrepreneurship researchers are comfortable exploring the role of environmental factors, they are less comfortable looking at the part that genetics plays. But as Song et al. (2014) have stressed, the need to account for more of the variance in organizational behavior suggests that the role of genetics should be more carefully considered.

Our analysis suggests that a non-trivial fraction of the correlation between creative personality and entrepreneurial behavior results from innate factors. Because the ways to enhance entrepreneurial behavior vary depending on the levels of genetic and environmental correlations, our results suggest that researchers need to think more carefully about the ways in which interventions might be used to increase the level of entrepreneurial behavior.

Our study contributes to personality research in entrepreneurship. Recent meta-analyses have established that personality factors significantly affect the tendency to start businesses. We find an effect of creative personality on the tendency to be an entrepreneur of equivalent size to that of the relationship between the Big Five personality characteristics and entrepreneurship found by Zhao and Seibert (2006), the meta-analysis of entrepreneurship and achievement motivation by Stewart and Roth (2007), and between entrepreneurship and risk propensity by Stewart and Roth (2004). We also found a correlation coefficient between creative personality and opportunity recognition that is double the highest estimate above.

Because of the high correlation between creative personality and opportunity recognition, employers might consider using Gough's creative personality test to identify employees for jobs in areas where recognizing entrepreneurial opportunities is important, such as product development and corporate entrepreneurship initiatives.

Our study also contributes to the debate on the domain specificity versus the domain generality of creativity (Baer, 1998; Kaufman et al., 2009; Plucker, 1998; Sternberg, 2005). "Whether creativity is a general, domain-transcending set of skills, aptitudes, traits, propensities, and motivations that can be productively deployed in any domain – or, conversely, whether the skills, aptitudes, traits, propensities and motivations that lead to creative performance vary from domain to domain – is a key question in creativity research and theory" (Baer, 2010, p. 321). The levels of phenotypic correlation that we found, and the proportions accounted for by genetic and environmental factors, suggest a middle ground in the debate between domain generality versus domain specificity of creativity. Creative personality is associated with a significant, but not overwhelming, part of opportunity recognition. Moreover, common genes characterize a sizeable, but far from total, fraction of the correlation between these two variables. This finding is consistent with recent work suggesting a fusion of the two differing perspectives on creativity (Baer, 2010).

In addition, our study has implications for molecular genetics research in entrepreneurship. Because common genetic factors account for having a creative personality and the tendency to recognize entrepreneurial opportunities and start businesses, genes associated with creativity are plausible candidate genes for molecular genetics studies of entrepreneurship. Versions of both the TPH and Neuregulin genes that have been associated with creativity (Keri, 2009; Reuter et al., 2006) might also influence entrepreneurship. Therefore, both of these genes would be good candidates to test for association with opportunity recognition and the tendency to start

**Table 5**
Bivariate genetic analyses.

| AE model | $r_A$ | $r_E$ | $r_C$ | Phenotypic correlation | % of phenotypic correlation due to genetic influence |
|---|---|---|---|---|---|
| Creative personality — recognition | 0.68 | 0.27 | 0 | 0.43 | 66 |
| Creative personality — start businesses | 0.42 | 0.07 | 0 | 0.20 | 82 |

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**Table 6**
Bivariate genetic analyses after controlling for the Big Five and sensation seeking (ss).

| AE model | $h^2$ of recognition/start businesses adjusted for big 5 and ss | $r_A$ | $r_E$ | $r_C$ | % of r due to genetic influence |
|---|---|---|---|---|---|
| Creative personality — recognition | 0.24 | 0.46 | 0.17 | 0 | 60 |
| Creative personality — start businesses | 0.18 | 0.25 | 0.04 | 0 | 71 |

businesses. These genes may also be important for identifying gene–environment interactions in entrepreneurship (Quaye et al., 2012b).

Our study has several limitations. Approximately 92% of the sample is female, hindering our ability to generalize our results to males. While we have no reason to believe that genetic factors would only influence the correlation between creative personality and entrepreneurship in women and not men, we cannot show the generalizability of our findings across gender either.

In addition, like all twin studies, our study assumes that there is no assortative mating. Assortative mating occurs when people marry people who are similar to them and could bias the results of twin studies (Plomin et al., 2008). Assortative mating increases the likelihood that children of similar parents receive the same genes for some characteristics than children of non-similar parents. As a result, it increases the similarity between dizygotic twins, while it does not affect the similarity of monozygotic twins, who are 100% genetically identical irrespective of assortative mating (Guo, 2005). Assortative mating thus *underestimates* the heritability estimates in a twin study. While we have no evidence of parental assortative mating with respect to creative personality, opportunity recognition and starting businesses, we acknowledge that this could bias *downward* the results of our study.

Our study also rests on the validity of the creative personality scale, which was derived from the 300 item Adjective Check List using the empirical criterion keying approach. While some research has challenged this approach to scale creation (Craig, 2005), we believe that this measure of creative personality is appropriate for the following reasons. First, a number of studies have ascertained the concurrent, convergent and discriminant validity of this scale (Domino, 1994; Kaduson and Schaefer, 1991). As Waller et al. (1993) argue, "although the CPS is an empirically keyed scale, the majority of adjectival descriptors load saliently on a general factor … [and] meaningful information about the genetic architecture of creativity can be gleaned by examining the phenotypic resemblances … on the CPS" (Waller et al., 1993: 236). Second, the CPS scale has been used in numerous studies to tap creative personality as a unidimensional construct, including Zhou (2003, Journal of Applied Psychology), Madjar et al. (2002, Academy of Management Journal), Carson et al. (2003, Journal of Personality and Social Psychology), Oldham and Cummings (1996, Academy of Management Journal), and Batey and Furnham (2008, Personality and Individual Differences). Third, a number of authors have argued that Gough's creative personality scale (CPS) is "one of the most widely used and respected" (Oldham and Cummings, 1996: 609) measures of creative personality and that "the CPS is the most widely used paper-and-pencil measure of the creative personality" (Sheldon, 1995: 27). Fourth, we excluded the four most problematic adjectives that compose the scale (sexy, snobbish, honest and sincere) and re-ran the analyses. The results were qualitatively similar to the original analyses.

Furthermore, the validity of our results depends on the robustness of the equal environments assumption. For this assumption to be violated environmental factors must treat MZ twins more similarly than DZ twins with respect to creative personality, recognizing opportunities and starting businesses. While we have no reason to believe that this would be the case, we do not have the information to empirically ascertain the validity of the equal environments assumption in this study.

Finally, the generalizability of our results depends on the degree to which the environment for entrepreneurship in the United Kingdom is representative of the environment for entrepreneurship around the world. Some observers (Schreiber and Pinelli, 2013) have argued that the United Kingdom is very supportive of entrepreneurial activity. Plomin et al. (2013) have argued that genetic effects may be higher in contexts in which environmental conditions are more supportive of a behavior than in contexts in which environmental conditions are less supportive. As they wrote, "If environments were made the same for everyone in a particular population, heritability would be high in that population because individual differences that remained in the population would be due exclusively to genetic differences" (Plomin et al., 2013: 92).

We have no way to ascertain how different environmental conditions for entrepreneurship are in the United Kingdom compared to other countries. Therefore, we have no way to evaluate whether the genetic and environmental proportions of the phenotypic correlation between creative personality and opportunity recognition and the tendency to be an entrepreneur would be different in other countries.

We conclude by strongly encouraging additional research on the interface between creativity and entrepreneurship. We entirely concur with the following statement by Zhou and Shalley (2009) in the concluding chapter of their excellent *Handbook of Organizational Creativity*: "… one could argue that all entrepreneurs need some level of creativity, whether it is identifying an opportunity, coming up with new ideas, being creative in how their ventures seek venture capital finding, or pitching their ideas to potential investors. We believe that entrepreneurial research and creativity research have natural connections, and we think the two fields would benefit from a discussion of some shared research interests." (Zhou and Shalley, 2009: 360).

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