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Inventors and New Venture Formation: the Effects of General Self-Efficacy and Regretful Thinking

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This research assesses two individual differences—general self-efficacy and regretful thinking—in the context of technological innovation. Results, obtained from a random sample of 217 patent inventors show that both general self-efficacy and regretful thinking distinguish inventors who started a business (i.e., technological entrepreneurs) from inventors who did not start a new business (i.e., technological nonentrepreneurs). More to the point, patent inventors, who at the time of our survey were actively involved in new business formation, tended to have significantly higher self-efficacy. Also, while technological entrepreneurs tended to have stronger regrets about business opportunities, technological nonentrepreneurs tended to have stronger regrets regarding career and education decisions. The two groups did not differ in terms of the quantity of these regrets. Implications for theory, practice, and future study of individual differences in entrepreneurship are discussed.

The field of entrepreneurship seeks to understand how opportunities are discovered, created, and exploited, *by whom*, and with what consequences (Shane & Venkataraman, 2000; Venkataraman, 1997). Although the person—the entrepreneur—is central to the creation of new ventures, entrepreneurs themselves are seldom explicitly taken into account in formal models of new venture formation. For example, notwithstanding the important role that entrepreneurs play in forging new ventures and creating new jobs, research to identify attitudes, traits, behaviors, or other characteristics that distinguish entrepreneurs from others remains questionable. The goal of this article is to assess two dimensions (general self-efficacy and regretful thinking) on which entrepreneurs and nonentrepreneurs may differ.

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Challenges to Research on Individual Differences in Entrepreneurship

Identifying attributes that distinguish entrepreneurs from nonentrepreneurs is central to the field of entrepreneurship; yet with a few exceptions (e.g., Baum, Locke, & Smith, 2001) a paucity of research on *individual differences* in *entrepreneurship* has been published in leading journals in the fields of psychology and management. Several theoretical and methodological challenges may explain this situation. Some scholars argued that people become entrepreneurs because of low opportunity costs (Amit & Schoemaker, 1993). Others hypothesized that individuals choose between entrepreneurial or employment careers (or a combination of the two) based on expected utility, such as income, risk, work, and independence (Douglas & Shepherd, 2000). According to *disadvantage theory*, entrepreneurship is a reaction to barriers in the labor market: Striving to increase their income, immigrants, minorities, and others seek entrepreneurship when they learn that their job prospects are slim (Mesch & Czamanski, 1997). A similar view suggests that new ventures emerge when people encounter insurmountable obstacles in their task environment (Timmons, 1999). The main problem with such views of entrepreneurship is lack of balance; they overemphasize environmental factors and rationality and underemphasize the role of cognitions and individual differences. Indeed, utility maximization, low opportunity costs, and workplace barriers do not *necessarily* lead people to start a company. Finally, the fact that many entrepreneurs—as matched up to employees with comparable backgrounds and experience—earn lower income with lower earnings potential (Hamilton, 2000) hints that utilitarian paradigms, though undoubtedly useful, fail to fully explain individual differences in this context (Mitchell & Mickel, 1999).

Inappropriate sampling techniques, questionable measures, and inadequate statistical control (e.g., issues of direct versus indirect effects; cf., Baum & Locke, 2002) also hinder research on individual differences in entrepreneurship. For example, what is the theoretical rationale for comparing entrepreneurs with managers (Busenitz & Barney, 1997), bankers (Sarasvathy, Simon, & Lave, 1999), or students (Chen, Greene, & Crick, 1998; Krueger, 1993)? Entrepreneurs build new businesses regardless of resource availability (Timmons, 1999); they erect their firms from the ground up, are normally fully vested in their venture, and subsequently are liable for their firm's success or failure. Managers and bankers, on the other hand, command and control established businesses; they are agents not owners, and they are not as exposed to personal risks as entrepreneurs are. In that respect (excluding deeper cognitive phenomena, such as opportunity recognition, see Fiet, 2002), students are even less suitable as a comparison group.

The challenge of selecting appropriate control groups is related to the daunting question "who is an entrepreneur and who is not" (Robinson et al., 1991). Thus, an important factor that hinders research in entrepreneurship evolves around samples and procedures by which subjects are selected. First, due to the aura surrounding economic growth and innovation, some studies suffer from the bias of over-selecting successful entrepreneurs and most research simply ignores the issue of survival bias. Second, and despite the importance of innovation, few studies control for subjects' inventive capacity, and hence it remains unclear whether reported differences are due to group membership (e.g., entrepreneurs vs. nonentrepreneurs) or ability to innovate. Third, to our knowledge, few studies used homogenous groups of entrepreneurs and even fewer relied on random sampling techniques. Ignoring that large variations among entrepreneurs make comparisons within and across studies difficult, much research used convenient samples of entrepreneurs who work in diverse, frequently even unrelated, industries. Finally, researchers in entrepreneurship have a tendency to 'handpick' their samples despite the

fact that prestudy knowledge of group membership (i.e., entrepreneur vs. nonentrepreneurs) might have inadvertently introduced additional biases.

For the past several years, Baron and his colleagues (1998, 2000) and others (cf., Baum, Locke, & Smith, 2001; Shane, 2000) have sought to augment methodological rigor and create closer conceptual links between entrepreneurship and cognitions by using rigorous methodologies and well-established psychological constructs that seem relevant to understanding the characteristics and activities of entrepreneurs. Our research sought to extend this ongoing work. Building on emergent research on individual differences and entrepreneurship (Baron, 1998, 2000; Busenitz & Barney, 1997; Chen, Greene, & Crick, 1998; Honig, 1998, Stewart et al., 1999, to name a few), we focus on two dimensions that have been validated by psychologists, but which, for a variety of reasons, have not been adequately applied in entrepreneurship research. The factors examined are *general self-efficacy*—our belief in our ability to perform successfully (Chen, Gully, & Eden, 2001; Eden & Aviram, 1993) and *regretful thinking*, which are thoughts regarding events and outcomes different from the ones that actually occurred (Baron, 2000). As we explain below, we predicted that inventors who use their newly developed technologies to start new companies (hereinafter referred to as *technological entrepreneurs*) and inventors who work and invent for established organizations (hereinafter termed *technological nonentrepreneurs*) would differ on these two dimensions.

Why This Study Is Interesting

As we approach the theory section, it is important to identify some of the key factors that make this study interesting and valuable to entrepreneurship research. First, Davis (1971) asserts that theories become interesting once they refute old truths or long held assumptions. The foregoing review and the historical context suggest that, at least until very recently, studies on individual differences added limited value to entrepreneurship research. Similarly, we challenge the view that entrepreneurs—perhaps because they are future-focused—have very few regrets (Baron, 2000). Second, importance is also increased when what hitherto seemed to be a single phenomenon is in reality composed of assorted heterogeneous elements (Davis, 1971). For example, recent entrepreneurship research treated regretful thinking as a unidimensional or homogenous construct (Baron, 2000), but as our research shows such cognition is actually made of several distinct types of specific regrets. Third, research draws additional interest when it shows that what seemed to be a questionable methodological tool is in reality a good one. As we will show shortly, general measures of self-efficacy appear to be particularly useful under ambiguous conditions and multidimensional tasks (Chen, Gully, & Eden, 2001; Eden & Aviram, 1993). Moreover, research that combines a random sample and quantitative and qualitative methodology provides richer insights at the same time that it raises the standard on future studies on individual differences in entrepreneurship.

THEORY AND HYPOTHESES

Self-Efficacy: Beliefs in Our Ability to Effectively Accomplish Certain Tasks

Self-efficacy involves the belief that we can organize and effectively execute actions to produce given attainments (Bandura, 1997; Chen, Greene, & Crick, 1998; Gist & Mitchell, 1992). Self-efficacy impacts our perceived control, how much stress, self-blame, and depression we experience while we cope with taxing circumstances, and the

level of accomplishments we realize. It also influences our courses of action, level of effort, how long we persevere, our resilience in the face of obstacles, adversity, or failure, and whether our thoughts are self-hindering or self-aiding (Bandura, 1999; Wood & Bandura, 1989). Vasil (1992) found that when the effects of experience, academic rank, and disciplinary affiliation are controlled, scholars high in self-efficacy excel. While many occupations call for high self-efficacy (Gist & Mitchell, 1992), inventing patents is a good example since it is constrained by time, funding, and uncertain outcomes despite relentless intellectual effort. Moreover inventions are scrutinized, challenged, and frequently refuted before (and sometimes after) they attain patent status. Since the process of scientific discovery is strewn with technological obstacles, successful patenting rests heavily on sustained effort, creative work, and strong self-belief (Bandura, 1999; Gist & Mitchell, 1992; Wood & Bandura, 1989). In short, perceived self-efficacy is central to most human functioning, and since actions are based more on what people believe than on what is objectively true, thoughts are a potent precursor to one's level of motivation, affective states, and actions.

If self-efficacy impacts career undertaking, performance, and success, would it also predict, or at the very least be related to, entrepreneurial pursuits? We think that it would because of three main reasons. First, people avoid careers and environments they believe exceed their capabilities (regardless of the benefits these may hold), but they readily undertake vocations they judge themselves capable of handling (Krueger & Dickson, 1994), and the higher their self-efficacy, the more challenging the activities they pursue. Individuals high in self-efficacy not only prefer challenging activities but also they display higher staying power in those pursuits (Bandura, 1997). Since the undertaking of new business formation—particularly in high-tech domains—is replete with difficulties, high self-efficacy may be necessary (even if insufficient) for such pursuits. Second, because technological entrepreneurs operate at the crux of change, innovation, and market perturbation, they personally realize higher financial, technological, and legal uncertainties. On the other hand, inventors "working-for-others" continue to operate in relative seclusion and predictability; they are less exposed to market resistance, competitors' retaliation, or suppliers' protest. Past research indicates that under taxing circumstances, individuals with higher self-efficacy perform more adeptly (cf., Bandura, 1997). Thus, social cognitive theory suggests that technological efforts to overcome the adversities described above call for high self-efficacy. Finally, although some research has suggested that self-efficacy successfully differentiates entrepreneurs from nonentrepreneurs (Chen, Greene, & Crick, 1998; De Noble, Jung, & Ehrlich, 1999), as we noted earlier, such inferences stem from studies with students or managers. We suggest that starting a new venture — obtaining external funding, recruiting key partners and employees, and overcoming what appear to be insurmountable business and technological obstacles—is substantially different than managing an existing operation or undergoing classroom simulations. Since self-efficacy reliably predicts the scope of career options considered, occupational interests, perseverance in difficult fields, and personal effectiveness, we suggest that it will also be related to the pursuit of entrepreneurial activity. Thus our first hypothesis is as follows:

Hypothesis 1: Technological entrepreneurs have higher self-efficacy than technological nonentrepreneurs.

Regretful Thinking: Thinking About Unexpected Outcomes

Experiencing unintended detrimental consequences or imagining favorable outcomes that did not materialize is a frequent experience for most people. Such regretful thinking

often occurs in response to information about unfavorable outcomes and unmet expectations, and frequently leads, in turn, to strong emotional reactions, such as disappointment and blame (Zeelenberg et al., 1998). For instance, regretful thinking can be observed among Olympic athletes who win silver medals. Such athletes have been found to be less happy with their success than are athletes who receive bronze medals (Medvec, Madey, & Gilovich, 1995). Research on counterfactual thinking explains this seemingly anomalous result in the following manner: Silver medal winners are unhappy because they imagined winning a gold medal (i.e., they imagined better outcomes than they actually received), while bronze medallists are happier because they imagined receiving no medal at all (i.e., worse outcomes than they actually received). Thus, like counterfactual thinking, regretful thinking is a cognitive representation of alternative consequences and they are activated automatically, particularly (though not exclusively) in response to misfortunes and disappointments (Baron, 2000).

Regretful thinking is important because such strong sentiments may have profound effects on entrepreneurs' mood, understanding of cause-effect relationships, decision-making, and task performance (Roese, 1997). Research shows that regret and blame are particularly vivid in contexts involving product failure (Creyer & Gurhan, 1997). Although Baron (2000) found that entrepreneurs, as compared with students, experience fewer regrets, we suspect that technological entrepreneurs, because they encounter potent market and technological obstacles, experience substantially more regrets than others who invent yet take no part in the commercialization of their technologies. Championing a new venture can evoke strong emotions; capitalizing on poor opportunities (and the subsequent failure) or caving in to competition (and observing how others reap the rewards) can stir up strong regrets.

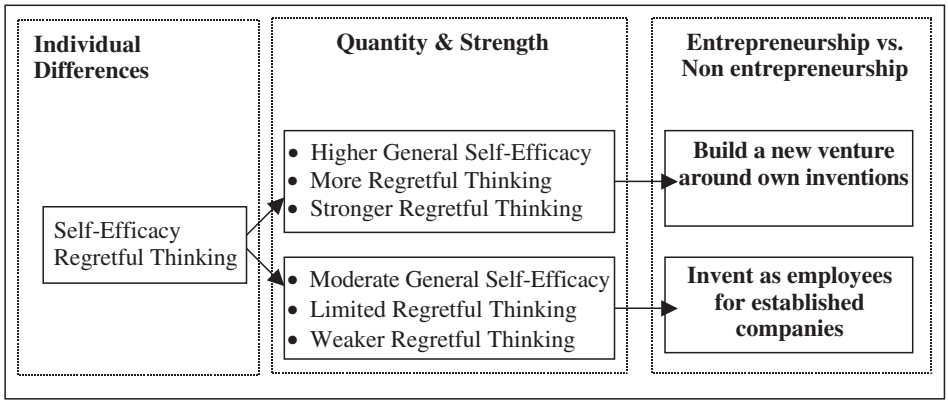
Since persons launching a new business based on their inventions are constrained by financial and nonfinancial resources, time, and technological know-how, it is reasonable to expect that they would experience many—and sometimes repeated—negative outcomes. It is not uncommon for entrepreneurs to identify an opportunity, struggle to attain resources, industriously develop a working prototype, and pitch it to prospective buyers, only to see it rejected—sometimes rather swiftly—by skeptical markets. Since technological entrepreneurs, as compared with technological nonentrepreneurs, make more private sacrifices and have more professionally, financially, and socially at stake, product rejections and limited capital may bear more memorable regrets. In short, exploiting technical opportunities through firm formation, working with very limited budgets, and battling to gain product legitimacy among buyers within ephemeral opportunity windows may bring early mishaps and failure. On the basis of these considerations, we suggest that entrepreneurs experience more regrets and experience them more intensely than nonentrepreneurs. We also suspect that entrepreneurs and nonentrepreneurs regret different things because the environment in which they work and the challenges that they face are substantially different. Hence, the following hypotheses:

Hypothesis 2: Technological entrepreneurs experience a higher number of regrets than technological nonentrepreneurs.
Hypothesis 3: Technological entrepreneurs experience their regrets more intensely than technological nonentrepreneurs.
Hypothesis 4: Technological entrepreneurs regret different things than technological nonentrepreneurs.

The above discussion and the predicted differences between inventors' self-efficacy and regretful thinking are succinctly captured by Figure 1.

Figure 1

Hypothesized Relationship Among Study Variables



METHODS

To avoid the selection biases discussed earlier, yet to obtain evidence on individual differences in this context, we used a random sample of 217 patent inventors. This random sample was obtained according to the following procedure: First, we attained from the U.S. Patent and Trademark Office (USPTO) a list of all the patent inventors (N = 4,861) who were granted patents for their inventions (e.g., patent class 606, which encompasses surgery devices) during 1997 and 1998. Since the list of 4,861 inventors included only minimal contact information (i.e., first and last name, city, and state), a large-scale effort took place to obtain the complete address and phone number for each and every inventor. As manual search deemed time consuming and costly, we used Visual Basic to scan the Nation Wide Phone Directory (NWPD) software that resides on CD-ROMs and then retrieves the data based on pre-specified criteria. When there was a match between an inventor's name and city in the USPTO dataset and the full address given by the NWPD software, we retained the inventor in our sample. The Visual Basic output encompassed 3,491 nonduplicated entries.

Although the Visual Basic output encompassed 3,491 nonduplicated entries, we randomly selected a sample of 586 inventors for our study. This was done using Excel Spreadsheet and the "randomize" command function. Then, a courtesy phone call was made to all 586 potential participants notifying them that a survey was sent to them. Ten working days later we called all the participants who did not send their surveys back, and then we sent our second batch of surveys. Finally, in two-week intervals beginning after the second mailing, two to six additional phone calls were made and surveys were sent to all nonresponding inventors. Hence, in contrast to previous studies that compared entrepreneurs and nonentrepreneurs—but "manually" selected their participants—we relied on a random sample of 217 inventors (37 percent response rate), all of whom invent in the same technological space at the same time period.

To identify technological entrepreneurs from technological nonentrepreneurs, we used a qualifying question (placed at the last section of the mail survey), asking inventors to indicate whether they used their invention to start or continue to build their own business. Such a qualifying question was used successfully in previous studies including

the ERC project mentioned earlier (Carter, Gartner, & Reynolds, 1996; Reynolds, 1997). This "stipulation" is important because it means that identification and classification of inventors as *technological entrepreneurs* or as *technological nonentrepreneurs* was made only after the surveys were collected and data were coded. Also, unlike Internet-type patents that may be developed at one's home, inventing surgical devices takes time and requires costly infrastructure (e.g., facilities and instruments). This implies that it is improbable that participants had ventured substantial amounts of their time, personal capital, and labor to devise useful, nonobvious, and valuable inventions, with which they did virtually nothing. While it is impossible to ascertain completely whether some inventors may be neither entrepreneurs nor nonentrepreneurs, combining the procedure described above with the technological space in which these patents were invented provide confidence in the validity and reliability of group membership (at least at the time inventors were surveyed).

Of the 217 qualified inventors, 55 (25 percent) used their invention to start a new company and therefore were classified as technological entrepreneurs (coded as 1), whereas the remaining 162 (75 percent) did not, and thus were classified as technological nonentrepreneurs (coded as 0). Sampling patent inventors is appropriate since patents are a proxy for important technological innovation, a precursor to newly developed products, and an indication of intellectual property and technological capital (Balkin, Markman, & Gomez-Mejia, 2000). Strategically speaking, patents also erect legal and technical barriers to competitors while creating opportunities for wealth. Indeed, our interviews of patent inventors, technology transfer executives, and patent attorneys suggested that patents serve as key footholds to specific markets; they are an important source of competitive insulation. Methodologically speaking, the use of inventors, all of whom invented patents at roughly the same time in the same technological domain, trims down on competing and confounding factors. For example, this study holds several contextual factors constant, including the technological domain, inventors' experience, and time in which an innovation was available to compete in the market.

Finally, as research should rely on appropriate samples and sampling techniques, so should it try to account for nonresponse bias. To this end, we compared the respondents—on age, formal education, annual income, and number of patents developed—with 46 inventors who refused to participate. Data on these inventors were obtained via postsurvey phone calls to nonresponding inventors, and analysis showed no significant differences between the two samples.

PROCEDURES AND OPERATIONAL MEASURES

Inventors were asked to complete a short questionnaire consisting of scales adapted from widely used measures of self-efficacy and regretful thinking. Although self-efficacy measures have generally relied on scales relating to specific tasks, some research calls for broader measures, particularly when the vocations under consideration have little in common or require a very diverse set of skills (cf., Bandura, 1997). Since starting high-tech ventures requires human capabilities in diverse domains (De Noble, Jung, & Ehrlich, 1999) and validated self-efficacy scales for patent inventors are not yet available, we used a *general self-efficacy* scale. This construct was measured in terms of the belief about what one can do under different conditions with whatever skills one possesses (Chen, Gully, & Eden, 2001; Eden & Aviram, 1993). This measure was an eight-item, seven-point scale (1 = strongly disagree; 7 = strongly agree) that was used successfully in previous research (Maurer & Pierce, 1998). Items included such statements as "I am strong

enough to overcome life's struggles," "I can handle the situations that life brings," and "I usually feel I can handle the typical problems that come up in life" ($\alpha = .89$). All eight measures of self-efficacy are depicted in the Appendix.

Unlike previous research that treated regretful thinking as a unidimensional or homogenous construct, we assessed three dimensions of regretful thinking, including a *quantitative*, *qualitative*, and *magnitude* measure of inventors' regrets. The quantitative and qualitative measures were based on inventors' responses to an open-ended question: "think about your life and career and list the decisions that you regret most." Thus, three different dimensions of regretful thinking were measured. First, we counted the *quantitative measure* of regrets by adding up the decisions that inventors regretted most. Second, a content analysis of the same decisions by two independent raters had identified six types of regrets (e.g., decisions regarding business opportunities, career, education, investment and finance, personal value, and relationships). Interrater consistency was high; in 92 percent of the cases they were in complete agreement. This was the measure of the *qualitative nature* of regrets. Finally, on the next page of our survey, participants were also asked to indicate, on a seven-point scale, how much regret they had experienced regarding the decisions they had just listed (1 = little regret; 7 = much regret). This was the measure of the *magnitude* of regrets. All three measures of regretful thinking are depicted in the Appendix.

Consistent with previous research on individual differences in entrepreneurship, the control variables were age, education, and annual income for 1998 (Baron, 2000). An additional control variable that our study brings to this type of research is a measure of innovation as captured by the number of patents obtained by each inventor (Griliches, 1990; Romer, 1996).

Analyses

Table 1 provides means, standard deviations, and intercorrelations for the measures. The average inventor in this study was approximately 47 years old, had almost 20 years of formal education, and at the time of the survey had more than 13 patented inventions

Table 1

Means, Standard Deviations, and Correlations among Study Variables[a]

	Mean	s.d.	1	2	3	4	5	6	7
1. Entrepreneurs[b]	.25	.43							
2. Age	47.23	9.33	.03						
3. Education	19.69	2.69	.20**	−.04					
4. Innovation	13.14	17.00	.04	.04	.10				
5. Income[c]	118,273	83,845	.03	−.01	.24**	.10			
6. General Self-Efficacy	6.01	.99	.18**	.03	.01	.11	.05		
7. Regret Magnitude	2.79	1.68	.17**	−.07	.08	.16*	.10	.14*	
8. Regret Count	5.99	1.04	.11	.12	.00	−.06	−.13*	−.01	.02

*p < .05 level (2-tailed); **p < .01 level (2-tailed)
[a]N = 217
[b]*Entrepreneurs* refers to technological entrepreneurs versus technological nonentrepreneurs.
[c]Income is annual earnings in dollars.

Table 2

MANOVA Analysis: Dependent Variable Means[a] For Entrepreneurs and Nonentrepreneurs

Dependent Variable	Entrepreneurs	Nonentrepreneurs	F-value	eta^2
General Self-Efficacy	6.30	5.90	5.41*	.03
Magnitude of Regrets	6.15	5.67	6.01*	.03
Number of Regrets	3.21	2.90	1.44	.01

Multivariate effect: Pillai's trace = .05, F = 3.80*, eta^2 = .05
* $p < .05$
[a] Means adjusted for covariates: age, years of education, and number of patents.

with average annual earnings of approximately $118,000. The subgroup of inventors who also became entrepreneurs (N = 55) had started 1.5 firms with two cofounders and had raised approximately $6 million to build his or her company. Entrepreneurs and nonentrepreneurs were closely matched on education, age, income, and innovations.

A MANOVA was used to examine the relationship between the entrepreneur and nonentrepreneur variable on a set of three dependent variables: self-efficacy, magnitude of regrets, and number of regrets. Variables such as age, years of education, and innovation (i.e., number of patents) were included as covariates.

RESULTS

The MANOVA revealed significant difference between entrepreneurs and nonentrepreneurs on the set of the dependent variables (Pillai's Trace = .05, F = 3.80, $p < .05$). The size of the multivariate effect of entrepreneurship on the set of dependent variables, as indexed by partial eta squared, was .05. Univariate ANOVAs confirmed that entrepreneurship had significantly higher self-efficacy ($F = 5.51$ $p < .05$) as well as stronger regrets ($F = 6.01$, $p < .05$). Stated differently, self-efficacy and magnitude of regrets were higher for entrepreneurs than for nonentrepreneurs (respectively 6.30 vs. 5.90 and 6.15 vs. 5.67). However, the two groups did not differ on the number of regrets (F = 1.44, p = ns). Table 2 shows the adjusted means for the three dependent variables broken down for entrepreneurs and nonentrepreneurs.

As described earlier, a content analysis of the qualitative measure of regretful thinking identified six types of regretful decisions, including *business opportunities, decisions regarding career, education, investments, personal values*, and *personal relationships*. A discriminant analysis suggested that technological entrepreneurs regret more decisions regarding business opportunities whereas technological nonentrepreneurs list more regrets about education and career decisions (Chi-square = 30.84; p = .01). The discriminant function accounted for 78 percent of the between-group variability. The discriminant function of the structure matrix and the test of group means are reported in Table 3.

Our study suggests several important findings. As stipulated by our first hypothesis and shown in Table 2, technological entrepreneurs' self-efficacy was significantly higher

Table 3

Discriminant Analysis: Structure Matrix of Regret Variables[a]

	Function	Wilks' Lambda	F	Sig.
Business Opportunity	.85	.94	23.58	.001
Education	−.43	.99	4.00	.05
Career	−.35	.98	6.07	.01
Value	.12	1.00	.45	.50
Relationship	.03	1.00	.02	.88
Investment	−.01	1.00	.58	.45

[a]Dependent Function: Technological entrepreneurs versus technological nonentrepreneurs.

than that of technological nonentrepreneurs. Thus, the data offered support for Hypothesis 1. Coincidentally, we also found a significant relationship between self-efficacy and patent inventors' annual earnings. To be more specific, patent inventors whose self-efficacy was in the top 10 percent earned over $35,000 per year more than patent inventors whose self-efficacy was in the bottom 10 percent. Thus, regardless of group membership, higher general self-efficacy was related to higher personal income. The difference in technological entrepreneurs' and technological nonentrepreneurs' regret count was not significant. Although, on average, entrepreneurs reported a somewhat higher number of regretful decisions than nonentrepreneurs, the difference was not statistically significant. On the other hand, the two groups differed on the magnitude of their regrets; technological entrepreneurs reported significantly stronger regrets than technological nonentrepreneurs (see Table 2). Additionally, and as seen in Table 3, entrepreneurs primarily reported regrets concerning business opportunities whereas nonentrepreneurs reported mainly regrets about their career and education.

To recap, findings reported in Tables 2 and 3 provide support for Hypotheses 1, 3, and 4, but not for Hypothesis 2. Technological entrepreneurs, as compared with technological nonentrepreneurs, tend to have higher self-efficacy, more intense regrets, and different types of regrets. Nonetheless, the two groups did not differ with respect to the quantity of their regrets.

DISCUSSION

The centrality of technical innovation to economic growth is not new and research is providing a better understanding of the innovation processes and strategies that yield high returns. However, we still know very little about the persons—the entrepreneurs—who discover and create "new combinations." To remedy this, we investigated four variables (two constructs, one of which was captured by three different measures) on which patent inventors who were classified as technological entrepreneurs and technological nonentrepreneurs may differ and found support for three of our four hypotheses.

Inventors who started a business were higher on general self-efficacy than inventors who did not start a business (Hypothesis 1). Evidence also showed that technological entrepreneurs experience stronger regrets than their counterparts (Hypothesis 3) and the two groups appeared to experience regrets over different types of decisions (Hypothesis 4). Technological entrepreneurs' regretful thinking focused mainly on business opportunities and technological nonentrepreneurs focused on decisions relating to education and careers. Contrary to Hypothesis 2, however, the number of these regrets did not differ across the two groups. Finally, regardless of group membership, highly efficacious inventors tended to earn significantly higher annual income. This result suggests that inventors with high general self-efficacy may attain a higher level of personal success (as measured by annual income) than inventors with lower levels of self-efficacy.

Since self-efficacy is crucial for the pursuits of challenging attainments, it is not surprising that it was significantly related to annual income, a general measure of personal success. More important to our study, general self-efficacy was related to group membership; inventors who used their patents to start or build new companies had significantly higher self-efficacy than inventors who did not use their patents in this manner. It has been observed that highly talented individuals often fail to leverage their capabilities, and a large body of evidence (e.g., Wanberg, Kanfer, & Rotundo, 1999) suggests that this may be due, in part, to deficits with respect to self-efficacy. In essence, it is difficult to attain challenging goals when one has doubt about one's ability. For this reason, we suggest that a strong perception of general self-efficacy may well be crucial in many entrepreneurial undertakings.

Unlike previous research that shows that entrepreneurs—as compared to others—engage in limited counterfactual thinking (cf., Baron, 2000), we found that entrepreneurs and nonentrepreneurs report an almost identical number of regretful decisions. We found that not only do technological entrepreneurs experience stronger regrets they also experience regrets over different kinds of decisions than their counterparts (i.e., business opportunities vs. career and education decisions). We attribute these findings, which diverge from the ones reported by Baron (2000), to our unique and random sample of patent inventors (rather than students) and our qualitative measures of regrets.

While the finding that technological entrepreneurs regret mostly decisions about business opportunities has high face validity (e.g., pursuing opportunities is at the core of many entrepreneurial activities), a key question is why did technological nonentrepreneurs, but not technological entrepreneurs, regret career and education decisions? Though this question should be fully addressed in future research, we offer the following explanation. Job autonomy, particularly in inventive capacity, influences how incumbents perceive their work and experience career-related regrets. Unlike technological entrepreneurs, technological nonentrepreneurs work and invent for their employers, and as such they encounter stronger barriers to career mobility, limited discretionary power, and of course, restricted autonomy. A career plateau—the point at which advancement is improbable—can occur to many astute inventors despite years of experience. Good engineers have strong problem-solving skills in their respective technical domains; however, to become executives or managers they need new skills in leadership, decision making, business acumen, working well with a diverse workforce, as well as foresight and perseverance. Thus, one's early decision to become a skilled scientist or engineer may limit the subsequent likelihood of being groomed for leadership roles and succession to the top management team (Daily, Certo, & Dalton, 1999). While our explanation is quite plausible, this proposition is beyond the scope of our study and thus awaits further empirical testing.

Limitations and Future Research

Even though regretful thinking is an important cognition in the context of decision making, until recently very little research has focused on this topic in the context of entrepreneurship. For example, researchers (e.g., Loomes & Sugden, 1986) have noted that decisionmakers anticipate and take into account that their decisions might bring about regretful thoughts. As such, future research on entrepreneurs' regretful thinking could be helpful in understanding how these thought processes and cognitions affect decisions and actions. For instance, regretful thinking, which is primarily associated with the presence of negative outcomes, together with people's natural tendency to avoid disappointment, could explain why some people, but not others, tend to be so cautious in their decision to launch a new venture. Others showed that people are generally risk averse and that this tendency is stronger under conditions of possible gains than possible loss (Kahneman & Tversky, 1982). To extrapolate from the work of van Dijk, Zeelenberg, and van der Pligt (1999), one reason for this tendency could be that opting *not* to start a new business may be associated with limited disappointment and few regrets. In other words, increased anticipation of disappointment and regrets might motivate risk-averse career paths. Being risk averse allows us to expect less, obtain what we expect more easily, and therefore avoid the risk of becoming chagrined from disappointments and regretful thinking. Clearly, cognitions, such as regretful thinking are an interesting area of research awaiting further investigation in the context of new venture formation.

Figure 1 is a crude depiction of the relationship between inventors' self-efficacy and regretful thinking and new venture formation. Naturally, methodological constraints limited our ability to test for other important individual differences (e.g., locus of control, expectancy, self-esteem, and so on) or contextual factors (e.g., resource availability). Similarly, the cross-sectional design prohibits any causal inferences, and thus directionality, despite the diagramed arrows, remains questionable. Notwithstanding these limitations, we hope that future research may draw on our simplified model and expand it to test additional cognitive differences. As described in the "Methods" section, our study focused narrowly on patent inventors who invented at roughly the same time period in a single technological domain (i.e., surgery devices). While this did not account for resource availability, it certainly controlled for other situational factors, such as technological context, experience, and time in which the innovation was available to compete in the market. Future testing of this model therefore should maintain the same level of methodological rigor, but at the same time try to account for other contextual and cognitive factors overlooked here.

One obvious limitation of our study is uncertainty regarding causality of self-efficacy. Since data were collected after inventors began building their new ventures, it is uncertain whether founding a company increases one's self-efficacy or whether high self-efficacy leads one to start a new venture. However, two points suggest that general self-efficacy is more likely to be a cause of starting a new venture than the result of it (Bandura, 1997). First, general self-efficacy is the result of lifelong experiences, and as such, it is quite stable by the time individuals are adults (Bandura, 1997). Thus, it seems unlikely that the experience of starting a new venture could, in and of itself, significantly elevate general self-efficacy. In fact, since we obtained data from entrepreneurs only a few months after they had launched their new ventures, the possibility that such short-term activity could significantly alter one's self-perception, which is based on many years of prior experience, seems unlikely. Second, general self-efficacy is shaped by individuals' success or failure in various activities. The new ventures founded by our sample of technological entrepreneurs were quite new—so new, in fact, that these persons had not

yet received clear feedback on whether they were (or were going to be) successful in this activity. For this reason, too, we believe it is more reasonable to assert that differences in self-efficacy contributed to the decision to become an entrepreneur rather than the opposite.

We hasten to point out, however, that self-efficacy is founded on a model of triadic reciprocal causation in which cognitive, affective, and behavioral patterns all operate as interacting determinants that influence one another bidirectionally (Bandura, 1999). We also realize that the possibility that starting a new business enhances one's self-efficacy exists. Hence, only further research—employing longitudinal methods—will adequately address this question and we therefore hope that future studies on entrepreneurship and self-efficacy may address this challenge more thoroughly.

The key challenge to cognitive researchers in field settings is the unavoidable tradeoff between casting a broad empirical net and attaining a high response rate. Unfortunately, extensive survey research (in field settings, such as with patent inventors) with innumerable scales and questions hinders response rates. Highly inclusive survey instruments (e.g., with a myriad of cognitive scales) are lengthy and time—consuming; and while such surveys may work in classroom settings, they are prohibitively difficult to justify to inventors and scientists who volunteer their scarce time. Hence, it is our view that precisely because we used a parsimonious survey, we were able to harness inventors' attention and goodwill (e.g., 37 percent response rate). Clearly, cognitive scholars must consider this delicate tradeoff between breadth of constructs studied and the qualitative richness of each construct before embarking on field research.

Finally, and in the context of the special issue on information processing and entrepreneurial cognition, we hope to communicate a broader vision for methodological and theoretical development. As discussed earlier, since information processing and cognitions are individual-level phenomena and entrepreneurial pursuits are highly multidimensional, it is incumbent upon us to pay closer attention to methodological factors (e.g., sample selection, contextual variables, and so on). This study, we believe, made important methodological strides and also provided insights regarding self-efficacy and regretful thinking, but the theoretical frontiers of information processing and cognitions are substantially broader. For example, future research and theory should focus on entrepreneurs' mental models—one's implicit cognitive framework of reality or unarticulated theory of action. Specifically, because mental models are determined by *past* experience, expertise, knowledge, and learning, do such models become a liability in *new* and unfamiliar contexts? How do entrepreneurs think, learn, rebound, and elude mental model traps as they create *new combinations* and ultimately wealth, even in declining industries? Other, and perhaps more basic questions, are "why do some persons but not others become entrepreneurs?" Or "what makes some entrepreneurs so much more successful than others?" Although cognitive processes are constructed to assist in decision making, the overwhelming evidence that cognitions become barriers to change suggests that this would be a fertile area for future research in entrepreneurship.

Conclusion

To recap, we suggested that efforts to attain greater insight into the characteristics of persons who discover, create, and exploit opportunities is important as it may yield rich dividends with respect to our ability to address fundamental questions concerning individual differences in the context of entrepreneurship. We showed that inventors who use their inventions to start a new business, as compared with those who don't, tend to have higher self-efficacy and more intense regrets over certain kinds of decisions. We also

found that while the two groups tend to regret different decisions, the number of regrets was highly similar. Finally, we also found that as a group, inventors with high self-efficacy tend to earn significantly higher income; patent inventors whose self-efficacy was in the top 10 percent earned over $35,000 per year more than patent inventors whose self-efficacy was in the bottom 10 percent. Although other studies assessed self-efficacy and regretful thinking, this research appraised these two factors simultaneously. Hence, our study assessed the cumulative variance that has not already been accounted for by previous research. Sample selection is another factor hindering entrepreneurship research. While in the past researchers "hand-picked" their participants (frequently from heterogeneously diverse business domains), this study relies on a random sample of inventors all of whom had invented patents in the same technological space and at the same time period.

In closing, entrepreneurial activity is a complex and costly process characterized by an unfavorable success rate (Baum & Locke, 2002). This suggests that identifying and investing in the right persons who discover and quickly transform such innovation into commercial offerings is important. One key implication then is that while management scholars and public and private investors should continue to study the market, technology, resources, and environment of business opportunities, we recommend that they also scrutinize the persons—the entrepreneurs. Certainly, research and investment decisions should consider a wide range of elements: the nature of the opportunity, resource attainment, market and competitive conditions, the experience and technical knowledge of the entrepreneurs, and so on. Included among these factors, we contend, should be characteristics of the entrepreneurs—modes of thought, behavior, and traits that may help, or hinder them in their entrepreneurial efforts. Since high self-efficacy appears to be one characteristic strongly linked to entrepreneurial pursuits, new venture growth (Baum & Locke, 2002), and personal success, scholars and investors may be wise to devote more attention to this factor.

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APPENDIX

General Self-Efficacy Scale

Please indicate the extent to which you agree with each of the following statements (circle one number for each item).

Strongly Disagree = **1 2 3 4 5 6 7** = Strongly Agree

1. I am strong enough to overcome life's struggles	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2. At root, I am a weak person	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3. I can handle the situations that life brings	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4. I'm usually an unsuccessful person	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5. I often feel that there is nothing I can do well	**1**	**2**	**3**	**4**	**5**	**6**	**7**
6. I feel competent to deal effectively with the real world	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7. I often think that I'm a failure	**1**	**2**	**3**	**4**	**5**	**6**	**7**
8. I usually feel I can handle the typical problems that come up in life	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Regretful Thinking

Looking back over your entire life, please list the things that you regret most:

_____

_____

_____

Little Regret = **1 2 3 4 5 6 7** = Much Regret

Considering these things you listed on the previous page, how regretful are you?	**1**	**2**	**3**	**4**	**5**	**6**	**7**