On the Recognition of Venturing Opportunities in Science and Technology

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Abstract

This paper seeks to understand the psychological mechanisms which support the recognition of science and technology-based opportunities for new ventures. Opportunity recognition is viewed as a critical skill in venturing activities, but there is doubt about the mechanisms involved. The entrepreneurship literature contains a tradition of seeing opportunity recognition as a less than conscious process, that starts with an "initial intuition," and "involves a subconscious evaluation," a view that suggests the psychological process of directed attention, where the direction for any given individual is a function of personal interests and experience. A small number of qualitative interviews at the University of Sheffield are first reported that support the finding that such a cognitive mechanism is present. Then a scale used to measure "attention to use" in a survey of 494 science and engineering students at four UK universities is presented, along with its correlation with venturing and applied technology self-efficacy. The conclusion addresses the implications of recognising directed attention as a major component of opportunity recognition.

Entrepreneurial opportunity recognition and directed attention to use of technology

This paper seeks to understand the psychological mechanisms which support entrepreneurial opportunity recognition. That recognition is treated here from the perspective of Kirzner's (1979) entrepreneurial alertness, a perspective that calls attention to the unconscious processes of discovery. It begins with the proposition that a substantial fraction of opportunities recognised by nascent entrepreneurs are not conscious in the sense that they are not found through a process that is driven by rational search or even by the conscious focusing of one's attention. A cognitive theory of unconscious recognition and discovery is considered that might then explain this phenomenon, based upon the proposition that individuals develop a directed attention through interest and experience to quite specific domains.

A summary review of the opportunity recognition literature is offered focusing on the psychology of the recognition process that often precedes conscious search for an idea. The probe into the nature of the opportunity recognition process among a small number of mechanical engineering undergraduates at the University of Sheffield is then offered to provide a qualitative test of the source of ideas, leading to the conclusion that some unconscious process of screening and evaluating ideas must be at work. The next section offers a discussion of the theory of directed attention as a basis for considering what processes might be at play. The methods and results section then provides the findings from a survey of 494 second, third and fourth year engineering undergraduates at the

Universities of Cambridge, Sheffield, Strathclyde and York. In the process a measure of Attention to Use of technology will be presented, along with measures of pre-entrepreneurial behaviour and entrepreneurial intent. Concluding comments will reflect on the role of university education in the development of unconscious attention.

Opportunity recognition and entrepreneurial alertness

The general view of entrepreneurship that underlies this research is offered by Bygrave and Hofer (1991) who suggest that entrepreneurial research would do well to begin with a definition that the, "entrepreneurial process involves all the functions, activities, and actions associated with the perceiving of opportunities and the creation of organisations to pursue them". This definition has proven to be a useful starting point for others (Keh et al. 2002, Ucbasaran et al. 2001), perhaps because it anchors the study of entrepreneurship on a process concept. It also emphasises the role of perception, drawing attention to the cognitive mechanisms that the entrepreneur is said to employ, which may vary from stage to stage in that process. The concern here is the very first step, the recognition of opportunity, and the cognitive processes of entrepreneurial alertness that precede it. The premise is that opportunity recognition includes an unconscious process, in that it is not consciously directed and the individual is generally unaware of their state of alertness. The individual's attention is directed by current interests and intent, and shaped by past personal experience and known information. In this research, the concern is identifying a cognitive process of directed search for new applications of technology for undergraduates studying science and engineering.

Entrepreneurial alertness as advanced by Kirzner (1979) would seem to be an instance of some general form of directed attention. He suggests that the entrepreneur plays a key role in reestablishing market equilibrium by the discovery and grasping of opportunities that others do not see without actually searching for them. "Entrepreneurial alertness consists, after all, in the ability to notice without search opportunities that have been hitherto overlooked" (Kirzner 1979, 148). It would seem that these discoveries are made through some process of unconscious recognition by agents who are "spontaneously on the lookout" for unnoticed features in the environment: "Without knowing what to look for, without deploying any deliberate search technique, the entrepreneur is at all times scanning the horizon, as it were, ready to make discoveries" (Kirzner 1997, 72). Indeed, conscious search is quite difficult if one does not start by knowing what one is looking for, as when Minniti and Bygrave (1999, 41) suggest that, "entrepreneurial alertness leads to something previously unimagined."

Contemporary literature frequently cites Kirzner as evidence stressing the importance of the opportunity recognition (Ardichvili et al. 2003, Kaish and Gilad 1991, Kirzner 1979, Shane 2000). There are, however, wide variations in how much writers on opportunity recognition accept the unconscious nature of Kirzner's entrepreneurial alertness. At one extreme, some suggest that entrepreneurial discovery is the result of classic management techniques that are chosen and consciously directed, abandoning entirely Kirzner's view that entrepreneurial alertness is not consciously directed. Others occupy a more mixed position. Alvarez and Busenitz (2001) seem to include both the conscious and subconscious approaches but believe the distinguishing characteristic of entrepreneurs is their use of heuristics, defined as simplifying strategies. While they recognise that entrepreneurs make "significant leaps" (2001, 758), those leaps would seem in their view to follow from a conscious application of decision rules that allow them to deal with

ambiguous information and complexity. Studies of the source of entrepreneurial ideas provide evidence of both conscious search and spontaneous recognition, with Koller (1988) finding more opportunities found by discovery than by searching. Herron and Sapienza (1992) suggest that while the mechanisms underlying the search process may be open to debate, it "apparently involves a subconscious evaluation"; once it "has synthesized an opportunity, however, conscious evaluation will begin to operate" (52).

Whatever the balance, there appears to be widespread acceptance that entrepreneurial alertness has a strong intuitive or subconscious component. Ardichvili et al. (2003, 115) suggests that while conscious search is often important, on balance one should recognise the key role of alertness in recognising opportunities hidden in the information that flows past the future entrepreneur, concluding that whatever it is that happens in a process of passive search is a "more powerful determinant of discovery -- accidental or purposive -- than level of activeness of search. Therefore we include entrepreneurial alertness rather than search in our model". Not dissimilar views are found in Baron (2004) and Gaglio (1997).

A qualitative exploration

To explore this notion of unconscious discovery of technology applications, one author has conducted a focus group of undergraduate mechanical engineers at the University of Sheffield. Using questions that were items from a scale on attention to use of technology (see below), the students were asked about how often they had realisations or discoveries about technology, a question important to the quantitative survey methodology reported below. While the answers varied to some degree, the general consensus was that these students felt that they thought about a wide variety of problems, and about once a month they would spontaneously recognise that some technology might offer a solution. Conversely, when discussing a new technology, they said that about monthly or more often they would seize on either an entirely new application, or more likely a further application of an existing technology. Together these results supported the premise that there is an on-going process of some kind that links problems or needs and alternative uses of technology. Critical to the survey methodology, they were then asked to describe some of those realisations to determine how tangible and consequential they were, and what they were doing at the time.

Some examples drawn from a focus group transcript (Rodriguez-Falcon 2006) are instructive:

Samuel: When asked about when a concern for a problem had led to a technology of some kind, Samuel described the experience of not wanting to get up out of bed to change the channel on his television set, setting off the idea of using Blue Tooth technology to link his cell phone to his television. When asked what motivated this realisation, he said "Laziness, I think."

Samuel subsequently reconfigured his cell phone to control his television. Later he added remote control of his compact disc player. He now invites friends in and proudly shows his invention.

Beverly: The realisation she reported occurred while walking a substantial distance to the University on a cold morning that had turned warm by the time she arrived. "I start feeling hot, so [then I] just start wondering if you could develop a material or fabric that

sort of adapts to different climate or temperature changes…" When said she continues to think about the idea from time to time, and adds that, "Well it's in the back of my memory, maybe subconscious; [I] don't really think on it as much, but, yeah, it's something that I'd like to address, maybe sometime."

Timothy: His first recollection of a problem followed by recognising how a technology could help was not particularly impressive: when his electricity bill arrived in the post he recognised he had a problem, and he thought about taking advantage of the more efficient light bulbs on the market. This reminds us that all responses to questions about the frequency of linking technology to problems may be about mundane and well-established technologies, a point worth remembering when we see a large number of instances of recognition of applications reported in the larger survey below.

His second reported application idea occurred later in the interview, and occurred against a background that he was reading a novel that featured a group actively opposing any use of nanotechnology. While reading that book he had from time-to-time thought about how he might use nanotechnology. However, the recognition of a problem-technology linkage was in a conversation with his housemates about painting the inside of his house. After looking at colours they might use, he reported asking what if they could a get a "paint that changes colour on walls…," envisioning the possibility of a new kind of paint that would have complex molecules that might react to different electrical states controlled by the light switch.

Timothy also reported on an application link recognised on a class team that was assigned to an engineering problem to move an egg from point A to point B. His team had worked at brainstorming together to come up with novel ideas -- a form of directed search -- but did not reach a satisfactory design. Later, a team-mate went skiing, and after watching the chair lift operate, recognised that an egg-mover could operate on a wire. When he took the idea back, the team successfully applied the idea to their project.

Herman: He was unable to withdraw money from a bank machine with his gloves on. He took his gloves off, and at the time "I couldn't hold the card properly and I started shivering and again the slot is so thin so it took me at least two minutes to find the slot." He has since noticed "old people as they're struggling to put their cards in the cash machine," and he continues to wonder if a barcode scanner or a chip with user details could be installed instead.

Herman also thought of detachable heels to be used by girls who were taller than their dates, as well as expanding heels for the males. When he and a friend were later watching "a girl walk by and she was struggling to walk" in high heels, his friend suggested folding heels and Herman returned to thinking about his removable approach.

Lawrence: Lawrence came to Sheffield to study engineering because of an enduring interest in prosthetic hands, and he had recently seen a new technology "called nano-muscles, and it uses symmetrical currents to contract." It came to him that the approach could also be used to communicate sign language, so that among other things a robot could communicate with the deaf. When asked what he was doing at the time he commented that he made the connection in the shower.

There is little evidence of conscious search here. Some ideas are mundane, and undoubtedly many have been discovered previously by countless others elsewhere. We know, for example, of an undergraduate at the University of Ulster and a postgraduate student at Heriot-Watt University who also recognised the value of removable heels. Whatever their economic value, however, the reported instances confirm the presence of an on-going and spontaneous process among engineering students where they from time to time link problems or needs to technology. The ideas seem to arise from a recurring personal experience, from a long-standing interest and/or from an assigned task. The triggers were variously recurring personal need, a new problem or standing in the shower, rather than the result of deliberate search. There, thus, seems to be reason to believe that there is some unconscious process that leads to discovery, and it appears that as a result of their specialised technical knowledge, those discoveries are heavily biased towards the use of technology.

Selective attention

There is a rich literature in cognitive psychology that supports the premise that individuals are attentive to information both consciously, listening and assessing information with focused attention; and subconsciously, without awareness that they are attending to other sources. A much cited article reported that while individuals varied in their abilities, for the most part a given individual can track around five to seven blocks of related stimuli at the same time (Miller 1956). As an unavoidable consequence of limited attention resources, the human mind has evolved to serve as a strong filter that simply screens out phenomena not of immediate concern. Broadbent (1952) and Cherry (1953) studied how this subconscious filtering worked in their classic dichotic studies. In these experiments, the subject is asked to wear headphones with left and right earpieces that carry different voices talking about different content. They found that, in general, if the subject is asked to listen with, for example, the right ear, he or she can later describe with accuracy what was said to that ear but will remember virtually nothing about what was directed to the other. A strong conclusion in this and other experiments that have followed is that individuals have a substantial capacity to attend wilfully to one source, and that focusing is enabled by the mind automatically filtering out information provided by other senses and sources.

While we do concentrate our attention resources on some channels and seemingly leave others unattended, it remains that somehow we still notice particular information if it appears in those other channels. The classic example of this process was first cited by Cherry (1953) as the cocktail party effect, where in a crowded and noisy room with many channels of information flowing with information you can suddenly notice that your name was mentioned, and automatically orient and direct your attention to the source. Cherry's dichotic experiments also had the additional finding that there is a similar subconscious process that nonetheless continues to filter the unattended ear and recognises when the attention should be redirected. If the listener's name is spoken into the unattended ear, attention is immediately switched to that voice without conscious effort.

The underlying premise is summarised by Moskowitz (2002) who holds that there is a strong literature that, "people avoid and approach stimuli prior to recognition, without the individual being aware of the motivational influence." Note that this is not an ability to be commanded. We are selectively alert to information in a way that is not willfully directed in a process and we are not even conscious that it is on-going. (For a review, see Cowan

1997). Hence the existence of entrepreneurial alertness as a subconscious process is at least plausible.

The literature is less clear on what conditions cause this process to focus on some and not other information. Given the widespread phenomenon of recognising one's name, the literature question is what conditions are needed for selective attention to operate. This subconscious effect has subsequently been shown to include selective attention to a wide range of "self-relevant" information, but subconscious attention can also be directed by one's conscious goals (Srull and Wyer 1986).

It might be supposed that individuals who are strongly motivated and practiced in pursuing technical ideas might be expected to have developed an unconscious alertness to cues that would trigger recognition of entrepreneurial opportunities based upon their particular interests and experiences. Those professionally involved in or studying government might be alert to linkages and possibilities involving policy change; managers and business majors would recognise and apply novel marketing ideas in new ways, and science and engineering professionals and undergraduates would, by virtue of their interests and hours spent on technical matters, notice technical solutions -- probably tied to their work or course of study, or perhaps to the pervasive Internet technologies that so many are using. If this is the case, then it is likely that such alertness is the result of the training of their attention to filter for and notice opportunities involving the linking of technology and problems or needs.

Method and results

The processes underlying opportunity recognition are addressed in a study which draws on data collected at the Universities of Cambridge, Sheffield, Strathclyde and York in the UK at the beginning of the academic year. After filtering out undergraduates who were not in engineering, and the engineering students in their first year (who in October had only just started at the university) and second years who had only one year of university experience, there were 494 completed surveys available for analysis. After a discussion of the measurement of technology alertness, the data are used to test the hypothesis that technology alertness is predicted by technology self-efficacy, venturing self-efficacy, and entrepreneurial intent.

Measuring technology alertness and other variables

Technology alertness

In an effort to measure the alertness concept, items were developed to see if individuals were sufficiently self-aware of instances of when they had recognised a technology-problem linkage, whether they would be able to provide a rough recollection of how frequently they had such recognition events, and whether such answers were random guesses or constituted meaningful data for analysis. Item A, finding oneself wondering in class about how something just learned could be used, and item B, remembering that upon learning a new applied concept they got excited about an application, are at the core of the scale used here (Table 1).

Two other questions were expected to be closely related phenomena. The results from the item about how often these engineering students in the larger study saw something in their studies that could be used to address a social need (Item E) suggest this occurs for 39.6%

of these engineering students once a month. A total of 26.0% of students noted that more than once a month they realised while thinking about a problem that there was a technology which could be used in a new way to provide a solution (Item F).

Table 1 - Factor structure of alertness to technology

How often do you…	Frequency more than monthly	Component loading
A. Wonder while you are in class or a lab whether something you just learned could be used to improve a product or process	47.0%	.744
B. Learn a new applied science concept and get excited about an application idea (whether or not the idea was right)	43.9%	.737
C. Use a tool or device and it occurs to you that the activity involves some principle you have learned	66.1%	.713
D. As you learn about a principle, you realise on your own that there are special cases when the principle does not hold up	33.3%	.695
E. Think about some social problem or need that could be addressed by something you are studying	39.6%	.642
F. Realise while thinking about a problem that there is technology that could be used in a new way to provide a solution	26.0%	.636
G. While watching a movie or television, you become very aware that something has violated a science or engineering principle	62.0%	.610

46.8% of variance extracted. Alpha for 7 items = .807

These four types of alertness (A, B, F and E) are the questions presented to the mechanical engineering students at Sheffield. As a set, these episodes of alertness occur monthly or a little less often, at the same rates as found in the qualitative interviews. If one draws a line at a frequency of more than monthly, the proportion that reports a higher frequency varies from 26.0% who more often see new uses of technology, to 47.0% who more than monthly wonder while in their classes or laboratories about using what they have learned to make product or process improvements. It is the tangible nature of the examples the Sheffield student could provide that adds some credence to the belief that the instances of discovery and linking are real.

The other statements are a diverse set of questions about the recognition of science and engineering principles in daily life, and were expected to form a different scale component.

The result suggests that technology awareness is more diffuse, or perhaps more accurately, less differentiated among these students. All items have a component loading of .6 or higher on the same component, and a test of their reliability as a scale yields a satisfactory Alpha statistic of .807. A result that suggests the need to develop the scale further is the fact that the factor loadings only extract 46.8% of the variance.

Other variables

Conceptually one would expect alertness to be higher among students who are confident about their abilities, and their intention to be entrepreneurs. The self-efficacy measures follow the work reported by Lucas and Cooper (2005, 2006) that present measures of entrepreneurial intention and self-efficacy. That latter work demonstrates that there are two, separable forms of self-efficacy that can be measured with scales designed to elicit confidence in two different domains. One scale measures confidence in venturing, which is to say entrepreneurship in its more general sense, and is based on a series of judgments

the individual provides about their confidence in their ability to, among other tasks, write a business plan, estimate costs of a venture, select a marketing concept, and recognise an opportunity. The second scale has to do with confidence in one's abilities in the domain of applied technologies, including the tasks of grasping the best uses of a new technology.

To determine whether entrepreneurial intention drives alertness, we use a scale also developed elsewhere. The items include intermediate and eventual intention, with one item concerned with an opportunity in "the next few years," and the other open ended, "At least once I will have to take a chance to start my own company." For the present study, 20.7% of the undergraduates agreed or strongly agreed on a seven point scale that they would take a near-term opportunity, while 23.0% agreed or strongly agreed that they would at least once start a company (Table 2). A similar proportion of 19.6% agreed that a high risk/high pay-off venture appeals to them, and 20.5% agreed that they often think about ideas and ways to start a company. It might be noted that this level of agreement suggests a relatively high level of entrepreneurial intention. When combined in a scale, the Alpha coefficient of reliability is found to be .80.

Table 2 - Entrepreneurial intention scale

	Percent Agree or Strongly agree
If I see an opportunity to join a start-up company in the next few years, I'll take it.	20.7%
The idea of high risk/high pay-off ventures appeals to me.	19.6%
I often think about ideas and ways to start a business	20.5%
At least once I will have to take a chance and start my own company.	23.0%

Alpha = .80

Results

Two background factors commonly found to be predictors of entrepreneurial pursuits are gender and having a father that owns a business. Both are found here (see Table 3) to be consequential, with men having higher levels of self-efficacy for venturing ($r = .128$, $p < .001$) and entrepreneurial intent ($r = .234$, $p < .001$). The relationship between gender and technology applications self-efficacy is even higher ($r = .254$, $p < .001$). The reported frequency of instances of technology alertness is also higher for men ($r = .234$, $p < .001$). Father's entrepreneurial background plays less of a role, although consistent with the literature it relates both to venturing self-efficacy and entrepreneurial intention.

Two other checks on the data are reported for university and year of study. Because the largest number of undergraduates in this study are at the University of Strathclyde in Scotland which has a university system somewhat different from the three English universities, it seems prudent to see if its students are different on these variables. No differences are found, although it is clear that on average the Strathclyde participants in the study are more often in their fourth year ($r = .381$, $p < .001$). This leads to a further check to see if the students starting their third years are in some way different from those starting their fourth year. No meaningful relationships are found between year of study and the other variables and university and year are dropped from further analysis.

Table 3 - Relationships between background factors, self-efficacy, intention and alertness to technology

	A	B	C	D	E	F	G
A. Men	---						
B. Father owns a business	.015 (488)	---					
C. University of Strathclyde	-.014 (492)	-.088 (488)	---	.			
D. Current year (3rd or 4th)	-.021 (492)	-.070 (488)	.381*** (492)	---			
E. Technology application self-efficacy	.254*** (473)	.071 (469)	-.098* (473)	-.021 (473)	---		
F. Venturing self-efficacy	.128** (432)	.140** (428)	.020 (432)	.037 (432)	.646*** (426)	---	
G. Entrepreneurial intent	.196*** (478)	.210*** (474	-.074 (478)	-.028 (478)	.245*** (464)	.417*** (424)	---
H. Alertness to technology application	.234*** (483)	.082 (479)	-.150** (483)	-.090* (483)	.342*** (465)	.282*** (426)	.303*** (469)

N = 494 3rd and 4th year engineering students, October 2004. *p < .05, **p < .01, ***p < .001.

The strongest relationship in the study is between two types of self-efficacy (.646, p < .001). This result is to be expected, with those confident in one domain likely to be confident in others. A relationship this strong does create an interpretation problem that is resolved below by regression analysis that separates the effects of the two types of self-efficacy on technology alertness. Another expected finding is that venturing self-efficacy is related to entrepreneurial intention (.245, p < .001), a finding consistent with the literature.

Our central concern is with the effects of self-efficacy and intent on technology alertness, to test the view that alertness follows from domain-specific confidence and intention. The strongest relationship is found here between technology self-efficacy and technology alertness (.342, p < .001), followed closely by the relationship between entrepreneurial intention and alertness (.303, p < .001). The relationship between venturing self-efficacy and alertness is somewhat lower, although still quite significant statistically at r = .282, p < .001.

As a next step, regression analysis is used to separate out the over-lapping effects of gender, father's business experience, the two types of self-efficacy and entrepreneurial intention on alertness to technology application. Because the units of measurement differ substantially from one predictive variable to another, the standardised beta coefficients are provided so one can compare effect sizes. Consistent with the view that alertness is domain specific, technology self-efficacy and entrepreneurial intent are the strong predictors of technology alertness (beta = 5.175 and 5.088, both with p < .001) (See Table 4.) The effect of gender remains consequential when the effects of these other factors are separated out, but is still consequential (beta = 3.133, p < .001), while a father with an entrepreneurial background plays no role at all (beta = .019, not significant).

The striking result is that venturing self-confidence would appear to play no role at all in predicting alertness to new uses of technology (beta = -.025, not significant).

Remembering the strong relationship between the two types of self-efficacy, it appears that the correlation found between venturing self-efficacy and technology alertness is spurious, an artefact of their shared correlation with self-efficacy for the application of technology.

Table 4 - Regression Analysis

	Standardised Beta	t	
(Constant)		5.236	.000
Men	.151	3.313	.001
Father owns business	.019	.437	.662
Venturing self-efficacy	-.025	-.407	.684
Technology self-efficacy	.303	5.175	.000
Entrepreneurial intent	.249	5.088	.000

Multiple r = .490; r square = 24.0%; F = 25.440; df = 5, 402; p < .001.

Discussion and conclusions

This research suggests that entrepreneurial alertness as it relates to technology is an unconscious process of recognising linkages and solutions. Once recognised, they would appear to be the subject of conscious attention and evaluation. It seems likely that in a vast proportion of instances the idea is dropped, but the qualitative interviews suggest that some become recurring notions that are elaborated or refocused to test them as solutions to the context at hand. Thus, alertness to technology applications is a domain-specific form of entrepreneurial alertness found among engineers. When the opportunity is tangible and within the resources of the individual, like the mobile phone remote control and the wire egg-mover, the individual acts on the discovery, certainly an encouraging outcome that suggests that a future of technical innovation.

The strong relationships found in the regression analysis provide some indication of the origins of this alertness. Based on domain self-confidence, one could surmise that alertness is strong when the individual is testing and demonstrating that competence to themselves, and when the occasion permits, to others. It seems reasonable to expect analogous alertness among others. For example, those confident in their sales ability and who intend to pursue sales careers would be alert to opportunities for new sales approaches or channels. One can predict that as education and training, work experience, interests and intentions become more differentiated, the focus of alertness will increasing diversify from one individual to the next.

Whether there is a general form of entrepreneurial alertness is not tested here, and requires comparative data. Despite the fact that the students in this study were found to have relatively high entrepreneurial intent, however, the finding here that venturing self-efficacy among engineers does not increase alertness over that which is predicted by technology self-efficacy is very suggestive. It seems self-evident that public policy would like to see large numbers of engineers who “get excited about an application idea” and “realise while thinking about a problem that there is technology that could be used in a new way to provide a solution.”

It is likely that it is technology practice and subsequent enhancement of self-efficacy rather than entrepreneurship courses that strengthen this form of alertness. In that context, the most important thing we do not know from this research is whether the push for entrepreneurship among students detracts from the development of technology alertness in their fields of study.

References

Alvarez, SA and Busenitz, LW (2001) "The entrepreneurship of resource-based theory", *Journal of Management*, 27: 755-775.

Ardichvili, A, Cardozo, R and Ray, S (2003) "A theory of entrepreneurial opportunity identification and development", *Journal of Business Venturing*, 18: 105-123.

Baron, RA (2004) "The cognitive perspective: a valuable tool for answering entrepreneurship's basic 'why' questions", *Journal of Business Venturing*, 19: 221-239

Broadbent, DE (1952) "Failures of attention in selective listening", *Journal of Experimental Psychology*, 44: 428-433.

Bygrave, WD and Hofer, CW (1991) "Theorizing about entrepreneurship", *Entrepreneurship Theory and Practice*, 16: 13-22.

Cherry, E C (1953) "Some experiments on the recognition of speech, with one and with two ears", *The Journal of the Acoustical Society of America*, 25: 975-979.

Cowan, N (1997) *Attention and Memory*, Oxford: Oxford University Press.

Gaglio, C.M. (1997) "Opportunity identification: Review, critique and suggested directions", 139-202 in JA Katz (ed) *Advances in entrepreneurship, firm emergence and growth*, Greenwich, CT: JAI Press.

Herron, L and Sapienza, HJ (1992) "The entrepreneur and the initiation of new venture launch activities", *Entrepreneurship Theory and Practice*, 49-54.

Kaish, S and Gilad, B (1991) "Characteristics of opportunities search of entrepreneurs versus executives: Sources, interests, general alertness", *Journal of Business Venturing*, 6: 45-61.

Keh, HD, Foo, MD and Lim, BC (2002) "Opportunity evaluation under risky conditions: The cognitive processes of entrepreneurs", *Entrepreneurship Theory and Practice*, Winter: 125-148.

Kirzner, IM (1979) *Perception, Opportunity and Profit, Chicago*, Chicago: University of Chicago Press.

Koller, RH II (1988) "On the source of entrepreneurial ideas", *Frontiers of Entrepreneurship Research*, Wellesley, MA: Babson College.

Lucas, WA and Cooper, SY (2005) "Measuring entrepreneurial self-efficacy", paper presented to the SMU EDGE Conference, Singapore, July.

Lucas, WA, Cooper, SY, Ward, A and Cave, F (2006) "Developing self-efficacy and entrepreneurial intent for technology entrepreneurship: the role of work experience", paper presented at the 3rd AGSE International Entrepreneurship Research Exchange, Auckland New Zealand, February.

Miller, G A (1956) "The magical number seven, plus or minus two: some limits on our capacity for processing information", *Psychological Review*, 63: 81-97.

Minniti, M and Bygrave, W (1999) "The microfoundations of entrepreneurship", *Entrepreneurship Theory and Practice*, Summer: 41-52.

Moskowitz, GB (2002) “Preconscious effects of temporary goals on attention”, *Journal of Experimental Social Psychology*, 38: 397-404.

Shane, S (2000) “Prior knowledge and the discovery of entrepreneurial opportunities”, *Organizational Science*, 11: 448-469.

Srull, T and Wyer, R (1986) “The Role of Chronic and Temporary Goals in Social Information Processing”, 503-549 in R Sorrentino and E Higgins (eds) *Handbook of Motivation and Cognition: Foundations of Social Behavior*, Guildford CT: The Guilford Press.

Ucbasaran, D, Westhead, P and Wright, M (2001) “The focus of entrepreneurial research: Contextual and process issues”, *Entrepreneurship Theory and Practice*, Summer: 57-75.

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Summary

This paper seeks to understand the psychological mechanisms which support the recognition of science and technology-based opportunities for new ventures. Opportunity recognition is viewed as a critical skill in venturing activities, but there is doubt about the mechanisms involved. The entrepreneurship literature contains a tradition of seeing opportunity recognition as a less than conscious process, and certainly not the result of carefully crafted search processes. Schumpeter and Kirzner (1997) believe that entrepreneurial alertness is a non-conscious process of recognition; Herron and Sapienza, feel that the operation of initial discovery of entrepreneurial ideas "involves a subconscious evaluation" (1992, 52), and Ravasi and Turati consider that the entrepreneurial idea starts with an "initial intuition" (2005, 138).

Two literatures offer contrasting explanations for how a non-conscious process of entrepreneurial alertness operates. The first is more a personality trait, recognising that large numbers individuals engage fairly deeply with almost everything they are told. Such individuals are said to have a "need for cognition" (Cacciapo and Petty 1982). Evidence shows that those with a need for cognition have many attributes associated with entrepreneurs and university-trained scientists and engineers, and with psychological correlates, like self-confidence, one associates with entrepreneurship. A second literature offers an alternative, possibly over-lapping, view that individuals have a learned but unconscious "directed attention" to potential entrepreneurial opportunities. Individuals who are strongly motivated and practiced in pursuing venturing ideas would be expected to have developed an unconscious alertness to cues that would trigger recognition of opportunities based on their particular interests and experiences. Even among individuals with common science and engineering skills and experiences, some will have an entrepreneurial alertness that would trigger recognition of facts and linkages that involve new venture possibilities that others would not perceive.

This paper reports on on-going research exploring this second approach, attention to use. Qualitative evidence is presented from a focus group discussion of opportunity recognition conducted with mechanical engineering students at the University of Sheffield. A scale for measuring attention to use of technology is then offered, which includes items used as prompts in the focus group discussion. Results from this scale, given to 494 science, mathematics and engineering students at four UK universities are reported, showing that a viable scale can be created, and how this correlates with pre-entrepreneurial behaviour, entrepreneurial intent, venturing and technical self-efficacy.

The conclusion to the paper addresses the implications of recognising directed attention as a major component of opportunity recognition.