

Prior-Learning, Cumulative Science Experiences and the Absorptive Capacity of Bio-Entrepreneurs: A Case of the East Midlands Region, England

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Abstract

In the modern healthcare and medical sectors corporate bio-pharmaceutical firms continue to scale down their in-house research and development (R&D) activities in favour of outsourcing the services to bio-tech ventures. These small but, entrepreneurial research-oriented organisations have increased dramatically. They are predominantly owned by bio-entrepreneurs who are extensively experienced scientists. In the science-based industry they operate in, innovation “ecosystems” consisting of global business and social networks are a common feature. As such, they have to consistently exploit them to complement the knowledge gaps in their enterprises. In that context, the paper sets out to investigate five bio-entrepreneurs currently active in biotechnology within the East Midlands region in England. It particularly examines the role performed by their prior-learning and their cumulative science experiences in recognising, assimilating and productively applying science-related knowledge acquired in their innovation “ecosystems”.

Keywords: innovation ecosystems, bio-entrepreneurs, prior-learning, cumulative scientific experience, absorptive capacity

1. Introduction

Innovation “ecosystems”, in the science intensive healthcare and medical sectors, are the main sources of economic effects that include knowledge and technical know-how (Ho & Wilson, 2006). The term “ecosystem” is a new buzz word in the field of business management. It describes a form of economic co-operation and co-ordination amongst a wide range of business entities. Tahvanainen & Steinert (2013) explained that an “ecosystem” in business is, “a network of networks converging entire industries and technologies into complex, interwoven and global economic structures” (p. 1). Clearly, innovation “ecosystems” consist of individuals, material resources, communities, universities, research institutions and labs collectively working towards enabling knowledge flows, while supporting technology development (Bramwell et al., 2012; Mercan & Goktas, 2011). They provide companies with assets and resources such as new knowledge and information, financial capital, marketing expertise, networking opportunities (Jackson, 2011) which accelerate company growth and development. Collectively, the companies work towards supporting technology development and the free flow of fluid information (Bramwell et al., 2012). In such complex systems of multiple relationships, significant amounts of science-related data are generated. This has some implications for bio-entrepreneurs in the sense, that they have to effectively utilise their history and experience (antecedent influences) in science in order to identify and acquire useful knowledge to expedite the development of their bio-tech ventures. Burns (2012) elaborates on the antecedent influences of entrepreneurs highlighting that they are shaped by their business and social connections, culture, previous employment, and educational attainment.

Undoubtedly, bio-tech ventures operate in a constantly changing business environment which has become global as a result of the liberal trade structures governing trade today (Kalantaridis & Vassilev, 2008). This requires constant resource re-configurations to sustain their economic development. Against this backdrop, this study aims to advance the notion that prior-learning and the cumulative science experiences of bio-entrepreneurs can be a catalyst that facilitates the economic development of many bio-tech ventures. The extant literature has paid much attention to the concept of inter-organisational learning largely focusing at the organisational level (see

Dutta & Crossan, 2005; Lumpkin & Lichtenstein, 2005; Senge, 1990; Hibbert et al., 2010). There is however a dearth of studies that specifically examine the role of prior-learning and industry specific experiences of bio-entrepreneurs and yet, they establish businesses that provide employment (Eurofound, 2012) as well as manufacture life-saving drugs.

Taking this into account, this research addresses the following key questions:

- 1) What is the role of prior learning in enhancing the absorptive capacity of bio-entrepreneurs in their production processes?
- 2) How does their personal science experiences contribute to the development of their ventures?
- 3) How do bio-entrepreneurs learn in their innovation “ecosystems”?

In Storey (1994) seventeen multivariate studies were reviewed to examine the effects of antecedent influences on the development of entrepreneurial ventures. Storey’s study inferred that there is a strong association between an entrepreneur’s educational attainment (prior-learning) and the development of their venture. Kuratko (2013) contends that as entrepreneurs react to a diverse, multi-faceted, and imposing array of activities, events and developments they considerably influence the development of their ventures. Bessant & Tidd (2011) insist that the competences of owner-managers strongly influence the scope and the direction of their ventures. This opens up the debate regarding the wisdom to analyse entrepreneurs and their ventures as separate entities.

In light of Kuratko’s, Bessant’s, & Tidd’s views it makes it so difficult to examine entrepreneurs and their ventures as independent entities. As such, in seeking to contribute to the entrepreneurial learning literature and the concept of absorptive capacity (AC), this research explores the impact of prior-learning and the cumulative experiences of bio-entrepreneurs on their ability to “soak-up” new science-related knowledge in their innovation “ecosystems”. This also answers the call for studies that focus their analysis of entrepreneurial learning at an individual level (see Krueger, 2007; Cope, 2005; Corbett, 2005). In Crossan et al. (1999) new insights and ideas are seen as a by-product of individual learning which, when proven successful are eventually embedded into the organisation. The literature on learning recognises that learning takes place at individual level (see Rothaermel & Hess, 2007; Lichtenthaler & Lichtenthaler 2009; Cohen & Levinthal, 1990). From that point of view; it makes more sense to commence the analysis of the concept of absorptive capacity by examining the ACs of individual entrepreneurs. Equally, a number of recent studies have directed their efforts towards the field of entrepreneurial learning primarily focusing on individual learning and AC (see for example, Fogg, 2012; Smith, 2011; Zhang & Hamilton, 2010; Gold & Thorpe, 2008).

2. Background Literature

Process and substantive learning characteristics show the distinction between the concept of learning through collaboration and learning in innovation “ecosystems”. In technology-based industries, collaborative relationships make it possible for knowledge to be exchanged between individuals, firms, academic institutions, and other non-profit research organizations (Oliver, 2010). Indisputably, entrepreneurship is a concept embedded in cycles of continuous learning described as “double-loop learning” in Burns (2012, p. 477). Kim (1993) conceptualises effective learning as a revolving wheel of learning. Based on Kim’s account of effective learning, the science experiences accumulated by bio-entrepreneurs from their previous science-related assignments / projects within their innovation “ecosystems” can be viewed through the lens of a revolving wheel of learning. Smilor (1997) maintains that, entrepreneurs learn by replicating the actions of other entrepreneurs.

3. Bio-entrepreneurial Learning & Experience

Effective entrepreneurs are exceptional learners (Smilor, 1997). It is noteworthy to highlight that learning as concept is a very broad topic and it is by no means fully explored in this study. It is partially covered in this research to inform the debate on entrepreneurial learning and AC. In Huczynski & Buchanan (2007, p. 107) learning is described as the “process of acquiring knowledge through experience which leads to an enduring change in behaviour”. From that perspective, the most effective strategies for recognising new scientific knowledge for bio-entrepreneurs are informed, to a large extent, by their prior-learning and experience in life science (Simba, 2013).

Similarly, King & Lakhani (2011) agree that there is an association between individual learning and the stock of prior-related knowledge one holds. Related to this, Huczynski & Buchanan (2007) discuss procedural and declarative learning. The scholars express that procedural learning or “know how” is concerned with one’s ability to carry out skilled actions. They also insist that declarative learning or “know that” is one’s ability to store factual knowledge. Concerning the unit of analysis in this research—bio-entrepreneurs, it is not a misplaced judgment to view their vast knowledge acquired from previous science-related events using the

declarative learning framework.

Furthermore, Kolb (1984, p. 26) expounds the underlying principles of experimental learning stating that “ideas are not fixed and immutable elements of thoughts but, are formed and re-formed through experience”. The literature on entrepreneurial learning acknowledges that experimental learning is a process which attempts to explain how entrepreneurs acquire knowledge and enact new behaviours in recognising and acting on opportunities as well as organising and managing their ventures (see Petkova, 2008; Cobbett, 2007; Toiviainen, 2003; Cope, 2005). Deakins & Freel (1998) and Sarasvathy (2001) recognise that the majority of learning that occurs within an entrepreneurial context takes the form of an experiment. Schilling (2010) discusses experimentation that takes place in innovation “ecosystems”. She maintains that the process of experimenting is an important step in the development process of science-based firms as it enables them to test what works and what doesn’t. Similarly, Petkova (2008) presents a model of *entrepreneurial learning from performance errors* with a view to extend the psychology models of error-based learning. Petkova’s (2008, p. 4) model proposes that entrepreneurs’, “prior knowledge and cognitive biases can perform a significant role at each stage of the learning process and may determine whether the processes of error-detection and error-correction that lead to learning will actually occur”. Schilling’s & Petkova’s propositions have huge implications for bio-tech ventures as they are directly intertwined in their mental modes of learning particularly, their bio-entrepreneurs. Using Kolb’s (1984) view of learning by trying different configurations until one finds a combination that works, Cobbett (2005) makes a convincing argument. He argues that “cognitive mechanisms” or the mental processes through which entrepreneurs acquire, store, transform, and use information are the output of individual learning.

4. Absorptive Capacity

A comprehensive understanding of the concept of AC at a firm level is essential to how this study explains the significance of learning by individual entrepreneurs in their innovation “ecosystems”. According to Cohen & Levinthal (1990) AC is the ability of a firm to recognise, assimilate and apply external knowledge. In Zahra & George (2002) a clear distinction between potential and realised AC was made. Potential AC was related to knowledge acquisition and assimilation capabilities and realised AC was associated with knowledge transformation and exploitation. Lichtenthaler & Lichtenthaler (2009) conceptualizes AC as the ability to explore external knowledge. King & Lakhani (2011, p. 2) introduce the notion of “adoption capacity” which means the ability of a firm to adopt ideas from external connections. This is consistent with Cope (2005, p. 481) who maintains that individuals transform (using cognitive properties) their experiences (situative) into new knowledge.

Furthermore, Lichtenthaler & Lichtenthaler (2009) claim that new knowledge acquired from outside the firm (within innovation “ecosystems”) becomes useful when it is integrated with internal knowledge bases. A recent study by Jones et al. (2010) presents the idea of generative learning in global networks stressing that it is a critical step that informs the accumulation of specific and useful knowledge. Tidd & Bessant (2011) contend that AC is about accumulated learning and the embedding of capabilities. Crucially, in Cope & Down (2010, p. 4) a strong link is constructed “between the outcomes of learning (information, knowledge, expertise) that impact on the entrepreneur’s cognitive frameworks and the participative process by which these socio-cognitive resources are acquired”. The dated but inspirational works by a number of scholars (see Estes, 1970; Ellis, 1965; Bower & Hilgard, 1981) highlight that an individual’s learning is cumulative and that learning performance is enhanced when the primary goal of learning (to understand the new knowledge to be acquired) is related to what the individual already know. Cohen & Levinthal (1990) also make a crucial point suggesting that AC is a by-product of prior-innovation and problem solving which is dependent on individual ACs of members of an organisation.

When individual ACs of members in a firm and the firm’s ability to value, assimilate and commercially utilise new external knowledge are combined Lane et al. (2006) and Kim (1993) recognised that the duality modifies mental modes. In other words, the dualism modifies assumptions about the lived world. This is a fundamental point to make in the sense that, for global-oriented bio-tech ventures their bio-entrepreneur’s / owner-manager’s prior-learning and science-related experience can modify their cognitive biases which plays a decisive role in their economic development given that they source scientific knowledge in multiple countries. Indeed, sourcing knowledge from established or newly developed business or social networks (innovation “ecosystems”) domestically and in other countries consequently lead to a point of “knowledge saturation” hence sifting, sorting and decoding useful information requires prior-learning and industry-specific experience.

5. Research Approach

The study adopts a qualitative research approach. In particular, it follows an interpretive paradigm (Denzin, 1983) with the view to understanding the interactions of bio-entrepreneurs within their innovation “ecosystems” and

how they acquire knowledge. In so doing, the study obtains the unique truth about their prior-learning and science experiences.

Resulting from this, nuanced constructs (Gerring, 2005) about a new breed of entrepreneurs, who are not well-represented in the literature, are developed. More so, data gathered this way enabled the study to generate solid descriptions and interpretations about bio-entrepreneurs and their ability to absorb useful knowledge and information from their innovation “ecosystems”. To facilitate rich and useful data collection a case-oriented (COR) strategy was used. This is consistent with the literature on social science research methods. For example, Ragin (1992) claims that researchers who employ a COR approach do so partly, because their studies are exclusively qualitative and that the methods are more suitable with small research samples. As such, this study utilises five cases of bio-entrepreneurs currently active in biotechnology in the East Midlands region in England primarily focusing on their ability to expedite the development of their firms through the application of new knowledge. The logic for using multiple cases is to establish whether the findings from one case can be replicated across the research sample.

From this, the study was able to make plausible concluding statements concerning the role performed by prior-learning and the cumulative science experiences of bio-entrepreneurs in acquiring useful scientific knowledge in innovation “ecosystems” to develop their bio-tech ventures. Taking a cue from Saunders et al.’s. (2012) view on choosing a research sample; cases of bio-entrepreneurs were systematically selected on the basis that similar results were predicted to be produced from each case. In order for a bio-tech firm to qualify for analysis in this study it had to conform to the following criteria: a) the co-founder or CEO had to have a high qualification in education and vast experience in science; b) the bio-tech venture had to use the East Midlands as its home market; c) the bio-tech venture had to be part of a network; d) its top team management (TTM) had to consist of experienced individuals with experience in science; and e) the bio-tech venture had to show significant growth in 5 years since its inception. From a potential sample of 15 bio-tech ventures operating within a biotechnology network centre the criteria outlined above helped to narrow the participants down to five bio-tech ventures. Literal replication was used as a strategy for selecting appropriate cases (Yin, 2009; Huberman & Miles, 1994). The cases were intended to corroborate each other as such, systematic sampling was deemed appropriate.

A trade-off was made between systematic sampling and stratified random, cluster, and multi-stage sampling techniques. Stratified random, cluster and multi-stage sampling techniques turn to follow a sophisticated research design which generates a number of data sub-sets; making it so complex to explain a research phenomenon (Saunders et al., 2012). As such, the study preferred to use a systematic sampling technique for selecting a representative sample because of its features that include: (i) accuracy and easy to access the research sample; (ii) low costs; (iii) its suitability to the scope and size of the study; (iv) its ability to allow the study to choose bio-entrepreneurs from the same geographical concentration making it feasible to conduct face-to-face interviews; (v) its ability to facilitate the explanation of the role performed by prior-learning and the cumulative science experiences of bio-entrepreneurs in recognising, assimilating and productively applying science-related knowledge to argument firm-based competences. The criteria for selecting the research sample are presented under the data collection and analysis section.

To ensure *construct validity*, *internal validity*, *external validity* and *reliability* of the findings the study adopted ideas from Yin’s (2003/2009); Farquhar’s (2012); Stake’s (2005) and Voss et al. (2002). During the data collection phase interviews and documentary evidence were used for *construct validity*. At the data analysis stage casual links (Huberman & Miles, 1994), between prior-learning, the cumulative science experiences and the ACs of bio-entrepreneurs, were established as well as the identification of patterns of the competence displayed by the sampled bio-entrepreneurs with a view to enhancing the *internal validity* of the findings within each case. The basis for designing the study with multiple bio-entrepreneurs was to achieve *external validity* using *replication logic*. Pattern matching in case-oriented studies is seen as the most appropriate technique for case analysis (Farquhar, 2012; Yin, 2009). Data collected from the participants was transcribed and sent back for them to confirm whether it was an accurate representation of their account of events. The desired effect was to increase the *reliability* of the data collected for analysis. Yin (1998) insists that researchers who follow these strategies tremendously increase the quality of their case-oriented studies and they help to overcome traditional criticisms of the weakness of case study research.

6. Data Collection and Analysis

The unit of analysis for this study are bio-entrepreneurs/founders of small bio-tech ventures. They were chosen based on their academic attainment, competence in science, life science experiences and their ability to

“soak-up” useful knowledge for their bio-tech ventures. The bio-entrepreneurs were also expected to be part of an innovation “ecosystem”. Semi-structured interview questions were employed as a guide during discussions. The open-ended questions allowed the bio-entrepreneurs to tell a story about their experience in life science and achievements. The qualitative discussions with the bio-entrepreneurs lasted for 20 minutes on average. In addition to the interviews, their publicly available career profiles were utilised to gather existing information about their accolades and educational attainment. Company and University websites were also used as other sources of this type of data. The process of analysing data commenced during its collection phase. The empirical study constructs detailed profiles for each case. The logic for compiling detailed profiles for each case was to gain intimate knowledge of each of the individual cases as well as to understand each case on its terms (Huberman & Miles, 1994). Taking Bazeley’s (2013) advice that studies which solidly relies on coding techniques such as NVivo run the danger of being superficial as such, this study prefers to maintain the perspective of the cases by profiling each case.

Additionally, Yin (2009) maintains that case descriptions and profile summaries serve a much wider range of analytical purpose. Consistent with Yin, this study focusses on a representative sample from a large population of bio-entrepreneurs in the East Midlands in England. Bazeley (2013) insists that, in small-sample studies or for studies with a methodical or substantive focus on particular cases the preparation of a profile for each case is the most useful early step for both within-case and cross-case analysis. An important point relating to the strategy for data analysis adopted for this study is made by Stake (2005), who stresses that a case study can be both an analysis process and a product of analysis. In that sense, data analysis for this study is done inductively by using a case-by-case and across case analysis. The study also draws upon theories that exist in the literature in its analysis—pointing to elements of a deductive approach. Aronson (1994, p. 3) supports this way of analysing data suggesting that, “when the literature is interwoven with the findings, the story that the interviewer constructs is one that stands with merit”. Perry (1998) makes a convincing argument for adopting the duality insisting that, a study which is purely inductive potentially prevents a researcher from enjoying the use of existing theory while one which purely deductive restricts a researcher from developing new and useful theory.

7. Case Findings

This part of the study presents the research findings. It establishes the critical role performed by prior-learning and the accumulate science experiences of bio-entrepreneurs/owner-managers to the development of their ventures. In presenting the findings within each case, the study also draws upon secondary data which enables it to make strong inferences (Gerring, 2005, Huberman & Miles, 1994).

Case A

Bio-tech venture A’s bio-entrepreneur holds a PhD. He is a former global leader of Pharmacometrics at a large pharmaceutical company which was based in the East Midlands region in England and he has also worked in both Switzerland and Italy. In 2010 he formed a new bio-tech venture in England. Before establishing the new venture, he started and managed a similar business in America from 1991 to 1998. The knowledge and experience he gained from his American venture were instrumental to his comprehension of the sequence of processes and procedures that were fundamental in crafting a sustainable business venture in the life science sector in England. The bio-entrepreneur revealed that his company is part of a consortium of 24 other firms and research institutions in multiple countries. He also disclosed that at his previous employment he was involved in global science-related programmes.

The bio-entrepreneur acknowledged the role of declarative learning or “know that” in choosing a learning partner, described by Huczynski & Buchanan (2007) as one’s ability to store factual knowledge and this is what he said:

Choosing a business partner is like choosing your partner for life. I learned early in the US, that you want to keep your business and social connections throughout the life cycle of your business.

This statement concerning the bio-entrepreneur’s take on choosing a learning partner implies that the knowledge and experience he acquired from his previous business in the US was very useful in helping his venture to identify/locate a business partner with a “strategic fit”—meaning the extent to which a potential business partner is prepared to achieve the proposed operational objectives. In the literature, Corbett (2005) forcefully argue that the “cognitive mechanisms” or the mental processes through which entrepreneurs acquire, store, transform, and use information are the output of individual learning. The bio-entrepreneur was further probed about the degree of influence his learning, expertise and experience in science gained over the years has on his decision-making in the business. He categorically stressed that:

I think I use experience; it is really about developing a way of doing things and some of it is intuition—i.e. seeing things that are not connected and link them together to spark new product development. Some of this is also down to skills and knowledge. You could also say that a person who is successful uses intuition based on their learning and experience.

The evidence is convincing and it points to the fact that the bio-entrepreneurs' knowledge, skills and intuition are a by-product of his science experience, personality and learning. More importantly, using his experience from his previous associations established during his time with a large pharmaceutical company the bio-entrepreneur was able to develop technical capabilities in the form of statistical software (SAS, S+, R, and Matlab) and design modelling software (NONMEM, WinBugs, Monolix, WinNonlin, Berkeley Madonna). His mathematical science combinations enabled him to add value to business processes within his venture which significantly assisted new drug discoveries. Crucially, using his knowledge in science, he designed formulas for drug development and testing. This facilitated the development and growth of his venture as well as recognition of his capabilities by other bio-enterprises involved in developing clinical equipment and drug discoveries. The bio-entrepreneur accepts that his experience in life science acquired from his role as a global leader of Pharmaco metrics in his previous employment was instrumental in how he designed the mathematical science tools for use in his bio-tech venture to test new drug discoveries.

Case B

The founder/bio-entrepreneur of bio-tech venture B, similar to venture A, holds a PhD in medicinal chemistry and is educated to a post-doctorate level. In addition to his academic credentials, he has 14 years of experience in life science gained from his previous role at the world's fifth largest pharmaceutical company. His publicly available profile he is described an expert in drug discovery who has led various drug development projects for his former employers. He however concedes that, some experiments/projects that he was involved in were not successful and he suggests that it was part of the learning process. This is consistent with Schilling's (2010) and Petkova's (2008) views regarding learning through experimenting and entrepreneurial performance errors. Indeed, recalling a procedure that worked or did not work in the past is essential in drug discovery and development. Clearly, learning from past performances was an important part of the process of developing his entrepreneurial capabilities to discover and exploit opportunities. According to his profile the founder has a record of delivering drug discovery processes for the world's fifth largest pharmaceutical company. From that perspective, it is plausible to suggest that his science experiences were decisive to the economic development of his bio-tech venture.

To this end the bio-entrepreneur expressed that:

One has to understand the relevance of externally acquired knowledge to science and experience in previous science-related assignments play an important part of that. Given the experience our team of experts have in biotechnology we are in a better position to acquire the science that is necessary for our service.

The explanation of the role of prior-learning above also hints that in his company the science experiences of his top management team abetted the process of "soaking-up" useful scientific knowledge. In the literature Cohen & Levinthal (1990) affirms that AC is a by-product of prior-innovation and problem solving which is dependent upon individual ACs of members of an organisation. In that sense, it is adequate to infer that one's previous history and experience in life science can add value to their bio-tech venture by assisting in assimilating useful information that can be fundamental to a firm's sustainable growth and development. Gurău et al. (2010) echo similar sentiments in their study concerning the role of human capital in successful entrepreneurial ventures. In their study the scholars concluded that human capital available within an organisation can help the organisation to obtain positive business results. In the same vein, Murray (2004) found that in a firm where the founder was both the CEO and CSO, he rolled out the critical path to be followed as a blueprint in the process of acquiring essential technical capabilities to assist his venture to make new drug discoveries. This has striking resemblance with the bio-entrepreneur in bio-tech venture A who directs science projects using his experience acquired from leading international science-related R&D projects.

Case C

The bio-entrepreneur of bio-tech venture C is a co-founder of the business. The bio-tech venture was formed in 2002. His record shows that he is an academia and a world-renowned scientist in the field of super-critical fluid processing with 15 years of experience in the life science sector. According to a University website profile for staff, it was publicised that the bio-entrepreneur is a professor and he is also a Chair of Chemistry at the University. He is also said to have published over 300 papers in high-level scientific journals. His record further

documents that in the past decade, his research focused on the pharmaceutical formulation of drugs using super-critical fluids with ten patents filed. The record also discloses that he received a number of awards between 2001 and 2006 from the science community as recognition for his science ingenuity. Based on his antecedent influences, he was able to realise that super-critical carbon dioxide (scCO₂) could be used to mix sensitive substances into the polymers. This was the groundwork that his business needed to take-off. The bio-tech venture also grew by forging strategic alliances with other businesses which had complementary assets and those that had advanced technical know-how with a view to augment its internal capabilities. The bio-entrepreneur explains that the learning partners for his bio-tech venture were developed based on his past associations with them and the knowledge that the relationships would generate the required capabilities.

His philosophy of selecting learning partners is reinforced in the extant literature (see Petkova, 2008; Lane et al. 2006; Estes, 1970; Bower & Hilgard, 1981) which universally acknowledges that an individual's learning is cumulative and that learning performance is enhanced when the primary goal of learning is related to what the individual already knows.

When commenting on the success of the bio-entrepreneur's firm a venture capitalist (VC) who provides growth funding to entrepreneurial ventures explained that:

By combining world-class research with knowledge of the real needs of the pharmaceutical sector, the firm has made rapid progress.

In that respect, the study can infer that knowing that is required to complement firm-based competences is an important developmental step for bio-tech ventures which operate in the life science sector and it earns support in the form of financial capital from private investors.

More importantly, it facilitates the process of acquiring new knowledge especially, for bio-tech ventures whose bio-entrepreneurs source for new scientific knowledge from multiple countries.

Case D

The founder and CEO of bio-tech venture D is a medical chemist with 23 years' experience in the pharmaceutical industry. His record shows that he holds a PhD in synthetic organic chemistry and he took a post-doctoral research position at a University before starting his own venture in 2004. He has experience in science-related research projects which was acquired during his time at the world's fifth largest pharmaceutical company as well as in a commercial environment. In the past the bio-entrepreneur explains that he was involved in a wide range of drug discovery programmes.

He states that the programmes ranged from lead generation libraries, hit-to-lead campaigns, all the way to successful lead optimisation projects and candidate drug selection. This highlights the idea of generative learning which is achieved through engaging in research projects that include a wide range of participants from multiple countries. Such innovation "ecosystems" allow new product ideas to be generated, debated and honed. According to his bio-tech venture's website, in 2011, the bio-entrepreneur won the Science and Technology Entrepreneur of the Year Award as recognition for his significant personal contribution to the success of the company he established and runs. This endorses the view that bio-entrepreneur imprint their "DNA" in their ventures and they perform a major role in making their strategic choices using their cognitive biases. Over a period of 8 years, the bio-entrepreneur expressed that he has added to the growth of his bio-tech venture by developing science testing tools to enhance drug discovery and testing for their clients.

To underscore the importance of entrepreneurial learning at an individual level, the bio-entrepreneur explained that he is also involved in a European funded collaborative research programme which is aimed at speeding up the discovery of new drugs. He states that participants of the programme range from scientists working for large pharmaceutical companies to bio-entrepreneurs who manage bio-enterprises as well as academic researchers. As his company focuses on the delivery of integrated drug discovery taking part, in a drug discovery programme which involves international participants, can considerably enhance his cognitive biases which underpin his ability to acquire useful scientific knowledge essential for drug discovery and testing in his venture. Innovation "ecosystems" in science-based industries are designed to aid the discovery of new products and are characterised by an array of experiments (Bramwell et al., 2012).

In the literature (Cobbett, 2007; Petkova, 2008; Schilling, 2010; Cope & Down, 2010) the process of experimenting is viewed as an essential developmental step for entrepreneurial ventures in the sense that it allows entrepreneurs to test what works and what doesn't. Commenting on the opportunity to acquire new drug development processes that are necessary for his bio-tech venture the bio-entrepreneur explained that:

The really exciting aspect of this project is the opportunity to discover novel drugs through the collaboration of seven international pharmaceutical companies and an open call to academics and industry across Europe.

Learning through innovation “ecosystems”, described as a participative learning process by Cope & Down (2010) makes it possible for individuals to exchange scientific knowledge and technical know-how and it helps to bridge any knowledge shortages that might exist in a firm. This seems to be fairly consistent with Gordon & Jack’s (2010) findings. In their study regarding higher education institutions’ engagement with SMEs to develop social capital the scholars conclude that, a learning environment (innovation ecosystem) provide SMEs and their owners the opportunity to create social capital which has a positive impact on firm development.

Case E

According to her personal profile the bio-entrepreneur/founder of bio-tech venture E started her academic life as a bio-chemist. After finishing an undergraduate degree in biology, her *curriculum vitae* discloses that she went on to complete a PhD in bio-chemistry and then started to work with a group of immunologists at a Royal Free Hospital (RFH). She acknowledges that the experience gained from working with other immunologists at the RFH was fundamental to her decision to set up a *hybridoma* laboratory which was funded by a Technology Group. The bio-entrepreneur also explains that she was involved in a leading edge research developing *monoclonals* with potential commercial applications. Strikingly, her involvement with immunologists and research to develop *monoclonals* significantly influenced her decision to jointly establish a bio-tech venture.

Another point to make is that, her innovation “ecosystems” were central to the development of the bio-tech venture because they formed part of her knowledge supply-chain. More importantly, her science background enabled her to contribute to the development of a new technology targeted at overcoming a number of deficiencies with platelet transfusion making the therapy more widely and easily available. Her passion to continue making new discoveries can be seen in the way she contributed to the development of the platelet transfusion technology which was pivotal to the economic prosperity of their venture. This is in line with Burns (2012) who takes the view that entrepreneurs engrave their “entrepreneurial DNA” in their ventures. In that respect, the bio-entrepreneur explains that, “for both of them the motivation is to develop the product and to see it work”. This may also imply that in making new technological developments for their bio-tech venture the bio-entrepreneur and her co-founder ensure that the new technology works by directing all their efforts in the form prior-learning and cumulative science experiences towards its success. According to a University website where she is employed as a Professor the bio-entrepreneur is currently not involved in teaching at the institution but, she is engaged in research.

This emphasises her desire to continue learning which is vital to the process of “soaking-up” useful scientific knowledge and for updating her cognitive biases. The bio-entrepreneur explains that the process of setting up their bio-tech venture involved her increasing her knowledge of business—finding out “the rules of the game”. Her statement is well-represented in the literature. Simba (2013) posits that bio-entrepreneurs engage in a “trial and error” method until they find the right knowledge combinations that complement their internal knowledge bases. Schilling (2010) stresses that experimenting is an important step in the development process of science-based firms as it enables a firm to test what works and what doesn’t.

8. Cross Case Findings

This section of the research provides a cross-case synthesis (Yin, 2009) with a view to build a common narrative (Bazeley, 2013; Huberman & Miles, 1994) about the prior-learning and the cumulative experience of the founders of the sampled bio-entrepreneurs and their bio-tech ventures. More importantly, the idea is to identify whether there are any relationships in their antecedent influences that assist them to “soak-up” useful scientific knowledge necessary for development of their bio-tech ventures. Table 1 below illustrates the similarities and differences across the cases.

Table 1. A cross-case analysis of bio-entrepreneurs

	Bio-entrepreneur in case A	Bio-entrepreneur in case B	Bio-entrepreneur in case C	Bio-entrepreneur in case D	Bio-entrepreneur in case E
Structural Dimension	Strong global academic network and industrial-related business and social connections. Participated in science-related projects.	Same as bio-entrepreneur in case A	Same as bio-entrepreneur in case A, but with a strong academia and he is a well-known science professor	Same as bio-entrepreneur in case A. And he also participates in international drug discovery programmes	Same as bio-entrepreneur in case A. The venture also relies on VCs for funding to develop its technology
Relational Dimension	Trust is based on shared representations and interpretations of science	Same as bio-entrepreneur in case A	Same as bio-entrepreneur in case A	Same as bio-entrepreneur in case A	Trust is based on shared representations and interpretations of science
Cognitive Dimension	The top management team consists of experienced scientists in drug discovery projects with the bio-entrepreneur spearheading the operational strategies of the venture	Same as bio-entrepreneur in case A	Same as bio-entrepreneur in case A, but with a skew towards academia. Also his venture sponsors PhD research students	Same as bio-entrepreneur in case A	She is a co-founder of the venture. Their team consist of scientists and members with commercial experience
Prior-Learning	Started a similar company in America between 1991&1998. He holds a PhD qualification in Chemistry	Held various roles–leading science-related R&D projects globally. Hold a PhD	He has published over 300 science papers demonstrating that he is a researcher. Also he is a renowned world scientist	Same bio-entrepreneur in case B	Laboratory and hospital research related experience. She also holds a PhD
Cumulative Science Experience	He has over 20 years of science experience	Has 14 years science-related experience	Has 15 years of experience in science	He has 23 years' experience in the pharmaceutical industry	She has 16 years' experience in biochemistry, molecular biology and medicine
The role of prior-learning & the cumulative science experience on the ability recognise, assimilate and apply new knowledge productively in the venture					
Developed firm-based competences	Recalling his experience and prior-learning in innovation “ecosystems” The bio-entrepreneur designed Mathematical science tools for mechanistic modelling (R-sim & U-per). Used to test and predict performance of a diagnostic test	Similar to bio-entrepreneur in cases A& D he was instrumental in developing drug discovery and testing tools for this venture	The bio-entrepreneur realised, through his learning and science experience, that super-critical carbon dioxide (scCO ₂) could be used to mix sensitive substances into the polymers	Using his cognitive biases, the bio-entrepreneur was instrumental in developing a new drug discovery and testing tools.	Recalling their cumulative science experience with a co-founder the bio-entrepreneurs developed a new technology that controls bleeding by binding to the blood protein, fibrinogen. The new type of treatment is seen as safer and easier to use

Synthesising data from the primary and secondary sources the study is able to construct a clearer picture regarding the role performed by prior-learning and the cumulative science experience of bio-entrepreneurs. In addition to the two factors (prior-learning and cumulative science experience) the process of combining information to determine their importance also considers the structural, relational and the cognitive dimensions which are related to how bio-entrepreneurs accumulated social capital through innovation “ecosystems” which was indispensable for their bio-tech ventures. In order to measure the impact of the antecedence influences of bio-entrepreneurs in recognising useful information for the venture the last variable on Table 1 above illustrates

the specific outcomes of individual learning. Strikingly, out of five bio-entrepreneurs one of them was a female who jointly runs the venture with another female co-founder. This demonstrates evidence of women who are also involved in scientific entrepreneurship. It is also intriguing to note that all the bio-entrepreneurs in the sample have a strong academic background in chemistry and pharmaceuticals and they have previously worked, at the very least, for a large pharmaceutical company before starting their own ventures.

They also have more than 14 years' experience in life science. Murray (2004) maintains that the inventor's (the equivalence of a bio-entrepreneur) role in their ventures is determined by a wide range of factors including: personal preferences, career stage, and professional norms. Similarly, Burns (2012) comments that entrepreneurs influence the strategic direction of their ventures and they aim to engrave their "DNA" in the venture. Science-related projects in innovation "ecosystems" are characterised by experimentation with a view to make new discoveries and as such, all the bio-entrepreneurs, at some point, before establishing their bio-tech ventures they participated in science-related projects which enriched their cognition of science. More importantly, they were able to experiment with different configurations until they discovered an effective one. Consequently, they were able to update their cognitive biases. This learning process was observed to be critical for their bio-tech ventures especially for informing the process of designing essential mathematical science combinations and chemical compounds necessary for new drug discoveries and for testing them. This observation is consistent with Gurău et al. (2010). The scholars insist that the strategic roadmap of new bio-tech firms requires competent directors for better performance and development.

A closer look across the profiles of all the bio-entrepreneurs further reveals that they are well-educated scientists with expertise in the bio-pharmaceutical technology and product development. It is also fascinating to note that 75% of the bio-entrepreneurs run their bio-tech ventures along with their academic commitments. Perhaps this explains their drive to continuously engage in drug discovery activities of learning with a view to constantly updating their cognitive biases and to sustain the development of their bio-tech venture. In that sense, it is safe for the study to suggest that the main fulcrum of a bio-tech venture is its bio-entrepreneur. Therefore, when analysing the AC of such small owner-managed ventures it is sensible to commence such an analysis at the individual level particularly, on the bio-entrepreneurs because of their degree of influence in terms of their direction and scope. Similarly, Gurău et al. (2010) observe that, mainstream bio-pharmaceutical enterprises are developed by successful scientists who aim to transform their innovations in commercial applications. Furthermore, Sony & Iman (2005) observed that there is a strong correlation between entrepreneurial competences consisting of industry specific skills, opportunity spotting skills and technical skills and the growth of a venture. Indeed, this was evidently clear from all the bio-entrepreneurs who were under the spotlight for the purpose of this study. In ensuring that the human capital within their bio-tech ventures contribute to internal knowledge bases all the bio-entrepreneurs linked-up with experienced scientists who became part of their top management team. Equally, their structural dimension which consisted of their business and social connections established from their previous employment and their research groups were critical to their continued learning because they formed part of their innovation "ecosystems" which facilitated the flow of scientific knowledge.

9. Conclusion

The research examined bio-entrepreneurs with a view to develop explanations about how their prior-learning and the cumulative science experience influenced their ability to "soak-up" useful scientific knowledge for their ventures. In that context, the profiling of each bio-entrepreneur and pattern matching cross the entire research sample enabled the study to conclude that prior-learning and the cumulative science experience of the bio-entrepreneur leads to enhanced AC. Indeed, as a consequence of their individual learning as well as the science knowledge of the members of their top team management, bio-entrepreneurs were able to acquire, store, transform and use information from their innovation "ecosystems" productively in their bio-tech ventures.

This introduces the advent of a business model adopted by science entrepreneurs in an industry which was often dominated by large bio-pharmaceutical companies. What this study has clearly demonstrated is that, by utilising their skills in science and competences developed from previous science-related projects/assignments the bio-entrepreneurs were able to update their cognitive biases which greatly assisted them in recognising and assimilating the right combination of resources necessary for designing or crafting new science technology for the economic development of their ventures. Furthermore, their antecedent influences shaped their decision-making process within their ventures including the process of selecting a learning partner and for formulating their operational strategies. The study discloses that bio-entrepreneurs who participated in the study are intimately attached to their bio-tech ventures and they have a strong desire to commercialise their discoveries. As such, it is plausible to infer that the study adopted a sensible approach in its endeavor to contribute to the concept of AC by placing the spotlight on the bio-entrepreneurs because of their huge influence on the direction

and the scope of their bio-tech ventures. In that sense, in seeking to contribute to the literature on entrepreneurial learning and the concepts of AC there is logic in examining entrepreneurs and their ventures as inter-connected units.

A look into the career of the bio-entrepreneurs of the bio-tech ventures sampled for the purpose of this study demonstrates that all of them are well-educated in science. In addition to that, the study also discloses that the structural dimension of the bio-tech ventures consists of learning networks (innovation “ecosystems”) populated with scientists from multiple countries. In that web of connections, the study infers that the most effective strategies for recognising useful scientific knowledge for bio-entrepreneurs are informed, to a large extent, by their ability to store factual knowledge about life science. More importantly, their ability to relate to new scientific knowledge which can be productively applied to their business processes with a view to complement/augment existing knowledge bases was meaningfully enhanced. Furthermore, the study discloses that in addition to rolling out the road map for their bio-tech ventures their cognitive dimension i.e., the top management team consisted of experienced scientists who also added value to their internal knowledge base thereby enhancing their AC. This underscores the essence of individual absorptive capacities to firm development.

As much as the study considers the chosen research approach for research to be appropriate however, there are inherent limits such as the generalisation of the research findings. However, in defense of the case-oriented research strategy adopted for this study the primary aim was not to generalise the findings to a large population but, to achieve what Yin (2009); Huberman & Miles (1994) describes as *analytical generalisation*. In terms of recommendations for future studies the research suggests a longitudinal variable-oriented research (VOR) study which utilises SPSS computer software to measure the impact factor of prior-learning and the industry specific experience over a predetermined period on the abilities of a bio-entrepreneur to “soak-up” useful knowledge for their bio-tech ventures.

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