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SERENDIPITY AND ITS STUDY

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Abstract *This paper explores the concept of serendipity and approaches to its study particularly in relation to information studies. The origins of the term serendipity are described and its elaboration as an exploratory and explanatory concept in science and the social sciences are outlined. The distinction between serendipity and serendipity pattern is explained and theoretical and empirical studies of both serendipity and the serendipity patterns are explored. The relation between information encountering and serendipity is also described and empirical studies of serendipity using Citation Classics are described. Studies of serendipity in information research are outlined and the experience of serendipity by inter-disciplinary researchers is examined in relationship both to a process model of serendipity and as an emergent behavioural trait. The paper provides an overview of the approaches taken to the study of serendipity and an indication of the methodological difficulties involved in its study.*

Introduction

The word serendipity was coined by Horace Walpole in 1754 with reference to the Three Princes of Serendip who were always making discoveries by accident. Thus serendipity was introduced as a word and defined as - "making discoveries by accident and sagacity, of things which one is not on quest of". However, it was Cannon (1945) in his book The Way of the Investigator who provided a more formal treatment of the role of serendipity in scientific discovery. Cannon's chapter on Gains from Serendipity explored the role of serendipity and provided some explanation of its importance and place in scientific research rather than its character as chance discovery. Cannon provides numerous examples of serendipity in relation to scientific research including the phenomena of galvanism and the relation between electricity and magnetism. In the biological sciences the role of the nervous system in the circulation of blood, anaphylaxis or allergy, immunization, the discovery of insulin, of vitamin K, and of sympathin. And, perhaps most famously, he cites Nobel's invention of dynamite and Fleming's discovery of penicillin (Cannon, 1945). In all this Cannon is careful to distinguish between pure chance and serendipitous discovery quoting Pasteur's dictum "Dans les champs de l'observation, le hazard ne favorise que les esprits prepares." (Cannon, 1945, p. 76-77) usually translated as 'In the fields of observation, chance favours only the prepared minds.' Although as van Andel notes Pasteur actually wrote 'des esprits prepares" that is 'prepared minds' and above the entrance to Harvard Medical school is quoted as 'Chance favours only the prepared mind' (van Andel, 1994, p. 635).

In the introduction to his book devoted to serendipitous discovery in science Roberts (1989) quotes both Pasteur and Flory –

'Significant discoveries are not mere accidents. The erroneous view is widely held, and is one that the scientific and technical community, unfortunately has done little to dispel. Happenstance usually plays a part, to be sure, but there is much more to invention than the popular notion of a bolt out of the blue. Knowledge in depth and in breadth are virtual prerequisites. Unless the mind is thoroughly charged beforehand the proverbial spark of genius, if it should manifest itself, probably will find nothing to ignite' (Flory).

These statements by Pasteur and Flory show that they understood what Walpole meant when he described serendipity as discoveries made by "by accident and sagacity". (Roberts, 1989, p. X).

The role of serendipity in relation to social research was explored by Merton who first referred to the role of serendipity in a footnote to his paper on 'Sociological Theory' (Merton, 1945) where he writes "Fruitful empirical research not only tests theoretically derived hypotheses; it also originates new hypotheses. This might be termed the "serendipity" component of research, i.e., the discovery by chance or sagacity, of valid results which were not sought for.' (Merton, 1945, p. 469). Merton continued his exploration of the role of serendipity in social research in his much expanded treatment of the concept in his article on 'The Bearing of Empirical Research upon the Development of Social Theory' (Merton. 1948). In the course of a more general exploration of scientific inquiry and the relationship between empirical research and the development of social theory, Merton provides an elaboration, of the role of serendipity in the development of social theory and theory building.

Serendipity and the serendipity pattern

Merton acknowledges Cannon for his employment of the word serendipity in relation to scientific exploration and for the provision of the numerous examples of serendipity in science; and Peirce for his recognition of the strategic role of the "surprising fact" in the process of what Peirce (1965) refers to as "abduction" the initiation and entertaining of a hypothesis as a step in inference (Merton, 1948, p. 506). Merton also introduces the distinction between serendipity and serendipity pattern. 'Serendipity is the discovery of an unsought finding, whereas a serendipity pattern involves observing a surprising and irregular finding, recognising that it is potentially strategic, and using it to develop a new theory or advance and existing theory.' (Perry and Edwards, 2010, p. 858.). Merton states that in the `*The Serendipity Pattern* - The unanticipated, anomalous and strategic datum exerts a pressure for initiating theory.' And that, 'The serendipity pattern refers to the fairly common experience of observing an *unanticipated, anomalous and strategic* datum which becomes the occasion for developing a new theory or for extending an existing theory (Merton, 1948, p. 506).

He analysed each of these three aspects of the serendipity pattern- `The datum is, first of all, unanticipated. A research directed toward the test of one hypothesis yields a fortuitous by product, an unexpected observation which bears upon theories not in question when the research was begun.' (Merton, 1948, p. 506.). in this `the observation is anomalous, surprising, either because it seems inconsistent with prevailing theory or other established facts.' (Merton, 1948, p. 506.) He also emphasizes that `the unexpected fact must be "strategic," i.e., that it must permit of implications which bear upon generalized theory' (Merton, 1948, p. 507). In summary then - `the serendipity pattern, then, involves the unanticipated, anomalous and strategic datum which exerts pressure upon the investigator for a new direction of inquiry which extends theory.' (Merton, 1948, p. 507.) Merton notes that 'instances of serendipity have occurred in many disciplines' (Merton, 1948, p. 507) and proceeds to give examples from sociological research including his own. `to illustrate the operation of the serendipity pattern: an unexpected and anomalous finding elicited the investigator's curiosity, and conducted him along an unpremeditated by-path which led to a fresh hypothesis.' (Merton, 1948, p. 509).

Merton's deployment of the concept of the serendipity pattern is in the context of his argument that 'empirical research goes far beyond the passive role of verifying and testing theory…it performs at least four major functions which help shape the development of theory. It initiates, it re-formulates; it deflect and clarifies theory. (Merton, 1948, p. 506) _. Merton explores the relation between the serendipity pattern and the reformulation pattern. In *The Recasting of Theory* –new data exert pressure for the elaboration of a conceptual scheme. 'Whereas the serendipity pattern centres in an

apparent inconsistency which presses for resolution, the reformulation pattern centres in the hitherto neglected but relevant fact which presses for an extension of the conceptual scheme.' (Merton, 1948, p.. 509). *The Re-Focussing of Theoretic Interest* - in which new methods of empirical research exert pressure for new foci of theoretical interest (Merton, 1948, p. 511; and *The Clarification of Concepts* –where empirical research exerts pressure for clear concepts). (Merton, 1948, p. 513).

Serendipity, the serendipity pattern and abduction

The role of serendipity and distinction between serendipity and serendipity pattern was further elaborated by van Andel (1994). 'Merton described serendipity as an observation of a surprising fact followed by a correct "abduction" (van Andel, 1994, pp. 635-636). van Andel also refers back to the distinction made in philosophy of science between deduction; induction and retroduction or abduction.

'"There are in science three fundamentally different kinds of reasoning. Deduction…Induction…and Retroduction…usually translated as Abduction…. Abduction consists in studying facts and devising a theory to explain them…It is a process of forming an explanatory hypothesis…The first starting of a hypothesis and the entertaining of it - abduction (van Andel, p. 636) (Peirce, 1965). Following Eco and Sebeok (1983) van Andel also distinguishes between three forms of abduction –

1. overcoded abduction - where discovery proceeds from a surprising fact to another surprising fact, based on a given rule;
2. undercoded abduction - where discovery proceeds from a surprising fact to a possible rule
3. and creative abduction - where discovery proceeds from a surprising fact to a new rule, that has to be invented.

(van Andel, 1994, pp.636-637) (Eco and Sebeok , 1983) provides examples of serendipity in relation to the domains of -

1. Science: Rontgen's discovery of X rays;
2. Technology: Ktesibios' hydraulic constructions;
3. Art: Picasso's 'blue period; and
4. Daily Life: Honda's sale of, and subsequent dominance of, the market for small motorcycles.

(van Andel, 1994, pp. 637-638).

And, discusses serendipity in relation to Traditions -

1. the Fairy tale: the swineherd who discovers roasting meat;
2. the apocryphal story: the discovery of coffee;
3. Fake, false or exaggerated serendipity: Newton, gravity and the falling apple;
4. Unknown, unpublished, hidden or denied serendipity: the discovery of heparine as an anticoagulant; and
5. Well documented authentic serendipity: the serendipitous discovery of X rays, and the pseudoserendipitous discovery of penicillin.

(van Andel, 1994, pp. 638-639).

He also differentiated between what he terms three appearances of serendipity –

1. Positive serendipity; a surprising fact or relation is seen and followed by a correct abduction; Rontgen's discovery of X-rays;
2. Negative serendipity; a surprising fact or relation us seen but not (optimally) investigated by the discoverer; Columbus' discovery of the 'New World'; and
3. Pseudo-serendipity (a term coined by Roberts, 1989) to discover, invent, create something you were looking for in a surprising way: Fleming's discovery of penicillin.

(van Andel, 1994, pp. 639-640).

From a study of over a thousand examples of serendipity van Andel identified seventeen serendipity patterns.

1. Analogy with same or different context: the stethoscope, wood pulp;
2. One surprising observation: irrigation;
3. Repetition of a surprising observation: AIDS;
4. Successful error: post-it notes;
5. From side-effect to main-effect: iproniiazide (developed for tuberculosis became a drug against depression);
6. From by-product to main-product (spin-off): the first synthetic dye 'mauve' from coal tar and birth of organic chemistry;
7. Wrong hypothesis: discovery of lithium carbonate as a treatment for mania;
8. No hypothesis: the creation of barium and crypton from uranium (Meitner, Frisch and Bohr called it 'nuclear fission');
9. Inversion: heparine as an anticoagulant;
10. Testing a popular "belief": vaccination with cowpox providing immunisation against smallpox;
11. Discovery by child, student or outsider: rubella as a cause of congenital defect (suggested by a mother to Austrian ophthalmologist Gregg);
12. Disturbance or interference: radio-astronomy from identification of the periodicity of 'noise' in transatlantic telephone cables;
13. Scarcity: cigarettes from discarded cigar butts;
14. Interruption of work: glycogenesis (sugar metabolism) in the liver discovered by Bernard;
15. Playing: the 'impossible tribar' created by Reutersvard bored at school (drawing first six then three cubicles around a star of David);
16. Joke: Verne's travel to the moon; but also the Sony Walkman invented by a Sony engineer with a sense of humour;
17. Dream or 'forgetting-hypothesis: Descartes' 1619 dream of a world ruled by mathematics where everything could be explained and calculated logically.

(van Andel, 1994, pp. 640-643; Campanario, 1996 p. 12.).

van Andel's classification, in itself, was a "tour de force" in the conceptual analysis of serendipity, no one before (or since) had attempted, or provided, such a detailed analysis and classification of the concept, but the categorisation developed by van Andel was also subsequently employed as the basis of the classification of serendipity in an empirical study by Campanario (1996).

Serendipity and Citation Classics

Campanario (1996) was the first to use Citation Classics as the source for a study of the extent, and nature of, reported serendipity - which in its use of Citation Classics provided a completely new

theoretical, methodological, and empirical departure for the study of serendipity. Campanario examined 205 Citation Classics from the 400 most cited papers. From this sample only 17 authors (8.3%) mentioned "some kind of serendipity" in the research reported and of these only 5 provided sufficient information to determine how the serendipitous discovery was carried out.

Campanario notes that there is no lack of recognition of the role of serendipity in epistemologies of science. 'However, there is a lack of advancement in this field, and even more surprising, there is a lack of studies on serendipitous discoveries.' (Campanario, 1996, p. 4). Campanario explains the reasons for this in the mythication of scientific research. He advances three reasons why serendipity would appear to be less frequent in accounts of scientific discovery than might be expected from discussions of the role of serendipity in philosophy of science and in epistemology of science.

1. Granting chance an important role in scientific discovery would cast some doubt on the necessary academic preparation for scientific work.
2. Modern scientific endeavour is based on a view of science as something that is totally under control.
3. In experimental sciences emphasize the need to control all of the variables that in a scientific experiment.

(Campanario, 1996, pp. 4-5).

Campanario goes on to note that - 'There are sciences (e.g. Astronomy) that area purely observational. This fact can affect the process of serendipity making accounts of serendipity more "acceptable". (Campanario, 1996, p. 5). But that this would seem to more the exception than the norm for most scientific research and that - 'the common sense of fair play resists the idea of granting the same merit to an unexpected discovery made by accident and one that is the fruit of careful planning and a lot of hard work' (Campanario, 1996, p. 5). This carries through to the distinction between the practice of science and the accounts given of scientific discovery. 'In addition, there are some factors that make difficult to do systematic research on the role that serendipity plays in science. In the first place some scientists may be reluctant to admit that the discoveries for which they are honoured were accidental.' (Campanario, 1996, p. 5). This introduces into the study of serendipity of science the important distinction between the context of discovery and the context of justification. As Campanario notes this produces a - very potent source of difficulty in studying the role of serendipity in scientific discovery: the usual way to report discoveries. Some epistemologists have suggested that there is a "context of discovery" and a "context of justification". Scientific discoveries are made in one way and announced in a very different way. (Campanario, 1996, p. 6).

Campanario provides some very telling examples of this - In the introduction of his famous Experimental Researches in Electricity, Faraday wrote the following sentences that need not commentaries: "These results I purposely describe, not as they were obtained, but in such a manner as to give the most concise view of the whole".' Faraday, 1965 p. 2. (Campanario, 1996, p. 6). And, 'Merton who wrote that "the scientific paper or monograph presents and immaculate appearance which produces little or nothing of the intuitive leaps, false starts, mistakes, loose ends and happy accidents that actually cluttered up the inquiry." (Merton, 1957, p. 638).

Furthermore, the importance of serendipity to scientific inquiry has been underlined by some very influential scientists and philosophers of science including Koestler (1964) who wrote "the history of discovery is full of arrivals at unexpected destinations, and arrivals at the right destination by the wrong boat." (Campanario, 1996, p. 6). And Pasteur famously much quoted as asserting "in the fields

of inquiry chance favours only prepared minds" (Campanario, 1996, p. 20). So despite the very real difficulties in studying serendipity Campanario considered it important to attempt the study the phenomena empirically and to try -

1. To ascertain the relative frequency of serendipity in the origin of some of the most cited papers of all times.
2. To classify the appearances of serendipity according to some categories. I have used those proposed by van Andel.
3. To check the usual division between context of discovery and context of justification. (Campanario, 1996, pp. 4-5).

As previously mentioned Campanario based his study of serendipity on the classification developed by van Andel- 'I have used a broad scheme to classify the appearance of serendipity. This scheme is based upon van Andel and I have used two categories -

1. The goal of a research project is reached accidentally;
2. In the course of an investigation something is discovered that does not have to do with the original research project.

(Campanario, 1996, p. 10.)

Campanario maps the 17 patterns of serendipity onto his two categories and notes that his - scheme can be complemented by using some of the 17 patterns of serendipity…described by van Andel (1994)" van Andel's serendipity patterns are "often compatible with both categories of his own" (Campanario, 1996.).

Campanario's use of Citation Classics to study serendipity has also been adopted in a study of serendipity by McBirnie (2012) who studied a sample of fifty first person narratives of serendipity taking from accounts in Citation Classics. Many features make McBirnie's study interesting – the use of Citation Classics as a source; the use of network analysis; and the restricted use of the concept of serendipity to the term "serendipity". In fact, her study restricted the use of serendipity to those Citation Classics which included the keywords – serendip; serendipity; serendipitous; and/or serendipitously; written in the first person singular or plural; and which described the narrators' own experiences of process in serendipity, classifiable using Campanario's (1996) taxonomy (McBirnie, 2012, pp. 142-144).

The recorded occurrences of serendipity in Citation Classics in McBirnie's study were correspondingly low. In fact, she only identified seventy six Citation Classics which met the restrictive search terms, or the occurrence of serendipity in only 1.5% of the analysed Citation Classics (McBirnie, 2012: 237). McBirnie argued that as the Citation Classics series encouraged author to highlight serendipity this would then seem a reasonable extrapolation. However, given the assumptions restricting the serendipitous experience only to those Citation Classics where the root terms of serendipity are used, the results, even compared to the results from Campanario (1996) of 2.9%, almost double the McBirnie figure, which would still seem to be lower than might be popularly expected. The conclusion from either McBirnie or Campanario would seem that serendipity is a relatively infrequent occurrence at least as represented in Citation Classics.

McBirnie was aware that this seemed to go against the feeling that serendipity was far more pervasive in scientific research. `Research anecdotes make up a large proportion of the serendipity literature. Both their sheer abundance and the serendipity-centric focus of these anecdotes can seem to imply that serendipity is common, that it happens "all the time". This idea has infiltrated

serendipity theory; for example Morton and Swindler, (2005, p. 346). Refer to serendipity as "a fundamental aspect of…research". Whereas, McBirnie concludes on the basis of her study of Citation Classics that "without serendipity" is by far the more common experience.' (McBirnie, 2012 p. 238). It is interesting that McBirnie also records that 74% of her sample of Citation Classics 'indicated findings as the significant research outcome; the remainder 26% reported methods (McBirnie, 2012, p. 238) but does concede that the results 'provide no information about whether serendipity leads to findings as the primary research outcome' (McBirnie, 2012, p. 238). McBirnie also observes that the results from the Campanario classification of Citation Classics showed that –

1. The sought finding is as common as the unsought finding; and
2. Pseudoserendipity (Roberts, 1989) occurs as often as – and potentially, even more often than – so-called 'true' serendipity.

(McBirnie, 2012, p. 239.)

What remains curious about the use of Citation Classics as a methodological approach is the discrepancy between explicit reported experiences of serendipity in the research literature, as recorded in Citation Classics, and the anecdotal reports of serendipity in accounts of scientific research and in descriptions of its role in scientific discovery in the philosophy or science.

The following quotations from Cannon and Merton are not untypical -

`In the life of an investigator whose researches range extensively, advantages from happy chance are almost certain to be encountered. During nearly five decades of scientific experimenting instances of serendipity have several times been my good fortune'. (Cannon, 1945, pp. 73-74).

'The serendipity pattern refers to the fairly common experience of observing an unanticipated, anomalous and strategic datum which becomes the occasion for developing a new theory or for extending an existing theory.' (Merton, 1948, p. 506).

This is also reflected in the relative frequency with which serendipity was mentioned as an emergent category in the study of the information seeking behaviour of interdisciplinary researchers.

Even before the coining of the term serendipity the importance of chance discovery had been commented on by researchers, again and again, as van Andell (1994) recounts with examples such as – Hooke from his preface of his *Lectiones Culterianae* [1679]; Priestly from his introduction of his *Experiments and Observations on Different Kinds of Air* [1775]; and Pasteur in 1854 in his opening speech as Dean of the new *Faculte des Sciences* at Lille. But somehow this slips through the net of studies based on the Citation Classics - though not so much on studies based on information encountering or information seeking. This raises questions about the methodological soundness of using Citation Classics as a basis for the study of serendipity in research.

Serendipity and information encountering

Erdelez (1997) recasts the study of serendipity in relation to the concept of the opportunistic acquisition of information and in particular to the notion of information encountering. Information encountering was introduced by Erdelez in 1997 from her study of accidental information acquisition in an academic environment (Erdelez, 1997; 1999). Erdelez further developed her work in the context of the Internet and Web as search environments (Erdelez, 2000) including encountering information useful for others on the Web (Erdelez and Rioux, 2000). She later studied information encountering in a controlled research environment (Erdelez, 2004), building on work by Toms (2000) and Campos and de Figueiredo (2001). Information encountering was originally conceived by Erdelez

as consisting of 'a memorable experience of unexpected discovery of useful or interesting information' (Erdelez, 2005, p. 179). She later revised this conception and defined information encountering as 'an instance of accidental discovery of information during an active search for some other information' (Erdelez, 2005, p. 180).

Erdelez (2005) considers information encountering to be a specific type of Opportunistic Acquisition of Information or OAI (Erdelez, 2005 pp. 179-180; Williamson, 1998) and categorised information encountering as a form of Opportunistic Acquisition of Information, itself a form of information acquisition, distinguishing it both form other forms of Opportunistic Acquisition of Information, and from intentional acquisition of information such as information seeking, while still coming under the general heading of information behaviour. Erdelez developed a functional model of information encountering identify the steps of the information encountering experience as – noticing; stopping; examining; capturing and returning (Erdelez, 2005).

This model assumed (1) an initial information seeking task related to the user's "foreground problem" and (2) one or more "background interest/problems/tasks" not actively addressed by the user's information seeking behaviour.' (Erdelez, 2005, p. 181). Then in relation to these the information encountering experience is a kind of interruption of the first by the second in that the user '1. Sees information potentially relevant to the background problem; 2. interrupts the original search process to examine the encountered information; 3. Saves the information that is deemed to be worth saving; and 4. Returns to the initial information search for the foreground problem. (Erdelez, 2005, 181-182.). She categorised information users in relation to information encountering as – super-encounterers; encounterers; occasional encounterers and non-encounterers (Erdelez, 2005, p. 179). From her study of information encountering in an academic environment she defined these as -

1. `Super-encounterers – respondents who very often experience information encountering, who relied on it, and considered it an integral element of their information seeking behaviour;
2. Encounterers – respondents who often experienced information encountering, who were aware of the chain of coincidental situations, but did not perceive how these connected to their information behaviour;
3. Occasional encounters – respondents who stated that they occasionally encountered information, and perceived it merely as a lucky incident; and
4. Non-encounters – respondents who stated that they very seldom encountered information.

(Erdelez, 1997, p. 417)

This typology is interesting not only least because of the variation in types of encountering but also because of the degree of self-judgement or self-perception in the extent to which respondents recognized or reported encountering.

Erdelez notes, in particular, that the super-encounters seemed to possess characteristics in common which differentiated them from the other types in that they shared a common excitement for information encountering; believed in creating situations conducive to encountering; were excited to share their rich encountering experiences with researchers; and positive reinforcement through many successful information encountering experiences, especially the "most memorable" ones.' (Erdelez, 1997, p. 417). This led Erdelez to speculate that 'a combination of psychological profiles and personal traits of the super-encounterers enhanced their chances of information encountering,

making them "serendipity prone". (Merton and Barber, 2004). (Erdelez, 1997, p. 417). Erdelez concluded that information encountering could occur in relation to problem specific and non-problem specific information seeking and that this therefore resulted in problem-specific and non-problem specific information encountering. Erdelez concluded that her study had implications both for information users and for information system design and both of these aspects have been explored in papers in recent special issue of information research edited by Erdelez and Makri (2011).

Serendipity and information research

Although, serendipity has long been a part of the intellectual scene, in particular, for the philosophy and sociology of science. There has been a considerable upsurge interest in serendipity much more recently in information studies and computer science, and again, in particular, for Human Computer Interaction. Researchers have explored the concept of serendipity and serendipitous experience in a number of empirical studies. This was in part because of a perception that there was a lack of empirical research on the subject. 'While serendipity gaining increasing attention in the context of information research these years there is a lack of empirical evidence to demonstrate the nature of serendipity in literature.' (Sun et al. 2011, p. 1). They also argued that the problem is not merely lack of empirical study but also problems in agreement concerning the definition of serendipity. 'There is currently a lack of consensus regarding existing definitions of serendipity, and a lack of empirical evidence to demonstrate people's perceptions of serendipity.' (Sun et al. 2011, p. 2). They cite Danzico's comment as 'falling somewhere between accidental and sagacity, serendipity is synonymous with neither one nor the other.' (Danzico, 2010, p. 16). This reflects McBirnie's view that 'Consensus on the term's meaning has not been reached. (McBirnie, 2008, p. 604).

Makri and Blandford consider that 'The study of serendipity in information research is an emerging research area. (Makri and Blandford, 2012, p. 707). Much of this stemming from the problem highlighted by Andre et al (2009) that as 'serendipity is inherently rare, so it is difficult for researchers to capture it for study.' (Sun et al, 2011, p. 3). To try to address this problem Erdelez (2004) and Toms (2000) have employed controlled experiments to try to study serendipity. As Bogers et al. (2013) note – 'The first exploration of inducing and measuring serendipity in a controlled lab experiment, was by Erdelez (2004) who framed serendipity as *information encountering*, distinguishing between foreground and background information needs.' (Bogers, et al, 2013, p. 703). More recently Mckay-Peet and Toms (2011) developed a measurement instrument for serendipity based on Bjorneborn's (2008) 10 dimensions of serendipity in physical libraries.' Bogers et al. 2013, p. 704. And, Bogers et al. (2013) report on their own study of measuring serendipity in the laboratory, examining the effects of priming and monitoring where twenty current and former library and information science students completed two fixed work tasks, bookmarking relevant pages (Bogers et al 2013).

But as Dantonio et al. (2012) report 'It has been found that serendipity is difficult to replicate in a controlled setting (Erdelez 2004; Toms and McKay-Peet, 2009). Therefore, serendipity has usually been studied in a naturalistic setting using interviews (Makri and Blandford, 2012; Mckay Peet and Toms, 2011) and most of studies of serendipity `are qualitative in nature – with semi-structured interviews the most commonly adopted method.' (Dantonio, 2012 p. 2). Thus, examples of serendipity studies include Erdelez who conducted surveys and follow up interviews with students and staff (Erdelez, 2005); Watson (2008) semi-structured interviews with library science academies and public librarians; McBirnie (2008) who interviewed jazz improvisers and academics; Sun et al (2011) carried out a mobile diary study of interdisciplinary PhD students; and Foster and Ford (2003)

and Makri and Blandford (2012) using semi-structured interviews with interdisciplinary academic researchers.

A model for this kind of approach is found in Palsdottir's (2011) study of opportunistic discovery of information by elderly Icelanders and their relatives. Palsdottir first sets out the different terms which have been used for this kind of information seeking - opportunistic acquisition of information (Erdelez, 1999); serendipity (Foster and Ford, 2003, Toms, 2000); accidental discovery of information (Williamson, 1998); non-directed monitoring (McKenzie, 2003); information seeking by proxy (McKenzie, 2003) or passive attention. Palsdottir, however, pragmatically concludes – 'What all these terms have in common is that they refer to the same kind of information seeking behaviour, namely that people sometimes find information by chance in unexpected places.' (Palsdottir, 2011, p. 11). Palsdottir adopted a Grounded Theory approach using open ended interviews and an interview guide with a convenience sample of twenty four people – half elderly people aged 70-90 and half their relatives. The interviews lasted from 45-75 minutes and were carried out in their own homes. Results indicated topics on which information had been found by chance – formal support from state or municipality; health; finance; recreational programmes and where to find other kinds of information, and they finding this from a variety of sources the media; family, friends and acquaintances; and interestingly from information grounds including a union for the elderly; a sewing club.

In another phenomenological study, using an analogy between serendipity and jazz improvisation, McBirnie (2008) interviewed two jazz improvisers and eight academics using non-random convenience purposive sampling, and semi-structured interviews. She found serendipity 'was perceived as a regular, but rare, occurrence.' (McBirnie, 2008, p. 607). McBirnie was keen to emphasise that the relation between control and serendipity was unclear and that great care must be taken over the inclusion of the concept of control, either intentionally or unintentially in the definition and that 'Van Andells' 'serendipity patterns may provide a more neutral definition of serendipity without excluding the possibility of a role for control.' (McBirnie, 2008, p. (604). She concludes 'although one cannot control the process of serendipity, one may be able to control one's perception of the result of the process.' (208, p. 611).

Sun et al. (2011) developed an ingenious approach to the empirical study of serendipity from the application of diary studies methods. Because of the problems involved in conventional diary study methods they developed a mobile diary application 'which allows participants to rapidly capture how serendipity happens in their daily life and the context in which they experience serendipity' (Sun et al, 2011, p. 1). The study involved participants recording their serendipitous experiences for one week, the diary entries were then discussed during post-study interviews. They combined the two main forms of diary study elicitation studies and feedback studies 'with results from feedback serving as a memory cue during the elicitation study' (Sun et al. 2011, p. 3).

Because of constraints with paper base diary study a mobile diary application was developed for Android compatible mobile phones three main functions – 1. a reminder to fill in the diary; 2. A write diary function; 3.and a view diary function. The diary also served as a reflective tool 'used during interviews to remind participants of their serendipitous experiences and elicit further details (Sun et al. 2011, p. 4). The sample consisted of eleven post-first year students recruited from the Doctoral Training Centre University of Nottingham. An initial briefing session was used to introduce the purpose of the study and to discuss the participants' views on the concept of serendipity. Interestingly the 'frequency of serendipitous encounters reported informally varied from "couple of times a week" to "once every couple of months" (Sun et al. 2011, p. 5). This was consistent with

Erdelez (1999) and McBirnie (2008) 'that serendipitous experiences were more common for some participants than others (Sun et al. 2011, p. 5).

Participants recorded their serendipitous encounters for one week, they were then interviewed for approximately one hour using a qualitative semi-structured approach. The interviews were designed to elicit information as to '1. how their serendipitous experiences came about; 2. the contextual factors that played a role in their serendipitous experiences and 3. the impact of serendipity on their research (Sun et al. 2011, p. 5). Twenty three diary entries were obtained and the two types of data collected - diary entries and post-study interview data. Diary entries and interview data were qualitative in nature.

From analysis of the data the themes which emerged were grouped according to -

1. participants' perceptions of serendipity;
2. the nature of a serendipitous experience;
3. the role of contextual factors in serendipitous experience.

(Sun, et al. 2011, p. 6).

In terms of the impact of serendipity it was found that the information encountered was emotionally positive; the serendipitous information often gave solutions to existing problems; information encountered strengthened researchers' existing research; the serendipitous information led researchers' in a new direction and was relevant to some general interests with usefulness becoming apparent over time (Sun, et al. 2011, p. 13).

The use of Critical Incident Techniques have also been deployed in Dantonio et al.'s (2012)study of coming across academic social media content serendipitously. They identified social media as a source of coming across information serendipitously. 'Whether students come across academic social media content serendipitously…conducted semi-structured Critical Incident Interviews with 15 post-graduate students from various disciplines (working on either a Masters or PhD dissertation) (Dantonio et al. 2012, p. 3). The 'fund students did come across academic social media content serendipitously often when undertaking unfocussed browsing during a break from other academic work.' Dantonio et al. 2012, p. 1.) Interview data was analysed 'by conducting an inductive grounded analysis Dantonio et al. 2012, p. 3). The interviewees discussed 27 memorable examples of coming across information serendipitously. They concluded 'People come across information serendipitously both in everyday life and as part of their academic research.' Dantonio, 2012, p. 1).

Serendipity and the interdisciplinary researcher: a process model of serendipity

Makri and Blandford (2011) have developed a process model of serendipity based on a study of how 'researchers come across information serendipitously grounded in real-world examples (Makri and Blandford 2011, p. 684). They reviewed a number of existing models of serendipity. McKay-Peet and Toms (2010) adaption of Cunha's (2005) to describe process of serendipity –

1. While searching for a solution to an information task;
2. And with certain percipient conditions and a serendipity trigger;
3. A bisociation (a surprising association between disparate previously unconnected pieces of information is made);
4. and an unexpected solution is found.

(Makri and Blandford 2011, p. 685-686).

Rubin et al.'s (2011) model which describes serendipity as 'the act of noticing perceptual clues in the environment combined with an element of chance (i.e. accident or perceived lack of control) and a prepared mind (based on previous experience or a prior concern) can lead to a fortuitous outcome (i.e. a perceived gain or happy ending).' (Makri and Blandford 2012, p. 686). However, they note that in this model the implication is that 'an experience can only be considered serendipitous on reflection.' (Makri and Blandford 2012, p. 686). A more process oriented model was that of Lawley and Tompkin's (2008) in which the prepared mind, experiences the unexpected event, recognises the potential, seizes the moment and amplifies and evaluates the effects. Put together Makri and Blandford (2012) considered that 'where Rubin et al.'s model provided the essence of serendipity but not structured process… Lawley and Tompkin's model described the process of serendipity thoroughly, but is less thorough in describing the essence of it ((I.e. the properties of an event that is, in hindsight, considered serendipitous) (Makri and Blandford 2012, p. 687).

Similar to Foster and Ford (2003) the focus was on interdisciplinary researchers. They employed used semi-structured critical incident interviews, in which the sample of 28 researchers were asked 'to discuss memorable examples of coming across information serendipity form their research or everyday life' (Makri and Blandford 2012, p. 684). Also similar to Foster and Ford (2003) 'the data collection and analysis followed many of the core principles of grounded theory methodology.' (Makri and Blandford 2012, p. 684). They found that there were shared common elements in the examples studied in 'the mix of unexpectedness and insight and led to a valuable unanticipated outcome.' (Makri and Blandford 2012, p. 684).

Their empirically-grounded process model of serendipity consisted of the following stages -

1. making a new connection or dissociation (Cunha, 2005) (involving a mix of unexpected circumstances and insight);
2. projecting the potential value of the outcome;
3. exploiting the connection;
4. leading to a valuable unanticipated outcome;
5. reflection on the value of the outcome;
6. consider as serendipity

During stages 3-5 there is reflection on the unexpectedness of the circumstance that led to the connection and/or role of insight in making the connection.
(Makri and Blandford 2012, p. 691).

The result of the valuable, unanticipated outcome can be in terms of being -

1. Knowledge-enhancing (i.e. providing a new insight or perspective that pushed the boundaries of existing knowledge);
2. Impactful (i.e. with a large and/or long lasting impact);
3. Timely (i.e. happening at the right time);
4. Time saving (time saving advancement in research; or sudden jump in understanding);

(Makri and Blandford 2012, p. 695).

The reflection on the value of outcome, unexpectedness and insight; and consideration as serendipity is theoretically rather than empirically grounded as 'interviewees considered it too abstract to "reflect on the process of reflection"' (Makri and Blandford 2012, p. 696).

Makri and Blandford (2008) argue that their 'empirically grounded model of serendipity provides a structured means of describing and reasoning about serendipitous experiences.' (Makri and Blandford 2012, p. 697) and 'has the potential to help researchers describe and reason about serendipitous experiences…"open their eyes" to potential serendipitous opportunities…make them more prepared for making and exploiting future serendipitous connections.' (Makri and Blandford 2012, p. 702). They concluded that 'Unlike existing models, ours captures both the process and essence of serendipity. It therefore provides a "recipe for serendipity that helps us better understand the phenomenon.' (Makri and Blandford 2012, p. 702).

They reviewed existing serendipity frameworks from Austin (2003) first set out in 1978; Liestman (1992); Fine and Deegan (1996); and Foster and Ford (2003). Austin (2003) described four types of opportunistic discovery of information –

1. blind luck (chance that comes with no effort);
2. happy accident (chance which is due to exposure to seemingly unconnected facts and experiences);
3. prepared mind (chance is perceived due to exposure to many facts related to the problem at hand);
4. and individual (chance favours a particular individual as a result of the person's distinctive knowledge or interest).

(Austin, 2003, p. 71; Bawden, 1986, p. 205; Makri and Blandford, 2012, p. 709-710; Sun et al. 2011, p. 2).

And that of Liestman (1992) who provided a six category model of serendipity as -

1. Coincidence (chance encounters as a result of random luck);
2. Prevenient grace (chance occurs because of efforts performed by those who are unseen and unknown);
3. Synchronicity (a result of the concurrence of two meaningful but not causally related events);
4. Perseverance (chance is encourage by looking hard for information);
5. Altamirage (serendipity happens as a result of the distinguished habit, expertise or character of an individual);
6. Sagacity (serendipity is due to a random juxtaposition of ideas, in which loose pieces of information frequently undergo a period of incubation in the mind and are brought together by the demands of some external events).

(Liestman, 1992, p. 526-530; Makri and Blandford, 2012, p. 710-711; Sun et al. 2011, p. 2).

Fine and Deegan (1996)

1. Temporal serendipity – "happening upon a dramatic instance";
2. Serendipitous relations – "the unplanned building of social networks"
3. Analytic serendipity – "discovering concepts or theories that produce compelling claims

(Fine and Deegan, 1996, p. 7; Makri and Blandford, 2012, p. 711).

Makri and Blandford considered that all the frameworks were useful to some extent on another in classifying the majority as either "happy accidents or requiring a "prepared mind"; none were to due to "blind luck" and only a few as "individual". They and were able classify most of their examples with one of Liestman's categories the most common being synchronicity, sagacity and prevenient grace; some involved altamirage and perseverance; some coincidence; but none with random luck . Fine and Deegan's classification proved easiest to apply and they `were able to classify all their examples as one of temporal serendipity; serendipitous relations and analytic serendipity with a roughly event split between all three.' (Makri and Blandford, 2012, p. 711). However, what they 'had hoped to find was a classification framework based on elements of the serendipitous experience, which would allow us to tease out similarities and differences between our examples. Such a framework is provided by Foster and Ford (2003) -

1. The information was of unexpected value (a) by looking in "likely" sources or (b) "by chance" (Foster and Ford, 2003, p. 332) or
2. The existence and/or location (rather than the value) of the information was unexpected; (Foster and Ford, 2003, p. 332)

The unexpected information had the potential to either, p.

1. Re-enforce or strengthen the researchers existing problem conception or solution; (Foster and Ford, 2003, p. 330) or 2
2. Take the researcher in a new direction "in which the problem conception or solution is re-configured in some way (Foster and Ford, 2003, p. 330)

(Makri and Blandford, 2012, p. 712).

However, although they found 'classifying our examples according to the second half of this framework to be quite straightforward…we found it extremely difficult to use the first half of the framework due to several ambiguities in the terminology used…these ambiguities made it difficult to use Foster and Ford's framework to classify our examples of serendipity with confidence. And as existing theoretical frameworks did not allow us to tease out similarities and differences between our examples, we therefore decided to construct our own classification framework grounded in the examples from out interviews.' (Makri and Blandford, 2012, p. 712).

Using the basic principles of the Grounded Theory approach they proceeded to construct a classification framework from analysis of 46 experiences of serendipity from the Critical Incident Interviews 'Serendipitous stories were written to summarise each and to facilitate comparison… that the common elements of unexpectedness, insight and value identified in almost all the experiences' (Makri and Blandford 2012, p. 706). On this basis they identified three questions to determine the elements of the serendipitous experience –

1. How unexpected were the circumstances that led to the connection being made?
2. How insightful was the making of the connection itself?
3. How valuable was or do you expect the outcome to be?

(Makri and Blandford, 2012, p. 714).

They analysed the serendipity stories against these criteria and carried out a member check to confirm the validity of their interpretation against five of these stories -

1. Daily dose of tubeworms (very unexpected, very insightful, very valuable);

2. Conference connection (very unexpected, somewhat insightful, very valuable);
3. Rotating the road (somewhat unexpected, somewhat insightful, very valuable);
4. Happy Honduras holiday (somewhat unexpected, somewhat insightful, somewhat valuable);
5. Who's watching me? (Not at all unexpected, not at all insightful, not at all valuable).

Makri and Blandford's (2012) model is derived from explicit study of serendipity and serendipitous encounters among interdisciplinary researchers, and, as they demonstrate can be used successfully to categorise and contextualise those encounters in terms of serendipity patterns. It is also applicable to other forms of research and to more everyday life encounters. It is therefore worth re-visiting the Forster and Ford (2003) model, where serendipity was not the explicit focus of the study but emerged as a category from the analysis of the information seeking behaviour of the researchers.

Serendipity and the interdisciplinary researcher: an emergent behavioural model of serendipity

The ideas of serendipity patterns introduced by Merton (1948) and expanded by van Andel (1994) and of underlying ability to experience serendipity as Erdelez's work suggests were revisited from a behavioural approach by Foster & Ford (2003) who generated a simple framework for the categorisation of serendipity events based on interdisciplinary researchers. The focus on interdisciplinary researchers and their behaviour is potentially important as it is noted that interdisciplinarity has increased considerably over recent decades (Foster, 2003). Interdisciplinary researchers are often deemed to be different and to exhibit alternative coping behaviour and behavioural nuances arising in great part from the contextual issues arising for them in dealing with a lack of knowledge and information overload that shape experience and information seeking (*see for example* studies by Palmer, 1999; Palmer 2001; Wilson, 1996). The context of experience was certainly important and for the interdisciplinary researchers experiencing serendipity in Foster and Ford (2003), p. they worked as researchers unbound by disciplinary contexts and stimulated to make connections because they were learning and gathering in unbounded circumstances. As Matlin (2002), noted in McCay-Peet (2001), suggested, p. knowledge is usually bound to the context in which it is found. The 'unbounded' theme is useful if we consider the wider disciplinary context of information seeking in which information seeking defines sources and methods depending upon discipline (Becher and Trowler, 2011). As interdisciplinary researchers have emerged they have found single discipline questions and the resulting answers to be variously limiting and problematic. It is perhaps not surprising that in working to unbound, decontextualise and increase their exposure to new knowledge they also experience serendipity.

In Foster and Ford (2003) the original naturalistic (Lincoln and Guba, 1985) approach to the research was not the study of serendipity, it was the identification of frameworks of information behaviour within which patterns of experience and thought became identifiable, p. serendipity emerged from the study of behaviour in the context of interdisciplinarity. The emergence of serendipity specific attributes followed with more focused attention to the observed events. The emergence of examples in Foster and Ford (2003) was valuable in avoiding the use of mechanistic or otherwise artificial options to capture evidence of serendipity. In reviewing the Foster and Ford (2003) after a number of years it stands out in the research notes made at the time, that the perception of serendipity as a novel attribute of interdisciplinary researchers emerged very early in data collection and analysis. Serendipity was noteworthy as something that although acknowledged was not deemed some a good researcher would countenance, and statements mentioning it do so in a semi-embarrassed way.

Foster and Ford's (2003) study provided an empirical approach to serendipity experienced by interdisciplinary researchers in this study they classified serendipity into four categories in which serendipity played a role in –

1. Reinforcing or strengthening the researcher's existing problem conception or solution;
2. Taking the researcher in a new direction, in which the problem conception or solution is re-configured in some way;
3. The unexpected finding of information the existence and/or location of which was unexpected, rather than the value;
4. The unexpected finding of information that also provide to be of unexpected value, p. (a) by looking in likely sources; (b) by chance.

At the time of initial publication a simple table represented the relationship between the four classifications of event. The focus in each was upon behaviour and outcome. In Foster and Ford's findings that cognition, recognition, source and response are represented.

Classes one and two detailed "the impact…of serendipitous encounters"; three and four described "the nature of these encounters" (Foster and Ford, 2003, p. 332). As the data analysis progressed the study move from emergence to examination of different aspects of serendipity the first category - reinforcing or strengthening the researcher's existing problem conception or solution was illustrated. The descriptions of serendipitous events recounted in simple language the very real instances. Each interviewee focussing on a particular aspect and using often quite specific examples and language, but with a thread running throughout that expressed the essence of serendipity events. The second category, that of taking the researcher in a new direction, in which the problem conception or solution is re-configured in some way. The third category where it was the unexpected finding of information the existence and/or location of which was unexpected, that is to say an information gap existed that wasn't suspected until it was flagged by a serendipity event. For category 4a and 4b there was a close relationship to sources, in category 4a where the unexpected finding of information that also provide to be of unexpected value, p. by looking in likely sources. And, the converse in category 4b - where the unexpected finding of information that also provide to be of unexpected value by looking by chance. The dimensions of control or chance were also explored – varying from randomness - through to deliberation combined with luck - through the product of others - or remembering things once known and attitude was also identified as a key factor in serendipity.

In this way serendipity was mapped as a complex aspect of information seeking behaviour that required further consideration. The framework adopted to approach serendipity was explored further at the level of coding and description in later work by Foster and Urquhart (2008; 2012). Foster Urquhart and Turner (2008) and Foster and Urquhart (2012), reported on an analysis of qualitative codes and code descriptions and tested these against two data sets. Foster and Urquhart (2012) presented the results of a code analysis project in which interview transcripts from the original Foster (2003) study and the JISC JUSTEIS project data were considered as part of a qualitative code testing exercise.

The transcripts spanned undergraduate students, Master's and Doctoral students and academics. A total of 65 transcripts were coded of which 22 coded in depth in multiple iterations, and a further 29 were coded with fewer iterations as coding agreement was achieved, the remainder were too brief for full coding. The coding exercise confirmed the earlier Foster and Ford (2003) approach to subcategories of serendipitous event. The coding was valuable in challenging whether serendipity could be visible in an independent data set and in testing whether different coders would view the

original data in the same way. The recoding and testing process were instructive as the coders found serendipity to be a difficult concept that can vary significantly in clarity, p. there are examples of very detailed accounts of serendipitous events, and a significant volume in which less descriptive answers indicate the presence of some generic form of serendipity without necessarily articulating it as completely as the researchers in the earlier Foster and Ford (2003) study.

Foster and Urquhart highlighted an interview quote as typifying the generic low level descriptions, p. I found some more websites recently that would have helped quite a bit but that's through finding them when we were looking for other stuff really [...] It was just me happening on them (D2/166107)." (Foster and Urquhart, 2012, p.791). Using the two data sets researchers and students were incidentally compared, with as Foster and Urquhart (2011, pp. 791) suggest, "The difference between datasets for this coding is suggestive of student searchers being more accidental in their experience of serendipity than the researchers in Foster (2003)..." Specifically, researchers exhibited far more sense of the wider context in which their work was situated and were attuned to serendipitous opportunity. That is to say there was a noticeable pattern of serendipity as part of regular interdisciplinary behaviour.   As we note over time many disciplines are becoming more interdisciplinary in their nature and interests, it will be relevant to examine the frequency of serendipity events across all researchers.

The key shift presented in Foster (2003; 2004) and onwards was the inclusion of serendipity within a behavioural model. However, when Foster and Ford (2003) was being written, an initial version of Foster's behavioural model was being developed that included serendipity and placed it within a wider perspective as part of a nonlinear model of information behaviour (Foster 2003; Foster, 2004). In the early forms of the behavioural model serendipity was presented as one behaviour of several belonging to one of three core process of "Opening" (see for example Foster, 2005, figure 2). The model highlighted a multi-level model including at a lower level a nested grouping of core processes and behaviour patterns including serendipity. Serendipity was viewed as part of model of information seeking behaviour which included context and acknowledges that clusters of behaviour are formed to become strategies, tactics or approaches to information seeking Foster (2003; 2004; 2012). For Foster and Ford (2003) the approach was merely one feature of a more detailed behavioural model *with serendipity as a behaviour nested within a contextual approach* it has been overlooked in some later work, as in for example Sun Sharples and Makri (2011). In failing to build a more explicit link with the emergent model the Foster and Ford (2003) paper allowed a gap between two different spheres of literature to develop, p. one that was inclusive of context and complex behaviour and one that was focused initially just on serendipity.

For Foster and Ford (2003) serendipity was an emergent category of event which is in contrast to later studies that focused upon collecting data specifically on serendipity. Interestingly, the timing of data capture is one factor inherent in many methods of data collection with some quite wide differences as the researcher either collects data close to the point of serendipity recognition (e.g. Sun Sharples and Makri, Erdelez or in the mid to longer term as in the citation classics used in McBirnie (2012) and in the critical incident accounts captured in Ford and Foster 2003). It is conceivable that such variations will lead to quite different interpretations and emphasis. In capturing serendipity data the variations can affect the comparability of results. For example, the sample in Sun Sharples and Makri, composed of 23 interdisciplinary PhD students had sufficient overlaps with the 45 interdisciplinary researchers in Foster and Ford (2003) to allow comparison of findings. Whereas the later work by Foster and Urquhart (2012) was valuable for testing the robustness of coding related to serendipity behaviour and drawing out contrasts between different populations. In all of these studies there were clear impacts upon researchers and their research

that reinforce the importance of serendipity and a number of central characteristics of serendipity events.

The emphasis of serendipity studies in the decade following Foster and Ford (2003) has tended to confirm many earlier findings. For example McBirnie's (2008, p.610) paper exploring serendipity confirmed many of the Foster and Ford (2003) findings and noted that both passive and active elements combine with context to define serendipity without a tableaux of behaviour. Likewise Sun Sharples and Makri (2011) confirmed the basis of the Foster and Ford (2003) framework but stressed that serendipity needed context and related behaviours to be highlighted to make sense. However in discussing the findings they claim novelty in adding a contextual understanding of human behaviour to interpreting serendipity, for example "our study emphasised that serendipity is closely align to people's information activity and we incorporated it in describing the nature of serendipity" (2011, Discussion section). While Dantonio, Makri and Blandford (2012) focused upon social media content as a source within which serendipity was experienced they seek to contextualise serendipity via a stress many elements of behaviour as contributing to serendipitous findings, for example unfocused browsing and seek to move towards understanding serendipity in relation to investment of time, of skill or of preparation (Dantonio Makri and Blandford, 2012, p.6).

Unfortunately the value of this in building further on existing work is limited as it omits reference to the papers associated with describing a behavioural model (Foster, 2004; Foster, Urquhart and Turner, 2008; Foster and Urquhart, 2012) which included serendipity within a framework of context composed of cognitive, affective, environmental factors. Disconcertingly the new emphasis on context by such studies emphasises that the context of serendipity as one part of behaviour as portrayed in Foster's model (2004) has been lost amidst the focus on serendipity as portrayed in the Foster and Ford (2003) paper. The omission led Sun Sharples and Makri (2011) to a reassuring assertion of the importance of context and behaviour in understanding serendipity, which when taken in the round is worthwhile in developing the study of serendipity, but it has at the same time illustrated the limited the extent to which new theoretical developments have been built on existing research.

Conclusion

Several different approaches to the study of serendipity in information studies have been described -

1. Survey and interview studies of information encountering;
2. Examination of serendipity from the study of Citation Classics;
3. Controlled experimental laboratory studies;
4. Qualitative semi-structured methods including Grounded Theory; Critical Incident and diary studies;
5. Study of serendipity as a process and as an emergent category in studies information seeking by interdisciplinary researchers.

There is no doubt about the importance and impact of serendipity. However, it is also clear that the nature of serendipity raises issues for methodical data collection. How do you reliably capture an event that by its nature has a large "accidental" component? Furthermore, despite many interesting studies and wide ranging approaches, serendipity as an event or outcome of behaviour or personality function, does not exist within a vacuum, it is the product of context. Foster (2004) illustrated serendipity as part of a wider behaviour model, and in this emphasised the role of context. But we note that even context is debatable and has been the subject of exploration in its own right, see for example Talja, Keso and Pietiläinen (1999) and Kari and Savolainen (2007).

Further research in this field must improve upon the methods of capturing events and as Foster and Urquhart (2008; 2012) suggest be based upon stable definitions and parameters. The study of serendipity spans practitioners, computer systems, psychology, information science and philosophy and is both strengthened due to the breadth of interest generated and weakened due to the fragmentation in which studies risk duplicating findings from slightly different viewpoints, misinterpret theories or miss opportunities to develop greater understanding. A review of the literature again suggests to us that serendipity might best be engaged with via an multidisciplinary team approach with a genuine dialogue between fields to contextualise serendipity.

The prevalence of a narrow range of data collection methods indicates researchers have found continued problems with many of the available methods commonly used in social and behavioural studies. There are questions arising around the extent to which new non-intrusive technologies may allow improved data capture is as yet unclear, in all cases it seems there must be a way for the researcher to learn when a serendipitous recognition occurs, either at the moment of the event or at some later point. It is certain that with wearable computing devices that new opportunities will arise along with the problem of whether technology will help deepen our understanding or encourage superficial engagement with a plethora of new data. Certainly we would urge that before researchers rush for technological data collection that there is engagement with some fundamental ontological and epistemological questions. Some such questions may include the following, p. As serendipity does not occur on a predictable schedule, should data collection to be a trawl of everything 100% percent of the time which statisticians and ethical researchers deem inappropriate? The Eureka moment of connection might well occur in an unusual time or space, capture post-event may be the only way to illustrate the event; what affect does this have on the quality of data captured? Some studies have considered that serendipity only occurs when it is recognisable or described as such by the subject. Are we sure serendipity has to be observed and recognised to exist? Does serendipity require an impact to exist? If it does require impact, what size of impact is worth noting and how should that be measured by researchers?

Above all it seems that the art of good research on this area is a balance between capturing events and of capturing their context and impact upon the people experiencing serendipity. There are several useful approaches to the nature of serendipity in existence and these offer a springboard for further research much in the way that Ellis' approach to characteristics of information seeking (1993) focused attention on the characteristics of behaviour as significant topics of investigation and led towards many further developments. It is interesting that information studies researchers are exploring serendipity within wider everyday life information seeking behaviour and extending the study of serendipity beyond research environments. Such research has potential to contribute towards applications in information literacy training and to algorithms underpinning Web 2.0 and search engine design.

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