Investigating Serendipity: How it Unfolds and What may Influence it

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Serendipity **is not an easy word to define. Its meaning has been stretched to apply to experiences ranging from the mundane to the exceptional. Serendipity, however, is consistently associated with *unexpected* and *positive* personal, scholarly, scientific, organizational, and societal events and discoveries. Diverse serendipitous experiences share a conceptual space; therefore, what lessons can we draw from an exploration of how serendipity unfolds and what may influence it? This article describes an investigation of work-related serendipity. Twelve professionals and academics from a variety of fields were interviewed. The core of the semi-structured interviews focused on participants' own work-related experiences that could be recalled and discussed in depth. This research validated and augmented prior research while consolidating previous models of serendipity into a single model of the process of serendipity, consisting of: *Trigger*, *Connection*, *Follow-up*, and *Valuable Outcome*, and an *Unexpected Thread* that runs through 1 or more of the first 4 elements. Together, the elements influence the *Perception of Serendipity*. Furthermore, this research identified what factors relating to the individual and their environment may facilitate the main elements of serendipity and further influence its perception.**

Introduction

Serendipity is often credited with contributing to innovation (Campanario, 1996), the acceleration of business growth (University of Canterbury, 2013), and new research directions (Foster & Ford, 2003). Thus, in the bigger picture, it is important to understand serendipity, what influences it, and what may facilitate it. However, although serendipity tends to grab headlines when it has a substantive and wide-reaching impact, serendipity's importance at the micro level should not be dismissed in terms of the positive affective response it evokes and the learning it sparks. Serendipity can bring simple pleasures and happiness to a person's everyday life (Rubin, Burkell, & Quan-Haase, 2011) and the surprise associated with serendipity has the power to jog our minds, to prod us to think, and learn more.

Anecdotes of serendipity surface periodically in the media and often include a narrative reflecting information needs, seeking, and use. These stories illustrate the notion that information is both incidentally acquired and purposefully sought (Williamson, 2005) and underline the relevance of serendipity within information science (IS). Julian Luxford, a medievalist, for example, was combing through 14th century manuscripts, conducting research on drawings when he stumbled upon marginalia from the 15th century referencing Robin Hood. The marginalia reinforced the belief that Robin Hood had inhabited Sherwood Forest and presented a rare negative view of the outlaw. Perceiving the marginalia's value, Luxford examined the research surrounding Robin Hood and shared his findings with the historical community (Luxford, 2009).

Serendipity has been defined as "the interactive outcome of unique and contingent 'mixes' of insight coupled with chance" (Fine & Deegan, 1996, p. 434), which is an apt description of Luxford's serendipitous experience. Serendipity, however, may be viewed from multiple perspectives, not unlike the multiple ways in which *information* has been conceptualized as thing (Buckland, 1991), thought and memory, a communication process, an artifact, and energy (Marchionini, 2010). Serendipity, for example has not only been conceptualized as an outcome (Fine & Deegan, 1996),

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but also a process (Makri & Blandford, 2012), a trigger (Thudt, Hinrichs, & Carpendale, 2012), and a method (e.g., Lenox, 1985). The diversity reflects the broad conceptual space of serendipity and hints at the difficulty of studying a phenomenon with such a "slippery nature" (Makri & Blandford, 2012, p. 684). But to make informed decisions about how to support serendipity in the context of work and research, we need to understand the phenomenon. This research helps lay this groundwork.

Prior Research

General information needs, seeking, and use models are characterized by their often-purposeful frameworks. Although serendipity is not immediately evident in these goal-outcome information models, they often describe parts of the experience. Ellis's (2005) model of information-seeking behavior captures Luxford's more routine information activities both when he stumbled upon the marginalia and when he followed up on the discovery—activities including *starting, extracting, verifying*, and *ending*. Serendipity is reflected in Dervin's (Dervin & Foreman-Wernet, 2003) theory of sense-making, the discontinuity we feel as we encounter unfamiliar situations and information to which we must adapt and ascribe meaning. Indeed, any number of information models could be pieced together to describe serendipity, but no single general model of information explains serendipity. When serendipity makes an explicit appearance in general information models it is in the form of serendipity-related constructs such as information encountering (IE) (Erdelez, 2005), passive search (Wilson, 1999), or incidental information acquisition (IIA) (Heinström, 2006) in which something—a hyperlink, a misshelved book—leads an individual to diverge from an intended path. But these constructs fall short of serendipity. More holistic interpretations of serendipity include how what was encountered was in turn used and are inclusive of pseudo-serendipity—finding something that was sought in an unexpected manner, not just finding something unsought (McBirnie, 2008; van Andel, 1994).

A model of serendipity is needed to help fill in the gaps in information needs, seeking, and use models and augment the underdeveloped elements of those models pertaining to serendipity; namely, what facilitates serendipity and the perception of chance, luck, or accident that captivates us when we read about serendipitous experiences or experience them for ourselves. The following review of prior research explores models of serendipity and what influences serendipity.

Models of Serendipity

Four recent empirical models in IS describe serendipity and were derived from research with a common purpose: to gain a greater understanding of serendipity in everyday life (Rubin et al., 2011) or research (Makri & Blandford, 2012; McCay-Peet & Toms, 2010; Sun, Sharples, & Makri, 2011). McCay-Peet and Toms's preliminary model is an adaption of Cunha's (2005) conceptual model and thus the latter is included in the Table 1. The main elements of the models are organized by theme: (a) *Precipitating conditions or context*; (b) *Noticing*; (c) *Connection*; (d) *Post connection*; (e) *Unexpected, chance, or accidental aspect*; (f) *Positive aspect or outcome*; and (g) *Reframing of or reflection on experience*.

Makri and Blandford's (2012) and Rubin et al.'s (2011) models highlight the internal thought processes of serendipity and how individuals come to perceive an experience as serendipitous, using words such as *consider, perceived,* and *reframe*. Developed through an analysis of 56 blog entry accounts of chance encounters, Rubin et al.'s model identifies four main facets of serendipity relating to *the find*: *prepared mind*, *act of noticing*, *chance*, and *fortuitous outcome.* The model illustrates how the individual reframes an experience as a story of serendipity in retrospect with the perception of a fortuitous outcome. Similarly, in Makri and Blandford's model, a person considers an experience serendipitous at the end of an iterative, self-reflecting process. Derived from a study of 28 interdisciplinary researchers' experiences of serendipity, the model illustrates that a person makes a *new connection* between some *thing* and a *need*, *projects the potential value of an outcome* of the connection made, and *exploits the connection* to gain a *valuable, unanticipated outcome*. A person may *consider the experience serendipity* after reflecting on the *outcome*, the *insight* involved, and its *unexpectedness*.

The remaining three serendipity models take a less inward-turning approach and focus more on what influences the process from the outset. In our preliminary model, we (McCay-Peet & Toms, 2010) adopted a conceptual model of the serendipity process (Cunha, 2005) from organizational management as a framework for the analysis of previously collected interviews with 10 historians on their information-seeking behaviors (Duff & Johnson, 2002). According to McCay-Peet and Toms's model, while *searching for a solution to task A* and immersed in *precipitating conditions*, a person perceives a *trigger* or external stimulus that sparks a *bisociation* or clash of mental models between previously unconnected information or ideas leading to an *unexpected solution to task A or B*. *Precipitating conditions* (Cunha, 2005) is the most salient element of this model, illustrating the hypothesis that serendipity may be facilitated. *Context,* similar to precipitating conditions, has been incorporated into a serendipity model derived from a mobile diary study and interviews of 11 PhD students to examine what hinders and facilitates serendipity (Sun et al., 2011). Sun et al. use Schmidt's (2000) conceptualization of context that includes human factors, the physical environment, and time.

The five models are complementary, offering different levels of granularity and perspectives, but generally converge on the main elements. The models, however, do not agree on what constitutes the *Unexpected, chance, or accidental aspect*. Moreover, precipitating conditions and contextual factors are proposed, but they primarily address the

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TABLE 1. Comparisons of the main elements of serendipity in five serendipity models.

Rubin, Burkell, & Quan-Haase, 2011	Makri & Blandford, 2012	Cunha, 2005	McCay-Peet & Toms, 2010, adapted from Cunha, 2005	Sun, Sharples, & Makri, 2011
Precipitating conditions or context				
		Search for Problem A; Precipitating conditions: relationships, temporal happenstance, active learning	Search for solution to task A; Precipitating conditions: relationships, temporal happenstance, active learning	Context: social and physical environment, time, pressure, focus of activity, attentional resources available
Noticing				
Facet B: Act of noticing: observation/ attention (relating to the find)			Trigger	Noticing, examining
Connection				
Facet A: Prepared mind: prior concern + previous experience (relating to the find)	Make new connection; Insight	Bisociation	Bisociation	Making connections
Post connection				
	Project potential value of outcome; Exploit connection			
Unexpected, chance, or accidental aspect				
Facet C: Chance: accidental nature/ perceived lack of control (relating to the find); Surprise	Unanticipated outcome, unexpectedness of circumstances	Unexpected solution; temporal happenstance	Unexpected solution; temporal happenstance	Unexpected connections, unexpected finding of information
Positive aspect or outcome				
Facet D: Fortuitous outcome: perceived gain/happy ending (relating to the find)	Valuable outcome	Solution for problem B	Solution to Task A or B	Positive impact (short term or long term)
Reframing of or reflection on experience				
Serendipity: re-framing events/ story retold/ unsought finding	Reflect on: value of outcome and unexpectedness of circumstances and role of insight; Consider as serendipity			

front end rather than the whole serendipitous experience. A more nuanced description of what may influence serendipity would aid in the development of approaches to support serendipity.

What Influences Serendipity

Prior research has pointed to a number of factors that may influence serendipity—individual differences, temporary states, and environmental characteristics. No factor, however, is more strongly associated with serendipity than the "prepared mind" (Pasteur, see Liestman, 1992). The importance of the prepared mind was noted in a case study of two scientists (Barber & Fox, 1958) in which both observed the same unexplained phenomenon but only one recognized its value and had a serendipitous experience. Personality traits and search styles may also influence serendipity. In studies ($N = 305$ masters' students; $N = 27$ ILS students) reported by Heinström (2006), extraverted students more frequently experienced IIA. A relationship was also found between IIA and *broad scanning,* "a search style where a topic is spontaneously explored through a wide use of sources" (p. 587)—a type of divergence that is tightly coupled with the phenomenon of serendipity.

Both digital and physical environments have been credited with supporting divergence and serendipity. An experi-

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mental study of 47 adults who were given search goal tasks and non-goal directed tasks to perform in a newspaper database found that the suggestions tool led participants to useful news stories they did not intend to find (Toms, 1997). Relative to physical spaces, Pálsdóttir (2011) conducted interviews with 24 elderly people and found that information grounds—informal social spaces that encourage spontaneous information sharing—facilitate opportunistic discovery of information. Over a period of 10 months Björneborn (2008) unobtrusively observed the behavior of library patrons in two Danish libraries. Interviews with 113 and think-aloud sessions with 11 of these patrons were designed to study the impact of the physical library space on divergence. Ten *serendipity dimensions* of the physical environment of the library were identified, including *diversity, pointers, imperfections, cross contacts, and explorability*. However, although researchers have identified characteristics of the environment that may foster information encountering and divergent behavior, we have yet to go that step further and confirm whether these characteristics support *serendipity*.

Research Questions

This article presents a portion of the first author's PhD work on serendipity (McCay-Peet, 2013). The study described here focuses on serendipity experienced by academics and professionals engaged in work that involves not only the use of information but also the development of new knowledge or the sharing and repackaging of knowledge in informative and sometimes creative ways. Based on the convergences, divergences, and underdeveloped elements of previous serendipity models (Table 1) we developed two main research questions:

RQ1 Do previous models adequately explain how serendipity unfolds in relation to one's work?

RQ2 What may influence the process of serendipity?

Understanding how serendipity unfolds and what facilitates it will help us in the development of environments that have the potential to support serendipity.

Method

This study used a semi-structured interview method. The scope of the research was limited to work-related examples of serendipity; however, examples did not necessarily occur entirely in the physical work place, reflecting the often-blurred boundary between work and everyday life. We performed a thematic analysis of the transcripts (Braun & Clarke, 2006) and part of the analysis included the application of the elements identified in previous serendipity models (Table 1) to the interview data.

Participants

Sampling for this study was non-probabilistic. Participants from a variety of fields were sought through universities' mailing lists as well as targeting people referenced in media reports of serendipity. An inclusion/exclusion questionnaire was used to ensure participants had at least one example of serendipity to explore in depth. No compensation was provided. Data collection ended when recurring patterns were identified (Guest, Bunce, & Johnson, 2006). The 12 participants were drawn from across Canada, included 7 females and 5 males, and were mostly between the ages of 46 and 65 ($N = 9$, 75%). Most participants ($N = 8$) held a doctoral degree and had worked in their fields for 6 to 42 years ($M = 22.3$).

Interview Protocol

Although concepts derived from prior research and models of serendipity (Cunha, 2005; McCay-Peet & Toms, 2010) were used as the basis for some of the interview questions, effort was made to ensure the exploration of participants' experiences was not solely based on predetermined concepts. The interview included questions about the participants' work, the definition of serendipity, a specific example(s) of serendipity, and serendipity in general. The main portion of the interview, however, centered on the example(s) of serendipity in order to ground the interview in memorable serendipitous experiences. The interview protocol can be found in McCay-Peet (2013).

Procedure

Participants were recruited and administered an inclusion/exclusion questionnaire. Recruitment and interviews took place from July to October 2010. Each 35 to 70 minute interview session, by telephone or in-person, followed the same procedure: presentation of research problem; consent form; demographics questionnaire; audio-recorded interview with first author; and follow-up consent form.

Data Analysis

Each interview was professionally transcribed and loaded into NVivo 9 software for analysis using a thematic analysis method (Braun & Clarke, 2006). The first author conducted several iterations of data analysis and peer debriefing within the serendipity research community was used throughout this period (Manning, 1997). Analysis began before three of the five models outlined in Table 1 were published (Makri & Blandford, 2012; Rubin et al., 2011; Sun et al., 2011); therefore, preliminary analysis was influenced by concepts identified in the other two models (Cunha, 2005; McCay-Peet & Toms, 2010). Aspects of the latter models were altered (e.g., *bisociation* became *connection*) or removed (i.e., *search for a solution to problem* or *task A*), and augmented (e.g., *unexpected thread*) to reflect the data. Definitions for codes were developed during analysis and then used to deductively code the transcripts. Partway through the analysis a research assistant with no expertise on serendipity coded a varied

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TABLE 2. Summary of participants and their examples of serendipity.

Participant	Interview length	Years spent in field	ID	Example
Digital humanities scholar	60 min.[a]	17	P1	Stumbled upon software that provided a new approach to studying the history of the book that led to a new research path.
Information manager	40 min.[a]	20	P2a	A chance meeting with a colleague on a bus provided an unexpected career opportunity.
			P2b	During lunch at a conference, a colleague unexpectedly offered an idea to improve the organization's search system.
Occupational therapy professor	50 min.[a]	24	P3	A chat over coffee with her boss led her to make an important connection between her work and that of a student and mentee.
Medical doctor	40 min.[a]	29	P4	An unexpected opportunity to interview for a residency changed the course of her life.
Occupational therapist/ therapy scholar	70 min.[b]	40	P5a	She found a new way to conceptualize her profession that had global implications.
			P5b	She was exposed to the notion of getting a masters education by distance that prompted her to take an unexpected path.
English literary scholar	60 min.[a]	22	P6	She found an incorrectly indexed manuscript that turned out to be a very important and previously unknown collection of a poet's work.
Education scholar	55 min.[b]	30	P7	She made a connection between water and her research on civility that led to an international collaboration to reduce water conflict globally.
Molecular biologist	55 min.[b]	15	P8	While skiing, she observed insects hopping on the snow that she later tested and found contained effective antifreeze proteins.
Creative writer	35 min.[a]	13	P9	While en route to a funeral, she spotted a phrase spray painted under an overpass that became the basis for her first book of fiction.
Journalist	40 min.[a]	6	P10	Stumbled upon an unsubstantiated claim in Wikipedia about the origin of an internationally famous song that led her to discover a near-forgotten piece of local history.
Computer scientist/ professor	70 min.[a]	42	P11a	Following a research talk she gave, a PhD student in the audience led her to a solution to a problem she may not have made on her own.
			P11b	Students brought a paper containing a puzzling formula to her attention that reminded her of another student's problem from 15 years earlier –further problem solving and analysis led to a new explanation.
Information management (IM) professor	45 min.[a]	10	P12	She happened to look up at her screen that displayed her TwitterDeck just when a tweet appeared with a link to slides that she found relevant and she was able to use in an upcoming class lecture.

Note. [a]interview conducted in-person; [b]interview conducted by telephone.

selection of six transcripts using rich definitions of the codes. Disagreements were discussed, codes and themes refined, and definitions clarified before the final phase of analysis in which selected extracts were related back to elements drawn from prior serendipity models (Table 1). This final phase helped us to confirm some of our findings, identify what was unique to our model, and led us to re-examine all elements.

Findings

Drawing from diverse work experiences, participants described 15 examples of serendipity (Table 2). Examples are attributed to participant numbers (e.g., P1) and an additional "a" or "b" is added for those with more than one example (e.g., P2a). To protect anonymity, names of people, places, and organizations have been changed and all participants are referred to as female.

Model of Serendipity

The study findings are discussed in this section within the framework of the serendipity models (Table 1). *Precipitating conditions or context*—one of the models' seven elements—will be addressed in response to the second research question regarding what may influence serendipity. Although this study confirmed elements identified in previous models, changes were made to their names and definitions to clarify and streamline them and reflect the current study's findings (Table 3). *Noticing* became TRIGGER, *Post Connection* became FOLLOW-UP, whereas *Unexpected, chance, or accidental aspect*, *Positive aspect or outcome*, and *Reframing of or reflection on experience* were modified and became UNEXPECTED THREAD, VALUABLE OUTCOME, and PERCEPTION OF SERENDIPITY, respectively. *Reframing of or reflection on experience* was also conceptually divided to become part of VALUABLE OUTCOME whereas another aspect of this original element was isolated to become the DELAY that sometimes occurs. The serendipity elements are written in all capitals (e.g., TRIGGER).

Figure 1 illustrates the process of a serendipitous experience beginning with a TRIGGER. The faded arrow reaching upward from CONNECTION to TRIGGER is dotted to allow for the possibility of a DELAY if an individual is unable to make a CONNECTION between a TRIGGER and

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TABLE 3. Main elements of the process of serendipity.

Element	Element name in previous serendipity models	Definition
TRIGGER	*Noticing*	A verbal, textual, or visual cue that initiates or sparks an individual's experience of serendipity.
DELAY[a]	*Reframing of or reflection on experience*	The interval that may occur when an individual perceives a TRIGGER but does not immediately recognize a CONNECTION between the TRIGGER and the individual's knowledge and experience.
CONNECTION	*Connection; Reframing of or reflection on experience*	The recognition of a relationship between the TRIGGER and the individual's knowledge and experience.
FOLLOW-UP[a]	*Post connection*	Actions taken to make the most of a TRIGGER or CONNECTION and obtain a VALUABLE OUTCOME.
VALUABLE OUTCOME	*Positive aspect or outcome; Reframing of or reflection on experience*	The positive effect of the serendipitous experience both realized and projected.
UNEXPECTED THREAD	*Unexpected, chance, or accidental aspect*	The unexpected, chance, accidental, or surprising element that is evident in one or more of the TRIGGER, CONNECTION, FOLLOW-UP, or VALUABLE OUTCOME elements of the serendipitous experience.
PERCEPTION OF SERENDIPITY	*Reframing of or reflection on experience*	An experience is understood or regarded to be serendipitous based on awareness of its TRIGGER, CONNECTION, VALUABLE OUTCOME, and UNEXPECTED THREAD.

Note. [a]Unlike the other elements in this table, DELAY and FOLLOW-UP do not have to happen for PERCEPTION OF SERENDIPITY to occur.

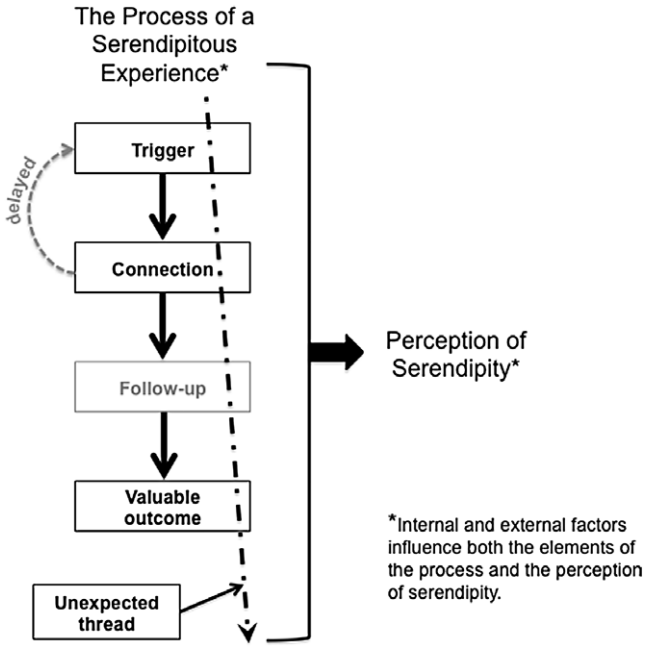

FIG. 1. The process of a serendipitous experience.

one's knowledge and experience. FOLLOW-UP is faded to represent the notion that VALUABLE OUTCOMEs and the PERCEPTION OF SERENDIPITY may occur before FOLLOW-UP is complete. UNEXPECTED THREAD does not exist on its own; rather, the unexpected is coupled with one or more of the other elements. The awareness of four crucial elements of the process of serendipity—TRIGGER, CONNECTION, VALUABLE OUTCOME, and UNEXPECTED THREAD—feed into the PERCEPTION OF SERENDIPITY. Finally, internal factors and external factors influence both the elements of the process of serendipity and the PERCEPTION OF SERENDIPITY.

Trigger

The TRIGGER element confirms the *Noticing* element found in previous serendipity models (Table 1). There was no discernable pattern of activity across all participant examples but something *external* to individuals served as a catalyst for serendipity. Three forms of TRIGGERs were identified: (a) verbal, (b) textual, (c) visual. Verbal TRIGGERs generally sprang from conversations among participants and colleagues, textual TRIGGERs were text-based cues observed in books or on web pages, and visual TRIGGERs were nontextual cues including observations of nature.

The most common type of TRIGGER was verbal. The social aspect of serendipity was readily apparent in the verbal TRIGGER—the notion that serendipity springs from interactions with other people or *relationships* (Cunha, 2005; McCay-Peet & Toms, 2010). The digital humanities scholar, for example, stumbled upon a new approach to studying the history of the book through a conversation with her husband about his work. Thinking she recognized a photograph on his computer screen,

> I simply said, "What's that?" and [Bob] responded [. . .] about the totality of what [Bob] was working on. And [Bob] said, "*it's particles of soil moving through the air above the Prairies.*" And I immediately said, teasing him *chuckling*, "[. . .] I'd only be interested if it was books on ships moving across the Atlantic." And [Bob] immediately teased me back and said, "*Well don't be so foolish.*" And I thought, it could be books on ships moving across the Atlantic, the software doesn't care. *laughing* And that was a eureka moment for me. (P1)

What the scholar's husband said to her during this brief exchange was the catalyst for helping her think differently about software that she had known about for years.

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Delay

The TRIGGER sometimes needs time to percolate or bubble in the individual's mind leading to a DELAY in making a CONNECTION. In the case of the occupational therapy professor (P3), she noted reading about a finding in her masters student's work (textual TRIGGER), talking with him about the finding over lunch (verbal TRIGGER), talking with him and one of his thesis readers about their common findings (verbal TRIGGER), and the tipping point when talking with her boss about the findings over coffee (verbal Trigger) before realizing she had a similar finding.

> I'd noticed it before in [John]'s work, [. . .] I hadn't ignored it. I just hadn't seen it in my own work. I hadn't framed my own work that way. Although it is funny because you'll see a poster out there and it is right clear through the poster, that I wrote some time ago [. . .]. So it has been percolating, but I just didn't see it, couldn't pull it together. (P3)

DELAY reflects an aspect of the *Reframing of or reflection on experience* (Table 1). DELAY is similar to the *incubation period* (McCay-Peet & Toms, 2010) and what Makri and Blandford (2012) refer to as *reflect on value of outcome*—both refer to a time-lag between an information encounter and when the individual fully recognizes the value or potential of the information encountered. However, although DELAY and *incubation period* refer to a period of time before the CONNECTION is made, *reflect on value of outcome* refers to further connections that are made after the original CONNECTION and is thus folded into our revised model's FOLLOW-UP element.

Connection

The CONNECTION element identified in participant examples reflected the *Connection* element in Table 1. The molecular biologist described the CONNECTION between the TRIGGER—insects hopping on the snow—and her knowledge and experience:

> We don't find that many [insects] have antifreeze proteins. But if they are active at sub-zero temperatures [. . .] there is a higher probability that they are going to have those proteins. (P8)

The relationship between the TRIGGER and the molecular biologist's knowledge and experience was crucial, indicating which insects most likely contain antifreeze proteins. Two subthemes of CONNECTION were identified that point to the nature of the relationship:

1. Known problem CONNECTION describes a relationship between the TRIGGER and the worker's previously identified or current problems. This finding is similar to Rubin et al.'s (2011) "solution to a prior problem or concern" (n.p.) and Foster and Ford's (2003) impact of "reinforcing or strengthening the researcher's existing problem conception or solution" (p. 330).
2. New direction CONNECTION describes a relationship was between the TRIGGER and new, previously unidentified work-related opportunities or directions. This is conceptually related to Rubin et al.'s "new action plan or action taken" (n.p.) and Foster and Ford's "taking research in a new direction" (p. 331).

The former has the potential to solve a prior problem or need whereas the latter opens up opportunities to pursue previously unidentified work-related problems or interests. Though the mental effort required for the two types differ, both may require a great deal of FOLLOW-UP.

Follow-Up

The element of FOLLOW-UP is partly evident in an information encountering episode as *capturing* (Erdelez, 2005). But FOLLOW-UP more fully encapsulates the post connection iterative process of *projecting potential value*, *exploiting*, and *reflecting* proposed in Makri and Blandford's (2012) model. The CONNECTION invariably sets off a series of actions. In the context of work-related serendipity, TRIGGERs and CONNECTIONs are not enough; effort must be applied to make an impact in an organization or community. These efforts varied in granularity, depth, and importance and included: (a) capturing, (b) preparation for application, and (c) opportunity taken.

Capturing involved the practical ways in which participants handled the TRIGGERs and CONNECTIONs before use and included e-mailing, recording, bookmarking, or photocopying. Participants also reported preparation for application—testing, further reflection, learning and research, networking, and writing abstracts, articles, reports, and books. The journalist who came across an unsubstantiated claim on Wikipedia, for example, needed to verify whether a speech that had inspired a famous song was made for the first time in his province:

> [. . .] My editor was saying, "well, if this is a speech he made a hundred times and just happened to remake it in [Town], then we are not that interested." (P10)

The journalist had to corroborate the claim to ensure the story was both legitimate and significant.

Finally, serendipity that could be described as unexpected opportunities for study and work differed from other work-related examples of serendipity—potentially suggesting a different type of serendipity. Participants simply had to *take* the opportunity presented to them. Although career and study choices had a cascading impact, the serendipitous experience itself did not include a direct impact on participants' organization, community or field. Instead, the VALUABLE OUTCOMEs were largely personal in nature.

Valuable Outcome

There must be a positive aspect to an experience for it to be perceived as serendipitous. For example, the excitement

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of making a CONNECTION, the pleasant surprise involved with the UNEXPECTED THREAD, or the rewarding challenge of some aspect of FOLLOW-UP. The VALUABLE OUTCOME may be described on three levels: (a) personal, (b) organizational or community, and (c) global. Many used descriptors such as *joy*, *intellectual pleasure*, and *satisfying personally* in reference to how it had a personal positive effect, ranging from minor to life changing. On an organization or community level, the molecular biologist (P8) noted the VALUABLE OUTCOME was an extension of knowledge in her area of research. One participant perceived that her experience generated global awareness of everyday injustice. The occupational therapy scholar's (P5a) insights, her new way of conceptualizing occupational therapy in relation to justice, sparked an interest in the everyday concept of "occupational justice." This raised awareness amongst those interested in occupational justice and helped to forge justice and human rights discussions with philosophers, educators, and policy makers on the world stage.

Beyond the realized VALUABLE OUTCOMEs, many expressed what they *hoped* would be VALUABLE OUTCOMEs as several were still in the FOLLOW-UP stage during interviews. Makri and Blandford (2012) similarly refer to reflections that lead to "forward-facing projections [which] are made on the potential value of the outcome" (p. 691) and prompt further activities. The information management professional noted,

> We were limping along and then this [idea for a search system] came along. To be honest, we are [still] limping along but I think we are limping in a more positive direction. (P2b)

Simply the *possibility* of VALUABLE OUTCOMEs that could have an impact at the organizational or community or global levels contributed to the PERCEPTION OF SERENDIPITY.

Unexpected Thread

UNEXPECTED THREAD reflects the unexpected qualifiers found in this study and in different elements of the prior models (Table 1). The current study noted unexpectedness potentially throughout the process of serendipity, from TRIGGER through to VALUABLE OUTCOME, though not consistently in all elements or across all examples. Participants used words and phrases such as *just happened to, surprising, blew my mind, accident*, *chance, random, unusual,* and *unexpected*—to describe the TRIGGER, CONNECTION, FOLLOW-UP, or VALUABLE OUTCOME. The occupational therapy professor, for example, noted that after realizing the unexpected CONNECTION between her research and others' this led to an unexpected collaboration (FOLLOW-UP):

> You don't usually work from combining three different studies and coming up with something. That is really, really unusual in this field. You usually go off in your corner and write your little thing. (P3)

In the example just given and in others, the UNEXPECTED THREAD was woven throughout the narrative of serendipity.

Perception of Serendipity

The PERCEPTION OF SERENDIPITY reflects the concepts of *consider as* (Makri & Blandford, 2012) and *a story retold* (Rubin et al., 2011) as serendipity. Makri and Blandford note "after reflecting on both the value of the outcome and the involvement of unexpectedness/insight, the experience can be considered as serendipity" (p. 692); in other words, VALUABLE OUTCOME, UNEXPECTED THREAD, and CONNECTION (insight) contribute to the PERCEPTION OF SERENDIPITY. Rubin et al., on the other hand, put more emphasis on the *unsought finding,* which aligns with the revised model's UNEXPECTED THREAD and TRIGGER elements. Put together, the perception of serendipity is linked to an awareness of TRIGGER, CONNECTION, VALUABLE OUTCOME, and UNEXPECTED THREAD elements of a serendipitous experience and this was reflected in our own study findings. The DELAY is not a necessary element to the perception of serendipity and whereas FOLLOW-UP may be needed to reach some of the potential organizational, community, or global VALUABLE OUTCOMEs, as already noted, serendipity may be perceived by simply anticipating and hoping for these outcomes.

Although prior models (Makri & Blandford, 2012; Rubin et al., 2011) are from the perspective of the individual who experienced serendipity, people who hear about the experience have their own perceptions, further underlining the subjectivity of the perception of serendipity. The molecular biologist's (P8) example was reported in the media as serendipitous because of the manner in which she stumbled upon the TRIGGER while skiing. Her own perception, however, was different—within the context of other examples of serendipity in science such as X-rays she had not thought of her example as particularly serendipitous. She periodically goes outside to collect specimens to be tested and,

> The only flaky thing about it was the time that I happened to notice these particular creatures was when I was skiing. They just happened to be abundant at that particular time and that's it. (P8)

There appear to be degrees of serendipity that may hinge upon the element of unexpectedness in the eye of beholder. On this note, it is noteworthy that the word serendipity does not actually appear in any of the reports of the Robin Hood marginalia discovery (see Introduction) despite the fact that this story contains all of the elements of a serendipitous experience. We labeled it as such.

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TABLE 4. Factors that may facilitate the process of serendipity.

Factors that may facilitate the process of serendipity (E = external; I = internal)	Definition	Elements of the process of serendipity[b]		
		Trigger	Connection[a]	Follow-up
Trigger-rich (E)	An environment that contains sensory cues that have the potential to spark serendipity.	X		X
Highlights triggers (E)	Something or someone who highlights, points to, or otherwise alerts an individual to TRIGGERs.	X		X
Openness (I)	To be curious or open or receptive to experience. Openness may describe a personality trait, conscious strategy, or a temporary state.	X	X	X
Prepared mind (I)	The individual's knowledge and experience.	X	X	X
Ability to make connections (I)	To be able to think critically or creatively about relationships between encountered ideas, information, and phenomena and the individual's own knowledge and experience		X	X
Enables connections (E)	Something or someone who encourages exploration, critical thinking, and the sharing of knowledge and ideas that make it possible to see relationships between information and ideas.		X	X
Enables capturing (E)	Something or someone who helps an individual record or copy a TRIGGER for later use.			X

Note. [a]What facilitates a CONNECTION also has the potential to shorten or help move individuals through a DELAY to a CONNECTION.
[b]Three of the main elements of the process of serendipity are included here as these three involve specific interactions between the individual and their environment and lend themselves to facilitation. Influences on VALUABLE OUTCOMES, UNEXPECTED THREAD, and PERCEPTION of SERENDIPITY are explored later in this section.

What may Influence Serendipity

Confirming, augmenting, and consolidating serendipity models enabled us to explore how each element may be influenced. Because our study examined examples of *serendipity* rather than *serendipity lost* (Barber & Fox, 1958), we primarily found factors that facilitated rather than hindered the process of serendipity. Although potential influences on VALUABLE OUTCOME, UNEXPECTED THREAD, and PERCEPTION OF SERENDIPITY were explored, we first examined factors that may facilitate TRIGGER, CONNECTION, and FOLLOW-UP. We found that the latter three elements involve interactions between individuals and their environment and thus lend themselves to facilitation (Table 4). These factors include: (a) four external or environmental factors—trigger-rich, highlights triggers, enables connections, and enables capturing; and (b) three internal factors relating to the individual—openness, prepared mind, and ability to make connections. The factors are written in bold italics (e.g., ***Openness***).

Trigger

Four key factors appeared to facilitate the TRIGGER: 1. ***Trigger-rich***, 2. ***Highlights triggers***, 3. ***Openness***, and 4. ***Prepared mind***. Although the first two factors represent external factors relating to the environment, the latter two represent internal factors relating to the individual.

1. **Trigger-rich***:* Many of the TRIGGERs sprung from interactions with other people involving both face-to-face interactions as well as asynchronous interactions mediated by information technology—what could be included under the broader category of *social and physical environment* (Sun et al., 2011) or the precipitating condition of *relationships* (Cunha, 2005). The IM professor (P12), for example, noted that the TwitterDeck application she had set up on her second computer screen allowed her to maintain awareness of topics by providing "access to this stream of thoughts and ideas from different people" who shared valuable resources. The medical doctor, similarly noted a dynamic environment:

> Potentially if things are really on the boil, and you are really in a dynamic environment with people who have lots of views and lots of ideas and things are happening and they have big social networks etc., etc., then things [. . .] do often happen. (P4)

Environments that are ***Trigger-rich*** allow individuals to brush up against information and ideas they may not have otherwise encountered that have the potential to spark serendipity.

2. **Highlights triggers***:* One of the challenges for individuals in dynamic, ***Trigger-rich*** environments is noticing a TRIGGER. The availability of *attentional resources* (Sun et al., 2011) is a factor; however, something or someone who ***Highlights triggers*** may help facilitate serendipity. The occupational therapy professor (P3), commented regarding her master's student's research finding:

> I wonder if I would have caught it as much if I hadn't had an encounter with him [the masters student] and *he was really excited about that finding*. [. . .] It really resonated with me. (P3)

The TRIGGER, in this case, was clearly highlighted through the *emotion* of the student, making it more salient to the scholar, helping it to stand out among the student's other findings.

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3. **Openness***:* Similar to Sun et al.'s (2011) findings, noticing the TRIGGER often appeared to occur during temporary states of unfocussed attention in which attention was not directed and behavior was more exploratory, more open. Some participants noted shifting their attention prior to noticing the TRIGGER. The digital humanities scholar described how she habitually takes a mental break, as she did when she stumbled upon her TRIGGER:

> When I'm working, I am aware that [. . .] I can probably *really* focus on something for about 55 minutes. And then I take a mental break. And the mental break might just be 60 seconds [. . .]. (P1)

It was during this type of temporary period of ***Openness*** in which participants like the digital humanities scholar allowed their minds and attention to wander, that they noticed the TRIGGER.

4. **Prepared mind***:* Many participants indicated the importance of their knowledge and experience in their field—their ***Prepared mind*** (Pasteur, see Liestman, 1992). The ***Prepared mind*** primes individuals to recognize a TRIGGER relative to their work. The importance of experience is evident in the creative writer's (P9) explanation for why she took special note of the graffiti that became the inspiration for her first work of fiction:

> [. . .] As a writer *I am really aware of text and how it sounds*. A lot of writers I talk to, especially poets, [. . .] are always looking for word combinations [. . .] So text is really important to me, as it is my tool as a writer. And so found text is always just exciting. (P9)

When the writer saw the graffiti on the overpass, she was able to recognize its potential value as a source of inspiration for her own writing.

Connection

Four key factors appeared to facilitate the CONNECTION element of serendipity: (a) ***Openness***, (b) ***Prepared mind***, (c) ***Ability to make connections***, and (d) ***Enables connections***. Although the first three are internal factors the last two are external. As DELAY is essentially a delayed CONNECTION, these factors may also help an individual get past a DELAY.

1. **Openness***:* ***Openness*** enabled the computer science professor (11b) to make a CONNECTION that she may have otherwise dismissed because of her ***Prepared mind***. She noted the importance of ***Openness***, referencing it as an ability.

> to be able to ignore the obvious objections of saying "no, that is just stupid," and say, "I have seen something like that before." (P11b)

The professor had been approached by students with a puzzling formula that she felt was wrong. Had she not been open and taken a closer look, she would not have been able to help solve a problem that had been at the back of the professor's mind for 15 years. Her ***Prepared mind*** could have hindered serendipity, but her ***Openness*** intervened.

2. **Prepared mind***:* How the ***Prepared mind*** facilitates the CONNECTION element of serendipity was most evident in the English literary scholar's (P6) description of why she was able to make a CONNECTION where no one else had:

> [. . .] Because I had had *that background preparation*, I was then able to make connections and see patterns [. . .]. If anybody had ever looked at it before they'd just probably seen it as just, "okay this needs to be filed under whatever." (P6)

The literary scholar was able to recognize the value of the poet's manuscript because of her ***Prepared mind***.

3. **Ability to make connections***:* Individuals actively make a CONNECTION by drawing on their own ***Prepared minds***, but these individuals must have the ***Ability to make these connections***, to think critically or creatively about potential relationships. A number of the participants specifically noted this type of ability or skill.

> [. . .] There were connections that I just didn't see before, that I had not been open to, receptive, and the links weren't there. I am not finding it in the research; I don't see water and civility being talked about in the research. *I am making that connection in a creative way.* (P7, education scholar)

When a CONNECTION was not readily apparent, creativity and the ability to think critically facilitated serendipity.

4. **Enables connections***:* In cases in which the relationship between the TRIGGER and the individual's knowledge and experience was difficult to grasp, help was needed from something or someone. ***Enables connections*** is related to ***Trigger-rich***, but goes a step further—the environment not only contains possible TRIGGERs, but actively engages individuals to think about those TRIGGERs. When asked whether she thinks colleagues spark serendipity, the occupational therapy professor replied that she surrounds herself with good people and sometimes they ask the right questions. She qualifies this, though, underlining the importance of the individual in making the CONNECTION:

> But I had to make the link; nobody was making it for me. Like [John] and [Jill] weren't making it for me and [Jen] wasn't making it for me. So there was a real interplay there between the social milieu and the accepting climate, but also that your brain has to be ticking. Do you require their questions to make your brain tick? I did that day. I don't know that I always. (P3)

The interaction between the individual and their environment is evident here. Through the conversation with her boss, Jen, the professor was able to finally connect the dots

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and see a new occupational therapy concept present in findings from three different studies.

Follow-Up

All of the facilitating factors of the TRIGGER and CONNECTION elements of serendipity also, in a more general way, facilitated the type of *preparation for application* FOLLOW-UP identified in this study. ***Enables capturing***, however, was unique to FOLLOW-UP and specifically supported the *capturing* type of FOLLOW-UP. For example, the English literary scholar (P6) was reliant on a librarian overseas to make microfilm copies of the manuscript she had stumbled upon. Without these copies she would not have been able to make the literary contribution that she did to her field.

Valuable Outcome

Not unlike Boden's (1999) notion of creativity in which she proposes that P-creativity entails generating an idea that is novel to its creator whereas H-creativity produces an idea that is novel to human history, novelty factored into the VALUABLE OUTCOME. Although this study indicated that it is possible to have VALUABLE OUTCOMEs on multiple levels, for academics and professionals, value may be mediated by what is already known or has been discovered. Some participants reported FOLLOW-UP activities that entailed confirming that their discoveries or insights were novel and set to work with FOLLOW-UP to ensure they would not be scooped. The molecular biologist, described one such scenario:

> So we purified [the protein] and then we cloned it. We reported the sequence [. . .]. And then somebody else came along and synthesized the protein and solved the structure before we were able to do it. So we got scooped. But before that [. . .], one of the graduate students had come up with a model that we published. (P8)

As this example shows, serendipity does not exist in a vacuum—serendipity both influences and is influenced by one's broader context and timing may influence the value of the outcome.

Unexpected Thread & Perception of Serendipity

An individual's awareness of the elements of serendipity is not sufficient to explain its perception. Rubin et al.'s (2011) serendipity model notes the importance of the *perceived lack of control* as it relates to *the find*. We found what facilitates the PERCEPTION OF SERENDIPITY is best illuminated in participants' reconciliation of control and lack of control—or the UNEXPECTED THREAD—in their recounting of serendipity. For example, the IM professor explained the randomness of her interactions with a social media site,

> Most of the time [TwitterDeck] is running in the background and sometimes you hear a noise [. . .] and that indicates a new message coming in. [. . .] And *I may or may not turn around* and look at my second monitor to read the message. Because sometimes I am busy and I don't read those messages all the time. (P12)

Although she acknowledged a level of control over her interactions with ideas and information on the site, this did not prevent the PERCEPTION OF SERENDIPITY. Similarly, other participants simultaneously held notions of *luck* and *choice* (P11) and *chance* and *preparation* (P6) within their experiences of serendipity suggesting that the interplay between internal and external factors that influence serendipity also influence its perception.

Discussion

This investigative study was designed to gain a holistic understanding of work-related serendipity. By drawing from previous models of serendipity and participants' specific examples, previous models were augmented and characteristics of the individual and the environment that may influence serendipity were identified. This section responds to our two main research questions relating to the model of serendipity and what may influence serendipity.

Model of Serendipity

We identified five main elements of the process of serendipity: trigger, connection (and possible delay), follow-up, valuable outcome, and unexpected thread. Furthermore, these elements feed the perception of serendipity. As well as confirming elements from prior models (Table 1), the consolidated model (Figure 1) augmented and clarified these models in the following ways:

- Specified three types of triggers: verbal, textual, and visual.
- Delay was identified as a separate (though optional) part of the connection element.
- Identified a new type of follow-up, opportunity taken, which may reflect a different type of serendipity (opportunity-oriented serendipity).
- Identified three levels of valuable outcome: personal, organizational or community, and global.
- Clarified the role of the unexpected in serendipity by identifying it as a thread that may weave through one or more of the elements of serendipity.
- Clarified that a valuable outcome need only be anticipated or hoped-for to prompt the perception of serendipity.
- Found that recognition of the serendipity elements does not guarantee the perception of serendipity.

Consolidating and augmenting the model of the process of a serendipitous experience contributed to the development of a definition of serendipity, which evolved over the course of the research. Based on our research, we define serendipity as

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An unexpected experience prompted by an individual's valuable interaction with ideas, information, objects, or phenomena.

Unexpected in this definition is an umbrella term that captures the notions of chance, accident, and luck reflected in prior research and other definitions of serendipity. But this definition makes room for the notion that the unexpected may be coupled with one or more of serendipity's elements, not tied to any one in particular element as in previous models, and thus representative of current conceptualizations and perceptions of serendipity that have broadened since the word's inception in 1754 (Merton & Barber, 2004). However, although it is important to capture the broad conceptual space of serendipity in the model and definition, it is also important to recognize that variants—pseudo serendipity and opportunity-oriented serendipity, for example—may require different methods of support.

The revised model points to a number of directions for future research. For example, in light of the identification of different types of triggers, we wonder whether some types of triggers may be more common in some domains. What may be categorized as triggers in prior research on scholars in the humanities and social sciences (e.g., Foster & Ford, 2003; McCay-Peet & Toms, 2010) are primarily verbal or textual in nature. Conversely, serendipity triggers in the sciences appear more visual in nature (e.g., Barber & Fox, 1958). Future research may examine how to approach support for serendipity in different domains based on the nature of their common triggers.

Furthermore, our research indicates that the perception of all of the elements of serendipity in an experience does not guarantee the *perception* of serendipity. But should we care as long as an individual or community reaps valuable outcomes? Serendipity is an important phenomenon to many professionals and academics such as historians (Martin & Quan-Haase, 2013). Thus, we would argue that striving to facilitate not only the elements of serendipity, but its perception in digital environments is important to designers and developers who want to attract and maintain users who value the phenomenon.

What may Influence Serendipity

In the language of Ingwersen and Järvelin's (2005) interactive information seeking and retrieval (IIS&R), context both influences and is influenced by *cognitive actors* and *information objects* over time. With respect to serendipity, the degree of novelty of the discovery or revelation is both dependent on the current state of a field of knowledge and, in turn, serendipitous findings impact that field of knowledge over time. At the micro-level, serendipity also involves an interaction between individuals and their environment and our definition of serendipity, an unexpected experience prompted by an individual's valuable interaction with ideas, information, objects, or phenomena, is designed to reflect this positive interaction. In order to increase the likelihood of serendipity, environments should be trigger-rich and highlight triggers but in turn individuals must be open to these triggers. Feeling overwhelmed by information encounters or feeling they take up too much time, for example, may impact whether potential triggers are dismissed or ignored (McBirnie, 2008; Yadamsuren & Erdelez, 2010). Moreover, environments may help by enabling connections, but individuals still need to have the prepared mind and ability to make those connections for serendipity to occur.

Serendipity may be facilitated by creating or immersing oneself in environments that are trigger-rich or contain the perceptual cues that act as a catalyst for serendipity. Trigger-rich settings include those designed to deliver information or provide opportunities for bumping into information such as libraries and unfamiliar environments (Sun et al., 2011), clubs and associations for the elderly (Pálsdóttir, 2011) and social media sites (Dantonio, Makri, & Blandford, 2012). Drawing attention to triggers may further facilitate serendipity because "a wealth of information creates a poverty of attention and a need to allocate that attention efficiently among the overabundance of information sources that might consume it" (Simon, 1971, pp. 40–1). Although visual saliency may lead to divergent behavior and serendipity (Björneborn, 2008) our findings further indicate that emotion or sounds that raise triggers above the din may also help prompt serendipity. When there is a delay in making a connection between information and ideas and one's knowledge and experience, this period may be supported through digital tools that encourage reflection and facilitate the incubation of ideas (Maxwell et al., 2012; Sawaizumi, Katai, Kawakami, & Shiose, 2007). Juxtapositions of ideas or information may also enable connections—something that may be possible through visualization tools that enable exploration (e.g., Thudt et al., 2012). However, whether these approaches support serendipity has yet to be confirmed. Differences in cognitive styles influence users' reactions to features of the interface (Chen, Magoulas, & Dimakopoulos, 2005) and highlighting triggers may not alleviate the inattentional blindness that leads even obvious items to go unseen (Wood, Cox, & Cheng, 2006). Moreover, mechanisms explicitly designed to facilitate serendipity may reduce perceptions of serendipity.

The prepared mind primes individuals to recognize potential triggers, helps them make connections, and follow up on them. Without the prepared mind there would be no connections to make. Preconceptions, however, may inhibit serendipity (Barber & Fox, 1958) and our study confirmed the potential of the prepared mind to act as a double-edged sword. Our *background books* or "preconceived notions of the world" (Eco, 1998, p. 54) help us recognize connections but may also prevent us from seeing something new. The ability of a person to make connections through creative or critical thinking as well as openness may temper the potentially negative effect of the prepared mind on serendipity. But it is diffficult to conclude from this study whether the personality trait of openness is at play or stategies or more temporary states of receptiveness and

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unfocussed attention. Although prior research indicated a relationship between broad scanning—a spontaneous search style—and IIA, no relationship was found between openness as a trait and IIA (Heinström, 2006). We can see, however, how extraversion, a trait related to IIA (Heinström, 2006), may play a role in serendipity—interactions between individuals and other people are important throughout the process of serendipity. Future research might examine whether social media tools, for example, make a significant contribution to the process of serendipity.

Conclusion

This article validated, and augmented prior serendipity models and explored how the elements of serendipity may be influenced through findings from interviews with academics and professionals. This research contributes to our knowledge of information interaction through the investigation of experiences in which information finds the individual, not solely experiences in which information is actively sought. Although a standard procedure for qualitative studies was followed, more participants may have changed the nature of the findings. This is particularly so given that while participants represented a diverse set of fields, there were only one or two representatives from each. Furthermore, observing serendipity has proven very difficult and thus we are primarily dependent on retrospective methods for understanding serendipity. Although participants were often able to describe the events surrounding their experiences in great detail, we were reliant on people's memories of experiences making it difficult to know how memories may have changed over time or what may have been forgotten. This research, however, points to a number of directions for future research, identifying several potential variables at play in the process of serendipity that beg further exploration and testing to allow us to develop validated suggestions for developers and designers for facilitating serendipity.

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