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Making my Own Luck: Serendipity Strategies and how to Support them in Digital Information Environments

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ABSTRACT
Serendipity occurs when unexpected circumstances and an 'aha' moment of insight result in a valuable, unanticipated outcome. Designing digital information environments to support serendipity can not only provide users with new knowledge, but also propel them in exciting directions they might not otherwise have travelled in - surprising and delighting them along the way. As serendipity involves unexpected circumstances it cannot be directly controlled, but it can potentially be influenced. However, to the best of our knowledge, no previous work has focused on providing a rich empirical understanding of *how* it might be influenced. We interviewed 14 creative professionals to identify their self-reported strategies aimed at increasing the likelihood of serendipity. These strategies form a framework for examining ways existing digital environments support serendipity and for considering how future environments can create opportunities for it. This is a new way of thinking about how to design for serendipity; by supporting the strategies found to increase its likelihood rather than attempting to support serendipity as a discrete phenomenon, digital environments not only have the potential to help users experience serendipity but also encourage them to adopt the strategies necessary to experience it more often.

Keywords
Serendipity; serendipitous; luck; encountering; chance; insight; creativity; design; digital information environments; information encountering

INTRODUCTION

An improvisational choreographer was on holiday in Italy, sitting in a garden with his daughter. His daughter insisted he played a game with her. The game involved stepping on the patio stones on the ground (which were made of uneven natural stones) without stepping on any of the cracks in-between the stones. The choreographer noticed that because the stones were not symmetrical, his and his daughter's pattern of steps was 'odd.' He suddenly had an 'aha' moment; he had wanted to find a way for a large group of people to pass through his studio floor space in a complex but unpredictable way. Playing this game with his daughter gave him the idea of using adhesive tape to create a system of uneven tiles on the studio floor. The uneven floor tiles made it impossible for people to move through the space in a predictable way. The choreographer had experienced serendipity.

The Oxford Concise English Dictionary defines serendipity as *"the occurrence and development of events by chance in a happy or beneficial way"* and points out that its origins are from the fairytale 'The Three Princes of Serendip' – where the princes *"were always making discoveries, by accident and sagacity, of things they were not in quest of."* (OCED, 2009). As suggested by this definition and supported by empirical research, serendipity occurs when unexpected circumstances and an insightful 'aha' moment result in a valuable, unanticipated outcome (Makri & Blandford, 2012a). Many scientific discoveries, from Velcro to Viagra, have been attributed to

serendipity (Roberts, 1989) and it has been found to be both an important element of academic research (Foster & Ford, 2003; McBirnie, 2008) and a driver for creativity more broadly (Czikszentmihalyi, 1997; Johnson, 2010). Previous studies have found that although serendipity cannot be directly controlled, it *can* be influenced. However, to the best of our knowledge, no previous work has focused on providing a rich, empirical understanding of *how* it can be influenced.

Supporting serendipity in digital information environments not only has the potential to expose users to new information and result in the acquisition of new knowledge, but also to propel users in useful and exciting directions they might not otherwise have travelled in – surprising and delighting them along the way. Several digital environments (including information environments) have been designed and design suggestions proposed with the aim of creating opportunities for serendipity. Most of these existing environments and design suggestions have been based on an intuitive (rather than empirically-grounded) and broad (rather than detailed) understanding of the phenomenon; their aim has been to create opportunities for users to have unexpected and potentially valuable experiences. Supporting serendipity at this broad level has resulted in the design of digital environments with varied functionality (from recommending unexpected and valuable content that users might not otherwise have discovered to visualising unlikely connections between data). However, a lack of an empirical underpinning makes it difficult to identify what functionality it is particularly useful to support through design. Whilst the slippery and subjective nature of serendipity makes it difficult to provide an empirical underpinning to design recommendations for supporting serendipity, it does not make it impossible. A detailed understanding of serendipity grounded in peoples' own accounts of their experiences of the phenomenon can provide designers of digital environments with a conceptual structure for identifying and reasoning about design possibilities for supporting serendipity.

Our study involved gaining a detailed understanding of how creative professionals 'seek' serendipity (i.e. their strategies aimed at increasing its likelihood). We interviewed 14 creative professionals (including a chef, a composer and a comedian) who told us they frequently experience serendipity and asked them whether they adopted any strategies aimed at increasing its likelihood. All of the creatives reported adopting strategies that they perceived to increase the likelihood of them experiencing serendipity. These strategies (e.g. 'varying your routine' and 'making mental space') form a framework that provides empirically-grounded guidance on what functionality it might be useful to incorporate when designing to support serendipity in digital environments - including digital information environments.

The rest of this paper is structured as follows; in our background section we discuss existing empirical studies of serendipity, focusing on those that shed light on an issue that is central to our study - whether and how serendipity can be controlled or influenced. We then discuss the problematic notion of designing to support serendipity and existing suggestions for designing digital information environments aimed at supporting the phenomenon. We also review existing digital information environments that claim to support serendipity. Next, we describe our interview study aimed at identifying the strategies creative professionals use to influence serendipity and discuss each of these strategies and their relation to previous work. We also discuss ways that existing digital information environments currently support the strategies and propose additional illustrative ways of supporting them.

BACKGROUND

'Seeking' serendipity

Several qualitative studies have sought to convey an enriched understanding of serendipity (e.g. Foster & Ford, 2003; McBirnie, 2008; McCay-Peet & Toms, 2010; Sun et al., 2011; Rubin et al., 2011; Makri & Blandford, 2012a; Makri & Blandford, 2012b). These studies have resulted in the creation of theoretical frameworks for classifying serendipitous experiences (Foster & Ford, 2003; Sun et al., 2011; Makri & Blandford, 2012b) and the creation of empirically-grounded models describing the process and essence of serendipity (McBirnie, 2008; McCay-Peet & Toms, 2010; Makri & Blandford, 2012a). We review these studies in Makri & Blandford (2012b). Here, we focus on studies that have examined whether serendipity can be influenced.

The notion of 'seeking' serendipity is, at first glance, an oxymoron; serendipity includes an element of unexpectedness (Makri & Blandford, 2012a) and therefore cannot be sought out at will. However, previous research has found that the phenomenon can, to some extent, be influenced. Several lab-based studies have been conducted, with the aim of 'inducing' or encouraging serendipity (e.g. Toms, 2000; Erdelez, 2004; Toms & McCay-Peet, 2009; Bogers et al., 2013). Although these studies had limited success, they provide encouragement that it may be possible to observe serendipity in controlled environments if we set suitable tasks

to participants. Outside of a lab setting, a couple of previous interview studies also provide useful findings related to encouraging serendipity; Foster and Ford (2003) attempted to find out whether inter-disciplinary researchers thought serendipity could be 'consciously influenced or controlled.' They noted varied viewpoints; whilst some researchers referred to serendipity as 'almost deliberate randomness,' others described it as 'making their own luck' through hard work, persistence and determination. McBirnie (2008) asked academics and jazz improvisers about the nature of serendipity and concluded that *"while seeking serendipity seems improbable, paradoxically, some degree of control may be possible"* (p. 601). Describing this as the 'paradox of control,' McBirnie suggested that whilst the unexpected circumstances that result in serendipity cannot be controlled, the perception aspect of serendipity (which involves noticing and acting on these unexpected circumstances) has greater potential for control.

But how exactly can we potentially increase the likelihood of serendipity? Cunha et al. (2010) suggest that *"serendipity involves prepared, curious and open-minded people"* (p. 320). In 1854, French scientist Louis Pasteur famously stated that *"in the field of observation, chance only favours the prepared mind"* and having a 'prepared mind' has been noted as important for creating opportunities for serendipity (Toms, 2000; André & schrafel, 2009; Rubin et al, 2011; Makri & Blandford, 2012a). Cunha et al. (2010) suggest that a prepared mind can be associated with character traits such as alertness, flexibility, courage and assiduity. Curiosity has also been proposed as an important trait for influencing serendipity; McBirnie's (2008) interviewees suggested that an 'openness' to serendipity in information-seeking could be achieved by being flexible during active seeking and ready to explore tangential information. McBirnie also described the concept of a 'serendipity filter' – which her interviewees reportedly used to control how open they were to serendipity in the face of internal and external pressures (such as mood and stress). Foster and Ford (2003) suggested that researchers could make themselves 'open' to serendipity by being alert to potential connections between material, by examining material that may only seem loosely related to their current information task and by not being 'blinkered' when presented with new material.

Findings that serendipity *might* be influenced (at least by some people) spurred us to examine the question of how to influence serendipity in more detail. But this was only half our motivation. We also wanted to inform the design of digital information environments. This paper therefore provides a practical understanding of the strategies creative professionals use to influence serendipity and uses this understanding as a basis of an empirically-grounded framework for informing the design.

Designing to support serendipity

The notion of designing technology to support serendipity is problematic. If we attempt to 'engineer' serendipity through technology, users may no longer perceive the experience to be serendipitous. Rubin et al. (2011) suggest this is because *"after all, at the very core of the term is the notion of chance, or unexpectedness"* while André et al. (2009) argue that, by *"designing specifically for serendipity, we remove all elements of chance and accidental finding, ending with something barely recognisable as serendipity"* (p. 310). Paradoxically, it may even be possible to destroy serendipity by attempting to create it (Farrar, 2010); by attempting to design it explicitly into digital environments, we run the risk of users no longer perceiving their experiences arising from the use of these environments as serendipitous. They might, for example start to 'expect the unexpected' (i.e. become used to being exposed to unexpected information). This might lead them to become 'immune' to any unexpectedness or value provided by the environment.

André et al. (2009) suggest that whilst it is not possible to design specifically for serendipity, it may be possible *"for a computer searching for patterns of association or of related interest to be able to surface something that to its user would be perceived as a serendipitous discovery"* (p. 310). Therefore whilst it is difficult if not impossible to 'design serendipity' into digital environments, technology has the potential to *create opportunities* for users to have experiences they might (subjectively) perceive as serendipitous.

Many existing digital environments designed to support serendipity have attempted to support it based on an intuitive (rather than empirically-grounded) understanding of the phenomenon. They have also attempted to support it as a discrete phenomenon – by focusing on how they can incorporate aspects of serendipity (such as 'unexpectedness' or 'value' – see Makri & Blandford, 2012a) into their digital environments. This is akin to trying to offer *"serendipity on a plate"* (Dantonio et al., 2012) and is a particularly challenging endeavour.

A new way of thinking about how to support serendipity in digital environments involves moving away from trying to 'serve up' serendipity itself and towards empowering users to create their own personal 'recipes' for it - by supporting strategies that may increase its likelihood. Designing to support 'serendipity strategies' (such as

'varying your routine' and 'making mental space') is arguably more straightforward than designing to support broad aspects of serendipity such as 'unexpectedness or 'value.' It is also arguably more straightforward than designing to support broad stages of the process of serendipity, such as making or exploiting the value of mental connections. This is because less of a 'creative leap' is required to move from strategy to design suggestion than from the essence or process of serendipity to design. Designing to support serendipity strategies can encourage users to integrate these strategies into their work and everyday lives, potentially helping them to experience serendipity more often. Although there are ethical implications for designing technology aimed at shaping users' behaviour and character traits, we believe exposing users to serendipity is potentially far more useful than harmful; serendipitous experiences are, by definition, positive. Whether designing to create opportunities for these positive experiences, or to encourage users to change their behaviour or character to potentially have more of them, we believe supporting serendipity in interactive systems where appropriate is overwhelmingly a good thing.

Existing design suggestions

Existing work that has examined how to support serendipity in digital information environments falls into two categories: design suggestions and design implementations. In this section and the next, we describe existing design suggestions and review existing digital information environments that claim to support serendipity. Before this, we briefly discuss the potential value of supporting serendipity in digital information environments.

Since the advent of the Web, search algorithms have become increasingly sophisticated. It is now relatively easy for searchers to find information they need. It is more difficult, however, for them to find information they need, but *do not realise* they need. The popularity of search has resulted in it becoming almost a de facto standard for information acquisition. However, there is much joy to be had from browsing (or 'surfing') the Web – particularly as a result of coming across useful information unexpectedly. Indeed, serendipity can be supported in its simplest form by providing hypertext links between loosely-related pages. Serendipity can be a surprising and delightful way of users finding information they need, but did not realise they needed – connecting users not only to documents, but also to people, places and events that they might not have discovered otherwise. Serendipity is also a potential way to burst what Pariser (2012) calls the 'filter bubble' – where personalised search algorithms exclude results because they do not think users will find them relevant, resulting in users remaining unaware of the existence of the filtered information.

Design suggestions for supporting serendipity in digital information environments are broad in scope, but complementary in nature; Erdelez (1995) suggests that digital information environments should make information 'more browsable' and include functionality to *"encourage users' curiosity and urge them to explore the information environment more fully" (p*. 165). Toms (2000) suggests that digital information environments *"must stimulate curiosity and encourage exploration so that users may make opportune discoveries"* (p. 2). André and his colleagues have suggested that digital environments can potentially help users to be *"as primed as possible"* (André & schraefel, 2009) (p. 20) to make and take advantage of unexpected connections. They suggest that digital environments might be designed to *"optimize the opportunity for insight"* (André et al., 2009) (p. 306) by surfacing information that users might perceive as serendipitous, thereby assisting them in *"(perceiving) connections and opportunities in various pieces of information"* (André & schraefel, 2009) (p.20). They also suggest that digital environments can enhance users' intra and inter-domain expertise so they are more likely to recognise potentially valuable connections (André et al., 2009; André & schraefel, 2009) and provide them with an infrastructure to enable connections to *"flourish"* (André et al., 2009, p. 312).

Bawden (2011) suggests several criteria for supporting serendipity in digital information environments that were first published in 1986 but are arguably still pertinent today. These include: presenting *peripheral, speculative and inter-disciplinary* information, presenting information in a way that brings out *analogies, patterns and exceptions, emphasising browsing* as an interaction style and *personalising* information to individual users' preferences and requirements. McCay-Peet and Toms (2011) present several 'serendipity dimensions' that can be regarded as design suggestions for creating opportunities for serendipity. These include *enabling connections* between content and *supporting exploration*, *introducing unexpected information*, *presenting a variety* of information and supporting varied information-seeking behaviours such as browsing and exploration, *triggering divergence* (by capturing a user's attention and initiating divergent thinking) and *inducing curiosity* by encouraging deep exploration or consideration of information.

Aside from these general suggestions, researchers have also made specific recommendations for supporting serendipity in digital search and browse environments. These include encouraging the exploratory browsing of material by keyword and subject heading and making search recommendations (Watson, 2008). Watson (2008)

also suggests incorporating: a Google-style 'I'm feeling lucky' button, loosely-related search results in a side-panel on the search results page, user-generated content (e.g. reviews) and search ranking algorithms that are less relevance and more topic-focused. Burkell et al. (2012) suggest introducing random elements into search queries, making some results more visually salient than others, notifying users when information related to a topic they were previously interested in is encountered (e.g. by using colour-coded results) and supporting the annotation and association of search results.

Existing design implementations

As well as existing design suggestions, there are various existing digital information environments that claim to support serendipity. These fall into three distinct (but not mutually-exclusive) categories; those that 1) recommend digital content, 2) make location-based recommendations and 3) facilitate information visualisation. All of these types of environments claim to support serendipity by providing users with unexpected and valuable content that they might not have otherwise come across. However, except where reported below, claims that these environments support serendipity have not been tested (e.g. by systematically evaluating how or how well they support important aspects of serendipity). This suggests important potential for future research.

Digital content recommendation

Many existing digital information environments recommend content that users might want to look at that they may not otherwise have come across. This is often based on similarity between explicitly stated interests, previous content viewed or search terms submitted. As well as the environments designed by Toms and her colleagues (see Toms, 2000; Toms & McCay-Peet, 2009), several other environments have also been developed that support similarity-based recommendation. For example, Letizia (Lieberman, 1995) tracked users' web-browsing behaviour and tried to anticipate potential Web pages of interest by autonomously exploring the links available on the page they were currently visiting and Beale's Mitsikeru (2007) modelled users' Web behaviour, determined the context of their interaction and looked ahead at the Web pages linked from the current page to recommend potentially relevant ones. In a similar vein, Campos and Figueiredo, (2001) developed Max – an e-mail based system that asked users to send it URLs or texts to describe their interests, generated Google search queries based on random selections of keywords from those interests and e-mailed links to some of the results to users.

Location-based recommendation

Several mobile information environments have been developed that make location-based recommendations for events to attend and places to visit. Only some of these environments are, however, still functioning. Magitti (Bellotti et al., 2008) supported users in spontaneously finding leisure events of interest. It presented them with recommended things/places to see, do, eat, buy or read to visit based on an awareness of their interests and predictions of their current activity (inferred from their location). In a field evaluation, users expressed delight at unexpectedly discovering new places in areas they had frequently visited before. Similarly, Sounds of Helsinki (Forsblom et al., 2012) recommended events at a music festival, with the aim of helping festival-goers discover new artists, bands or songs of interest. As most recommendations were for events users had not previously known about, the authors concluded that the app was *"effective in supporting serendipity"* (p. 255). They also noted, however, that *"the recommendations were not considered particularly interesting or relevant"* (p. 255).

Rather than focus on recommending nearby events to attend, GetLostBot (Kirman et al., 2012) and DistractMi (Coombe et al., 2011) focus on making users aware of places around them that they might want to visit. GetLostBot (Kirman et al., 2012) monitors users' Foursquare check-in locations and, when they seem to be following a predictable routine, presents them with maps and directions to a nearby undisclosed location with a similar type of venue (e.g. a bar or restaurant they might not have visited before). Similarly, DistractMi (Coombe et al., 2011) presents alternatives to a user's usual route, encouraging them to discover new places of interest by pointing out potentially interesting places along their route. In a similar vein, Serendipity (Eagle & Pentland, 2005) made recommendations for nearby *people* to meet. It matched academic researchers based on their stated interests and invited them to meet and potentially collaborate.

Information visualisation

Digital information environments that claim to support serendipity through information visualisation have been developed by Beale (2007), Thudt et al. (2012) and Kleiner et al. (2013). Beale's Haiku allowed users to visually explore their Web navigation paths which, according to Beale, *"supports the serendipitous discovery of related*

material" (p. 425). However, as is the case with most existing 'serendipity systems,' the claim that Haiku supports serendipity has not been tested in the form of a user-centred evaluation.

The Bohemian Bookshelf (Thudt. et al., 2012) allows users to explore book collections through a series of interactive information visualisations. Its design was grounded in several serendipity-focused design goals including providing flexible visual pathways, enticing curiosity and encouraging playful exploration. The visualisations include a 'cover colour circle' that provides a visual overview of books based on their cover colour, a 'keyword chains' visualisation that shows relations between books based on linked keywords, a dynamically updating 'timeline' visualisation that shows the relation between the publication year of a book and the time period the book discusses, a 'book pile' visualisation that gives the user a visual indication of the physical properties of books such as their cover colour and page count and an 'author spiral' visualisation that can be unravelled in a similar way to a paper scroll so that users can cycle through books categorised by author first name. When deployed in a university library, several users mentioned (without prompting) that they had made serendipitous discoveries using the Bohemian Bookshelf and that the bookshelf helped them find books they were not previously aware of.

Kleiner et al.'s (2013) 'Blended Shelf' interactive library visualisation is more closely based on the physical library environment, allowing users to view digital representations of a library collection on virtual shelves, in the order the books would be presented in a physical library. The authors claim that this *"enables implicit serendipitous support of the shelf browsing in the digital world"* (p. 577). When users are not actively interacting with it, the Blended Shelf displays new, recently returned, often borrowed and randomly selected books – functionality that may also support serendipity.

Beyond existing design suggestions and implementations

These design suggestions provide broad guidance for supporting serendipity (particularly in search environments). Existing design implementations tend to support serendipity through the provision of content and location-based recommendations and through information visualisation. However, most of these suggestions and implementations are based on an intuitive (rather than empirically-grounded) understanding of the phenomenon and this makes it difficult for designers of digital information environments to know what functionality it is particularly useful to support. Serendipity has been found to be an slippery and subjective phenomenon (Makri & Blandford, 2012a). This serves to broaden the potential design space and makes it difficult to design for based on intuition alone. Also, although there are several existing digital information environments that claim to support serendipity, these environments support similar functionality to one another (i.e. recommendation and visualisation). This begs the question: are there other design possibilities that go beyond existing design implementations (and suggestions)? Our study of the strategies creative professionals adopt aimed at increasing the likelihood of serendipity provides empirically-grounded guidance for identifying and reasoning about these new design possibilities.

METHOD

We conducted semi-structured interviews with 14 creative professionals – a population that frequently experiences serendipity in their practice (Czikszentmihalyi, 1997). The creatives interviewed included a chef, a creative software designer, an amateur games designer, a comedian, a composer, a singer song-writer, a jazz musician, 3 artists (visual, digital and installation), a photographer, a filmmaker, an improvisational choreographer and a participatory theatre maker. We chose to interview creative professionals because several creatives we met during our serendipity research told us that they not only experienced serendipity frequently, but actively and routinely adopted strategies aimed at increasing its likelihood. We also considered creatives to be an interesting population to interview because of the similarities between serendipity and creativity; both involve an insightful 'aha' moment (Czikszentmihalyi, 1997; Makri & Blandford, 2012a). Findings from early interviews suggested that the creatives' strategies for influencing serendipity were general in nature (i.e. not specifically linked to creative practice) and therefore might potentially be useful to a much broader population.

We took an evolving theoretical sample, where we contacted people from additional creative fields as the interviews progressed in order to test our understanding and assumptions across a broad range of professions. We achieved this through introductions provided by our interviewees. Contact was made by e-mail – where prospective interviewees were asked to come prepared with a memorable example of serendipity from their creative practice. We did not define serendipity either in our e-mail or during the interviews as we did not want to influence the interviewees' understanding of the term.

The interviews lasted between 45 and 60 minutes and were informal and discursive to encourage reflection.

They began with warm-up questions about the nature of the creatives' practice and the role serendipity plays in it. In the first half of the interview, the creatives discussed the memorable example of serendipity from their creative practice they had already prepared. We engaged the creatives in a dialogue about their example as we wanted both to ensure we had a detailed understanding of it and to encourage interviewees to reflect on the nature of serendipity. In the second half of the interview, we asked the creatives if they 'did anything [they] thought increased the likelihood of serendipity?' All of them reported that they did and our findings focus primarily on the strategies they self-reported. Although the interview data was anecdotal, we were able to identify patterns in their memorable experiences of serendipity and considerable overlap across participants in the 'serendipity strategies' they reported. This gave us confidence that our interview data was not based on idiosyncratic responses. This also gave us confidence that our interview data could potentially be used as a framework for thinking about how to design to support serendipity. However, it is important to note that as our findings were self-reported, the strategies the creatives discussed are those they *perceived* to increase the likelihood of serendipity. It would be difficult if not impossible to provide evidence that they actually increased the likelihood. However, future research might seek to elicit examples of when adopting these strategies resulted in perceived serendipity (or counter-examples of when they did not).

We used the stages of an empirically-grounded process model of serendipity developed in an academic research context (Makri & Blandford, 2012) as sensitising concepts (see Blumer, 1954) to provide a starting point for our analysis. We did not, however, ask specific questions about the model during the interviews as we did not want to influence the interviewees' reflective comments or risk shoehorning our data. Instead, we elicited their reflections on the nature and process of serendipity by listening carefully to words and phrases they used during the interview and asking questions that incorporated the wording they used. This inductive approach resulted in the emergence of a serendipity process that mirrored that of academic researchers, serving to validate the existing model in a new domain.

The data was analysed in accordance with the two key analysis principles of Grounded Theory methodology (see Corbin & Strauss, 2008); findings emerged through a process of *constant comparison*, where we 'listened' to the data and continually compared findings both within and across interviewees - *maintaining an attitude of scepticism* by asking critical questions of our findings. As developing a theory is not an essential part of Grounded Theory (Corbin and Strauss, 2008), we adopted a pragmatic approach and stopped our analysis at the point where we had a comprehensive, empirically-grounded set of strategies for influencing serendipity.

In order to make them easier to report, the interviewees' examples of serendipity were summarised as 'serendipity stories' – first-person narratives written in the creatives' words as far as possible. Three of these stories are presented in our findings section. An e-mail was sent to interviewees inviting them to check their 'story' for accuracy, and the stories were edited accordingly.

FINDINGS AND DESIGN IMPLICATIONS

All of the creative professionals reported that they routinely adopt strategies aimed at influencing serendipity; these strategies are the main focus of our findings. However, in order to contextualise these strategies in relation to the broader serendipity process, we first briefly discuss the process that emerged from the creatives' memorable examples of serendipity and present three of the interviewees' 'serendipity stories' that illustrate the entire process. We then discuss each of the strategies they used to support the process and ways that existing digital environments support these strategies. We also suggest additional illustrative ways that the strategies can be supported through design.

Serendipity process

The creatives' serendipity process was the same as that followed by academic researchers in one of our previous studies (see Makri & Blandford, 2012a). This serves to validate our existing empirically-grounded process model of serendipity in a new domain (creative professionals rather than academic researchers). As the focus of our study was on the 'serendipity strategies' related to aspects of the creatives' serendipity process (rather than on the process itself), we only present a brief description of their process here. This process involves making a mental *connection* (a bisociation) involving both unexpected circumstances and insight. Forward-facing *projections* are then made on the potential value of the connection and actions are taken to *exploit* the value. After an iterative process of projecting further value to be gained from the connection and taking more action to exploit the value, the process culminates in a *valuable, unanticipated outcome.* The process is shown in figure 1. This is a minor adaptation of the process model presented in Makri & Blandford (2012a), which we adapted for greater clarity of presentation. It does not differ substantively from the 2012

model in terms of content or scope.

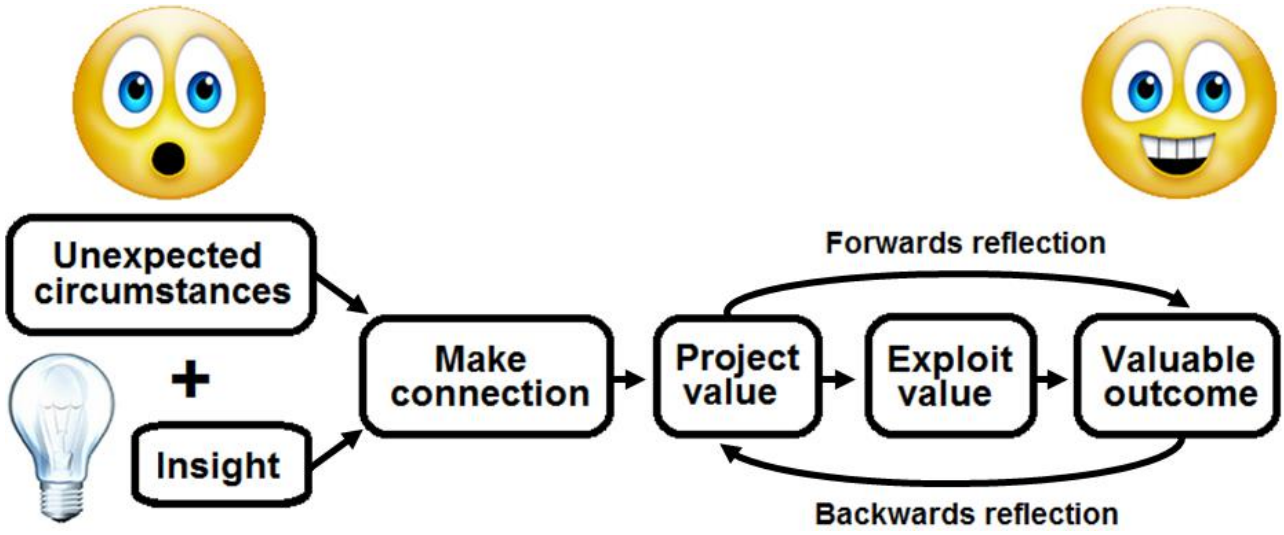

Figure 1: The serendipity process

Serendipity stories

The creative professionals reported they experienced serendipity frequently because it was integral to their practice. The visual artist explained that "*creative practice is always moving into the darkness. It's always assembling unknown elements, so without those chance connections you wouldn't have a practice.*" The photographer thought some people were *"more prone to serendipitous events"* than others and proclaimed herself *"queen of serendipitous events"* because she experienced serendipity so frequently. She can be regarded as a 'super-encounterer' (Erdelez, 1999), who relies on serendipity as an important means of encountering information. The creatives' serendipity stories were diverse. One involved a composer noticing parallels between the myth of the angel Lucifer and a journey he made on the London Underground, which resulted in him basing his composition on the tube journey. Others included a chef having the idea to serve a sea-salt-cured mackerel dish in his restaurant after visiting the seaside with his daughter for a different purpose and a participatory theatre maker adopting a new method based on a combination of the accidental findings of a previous participatory theatre project and her childhood experiences. These serendipity stories are presented below. The bold italic text in parentheses denotes a part of the serendipity process in figure 1 which can be noted in the story.

Fallen Angel (as told by the composer): I had been granted an award to make an experimental music and film performance piece. I'd decided to base the piece on the figure of the fallen angel Lucifer and had conducted research on peacock feathers as an emblem of Lucifer and the idea of the eyes as gateway to the soul. One day, I was taking a journey on the London Underground - from Angel to Highgate. As I went down the escalator at Angel, I noticed an advertisement that contained a large eye ***(unexpected circumstances)***. This image sparked a connection to the 'eyes' on the peacock's feathers that I had been researching and, through that, to the myth of Lucifer ***(make connection)***. I then made several mental connections between the tube journey I was about to make and the legend of Lucifer's fall. For example, I was descending towards the underground tunnel just as Lucifer had descended from heaven; I was also travelling from a station called 'Angel' to one called 'Highgate,' via another station called 'Archway' ***(make connection)***. I had written a version of the story of Lucifer's fall that had direct parallels to the names of these stations and I realised it wasn't too difficult to make a link between the station names and my research on the Lucifer myth ***(insight)***. I rapidly got the idea that I could structure the whole piece around the structure of this journey: from the descent into the tube at Angel to the re-emergence at Highgate ***(project value)***. I adopted this structure for the piece ***(exploit value)***, which also featured a film installation made from footage from that particular train journey ***(exploit value)***. The piece was given several performances and drew some very strong responses from audiences as well as positive feedback from its commissioners and funders ***(valuable outcome)***.

From ocean to plate (as told by the chef): I was planning to open a new restaurant and went with my daughter to the beach to look for stones I could use to serve butter on. Whilst choosing the stones and staring into the ocean ***(unexpected circumstances)***, I had an idea about a mackerel dish I was thinking of including on the new restaurant's menu ***(make connection)***. I knew that in Japanese cuisine, mackerel is often cured in sugar, followed by salt water and thought to myself 'why have I never heard of someone curing fish in seawater?' ***(insight, project value)***. So I started to experiment with seawater ***(exploit value)***. I first wanted to check it would be safe for consumption and then wanted to perfect the recipe for a sea salt-cured mackerel dish. I got a couple of buckets of seawater, brought it back to my home kitchen, boiled off all the impurities and passed it through the water filter (which extracted all the grit and sand). Then I flavoured the hot seawater with more salt, sugar, vinegar, herbs and spices and experimented until I worked out the best water temperature to cure the fish ***(exploit value)***. I was extremely pleased with the result; when you bit into it, it was just like tasting the sea. The sea salt-cured mackerel dish, served with broccoli and warm honey, made it onto the restaurant menu and was loved by our customers ***(valuable outcome)***.

Big person, tiny world (as told by the participatory theatre maker): I was talking on the phone to the project manager of an arts organisation I worked at about mundane things. She happened to mention the name of a visual artist who worked in my organisation ***(unexpected circumstances)***. This led me to remember a participatory theatre project that the visual artist had previously told me about. In this project, the artist asked people to make model boats and to name and decorate the outside of them. Then she left the room. When she returned, she noticed they had decorated the *inside* of the boats rather than the outside and added furniture and fittings. The project manager then asked *"are you working on anything at the moment?"* In that moment I thought up a completely new project and gave a fully-formed response: *"I want to do a project where people walk into an exhibition space which is full of suitcases and each suitcase that they open has a little town in it or a village or a place that's been made with tiny found objects and that it includes water and it includes little fires and it's got lighting and it's got audio, and I want to make that"* ***(insight, project value).*** We talked for ages about the idea and discussed whether and how it might work ***(exploit value)***. Later, I remembered when I was a child and lived in a house with a huge oak tree outside and used to make little houses in the roots of the tree with moss, twigs and acorns ***(insight)***. I thought again about what happened during the visual artist's boat decoration exercise ***(make connection)*** and thought how much people like to be the big person making a tiny world ***(insight)***. I've got a whole new way of working now (making places out of tiny found objects) and I use it all the time – as a performance basis and as a way of finding out how your own creativity works ***(valuable outcome)***.

Serendipity strategies

The creatives were aware that unexpectedness is an important element of serendipity and therefore did not try to 'seek' serendipity directly. However, they all routinely adopted strategies to support stages of the serendipity process (i.e. making unexpected, insightful connections and projecting and exploiting their potential value). These strategies, which are tightly linked to related behaviours and character traits, included *varying their routines, being observant*, *making mental space, relaxing their boundaries*, *drawing on previous experiences*, *looking for patterns* and *seizing opportunities*. A list of these strategies is presented in figure 2, alongside the stages of the serendipity process they were found to support.

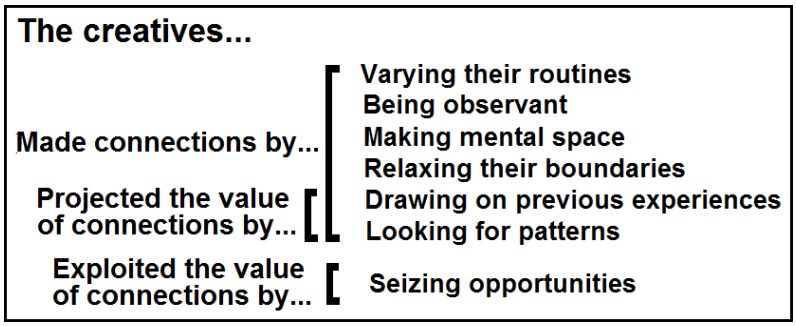

Figure 2: Strategies the creative professionals suggested increased their likelihood of experiencing serendipity

It is perhaps unsurprising that creative professionals adopt strategies such as these to support their creative

practice. Indeed, several of these strategies are well-documented in the literature on creativity and serendipity and creativity are related concepts – both involving an 'aha' moment of insight, but with creativity not necessarily involving unexpected circumstances. However, to the best of our knowledge, no previous research has identified an empirical link between strategies reported to enhance creativity and those reported to increase the likelihood of serendipity. This may well be because previous research has not taken a dedicated focus on what people do to influence serendipity. Several of these strategies are also already supported in existing digital information environments and in interactive systems in general. Indeed some of the environments that claim to support serendipity reviewed in our background section support one or more of these strategies. This is also perhaps unsurprising as these digital environments were designed with the aim of supporting serendipity and our study has demonstrated an empirical link between these strategies and serendipity (albeit a *perceived* link between the strategies and the *perception* of serendipity).

Although the strategies were obtained from interviews with creative professionals, they are not specific to creatives nor focused on influencing serendipity only in the context of creative practice. Indeed, many of these strategies were discussed (albeit using varied terminology) by academic researchers in one of our previous studies of serendipity when we asked them to reflect on the nature of serendipity and to discuss whether there was anything they could do to increase or decrease the likelihood of it happening (see Makri & Blandford, 2012a). The strategies are also general in nature; it is possible for everyone to be observant, relax their boundaries, seize opportunities etc. Therefore, just as we have argued about the strategies themselves, we hypothesise that digital environments designed to support these strategies not only have the potential to be useful to creative professionals, but to a much broader user population.

We now discuss each of the 'serendipity strategies' that the creatives reported to adopt with the aim of increasing the likelihood of serendipity. We also discuss ways that existing digital information environments support these strategies and provide additional illustrative ways that they might be supported through design.

Vary your routine

The creatives suggested that varying their routines provided more opportunities for making connections - by exposing them to people, places and information they might not have come across if they had followed a predictable routine. The amateur games designer explained that whilst this could involve 'going out and about,' it could also be achieved through undertaking any new experience:

> *"Going out and about and experiencing things is good. Sitting in front of my computer desk isn't going to help me create a game. I'm going to end up banging my head on the wall. With anything that's creative, you take ideas from everywhere. So, even just turning the TV on, just experiencing life will help increase the chances of serendipity."* – Amateur games designer

The photographer varied her routine by consciously taking different routes to work each day and, when visiting a new city, set herself arbitrary goals such as 'visit a market,' in order to see what happened on the way. She explained that putting 'something in action' is important for creating opportunities for serendipity:

> *"Something unexpected happened to me, but you have to put something in action too. You have to leave your house. You have to walk down the street. You have to look up, and then it happens to you."* – Photographer

Breaking existing routines is something that Czikszentmihalyi (1997) suggests is important for enhancing personal creativity. He states that *"comfortable routines are great when they save energy for doing what you really care about; but if you're still searching, they restrict and limit the future"* (p. 347).

Several of the recommendation-based digital environments discussed in our background section support users in varying their routines (e.g. by pointing them to digital content, places and events that they might not otherwise become aware of). Additional illustrative ways that digital information environments can support people in varying their routines include:

- Supporting people with overlapping interests to share useful information sources or links to useful information environments. Stumbleupon (www.stumbleupon.com) already recommends Websites that other users with similar stated interests have rated highly. Similar functionality might recommend sites based on *related* rather than stated interests. With any interactive system that aims to provide 'serendipitous' recommendations, there is a need to strike a delicate balance between providing suggestions that are neither so close to the user's interests that users find them valuable but not unexpected (perhaps because they were already aware of them) nor so far away from the user's interests that they find them unexpected

but not valuable.

- Suggesting new digital information sources or environments to access that are somewhat related to users' interests but that they may not already be aware of (e.g. sources/environments the user has not previously accessed, or sources/environments from a different, but potentially complementary domain).
- Informing users of similar (but importantly different) potential alternative digital information sources or environments when they frequently access the same source/environment. For example, users might be informed of the existence of Google Scholar if they frequently use Google to search for academic material. Or users might be informed of a digital library that contains some content that overlaps with the content held by a digital library they frequently use.
- More closely integrating search and browse functionality to encourage users to browse related information after conducting a search. For example, by presenting a link to related Web pages or documents alongside each search result. Google Scholar already links to 'related articles' in search results. This functionality could be extended to search engines or digital libraries more broadly.
- Supporting users in reflecting on their work and leisure routines in order to identify ways they might vary them. For example, by stepping users through their recent calendar entries and spurring them to think about (and find relevant information on) how they might vary their routines – working in different environments and with different people, developing new hobbies etc. This suggestion places greater agency on the user as opposed to the system, highlighting that the balance of agency between user and system is an important consideration when designing to support each of the serendipity strategies.

By giving users a taste of the serendipity-related benefits of varying their routines, digital environments (including information environments) have the potential to encourage them to regularly inject variety into their work and everyday-life routines.

Be observant

Being observant involved the creatives keeping their eyes and ears open to things happening in their environments and adopting a curious and inquisitive approach towards things they noticed. As explained by Czikszentmihalyi (1997), it is not enough to notice changes in the environment. It is necessary to *"stop to look at the unusual car parked at the curb, taste the new item on the cafeteria menu, actually listen to your colleague at the office"* (p. 347). The creatives described the importance of alertness and assiduity for making connections they might otherwise have missed. Both of these personal qualities were found to be important for preparing the mind by Cunha et al. (2010).

The participatory theatre maker noted that it was important to 'recognise' and 'be receptive' to connections, which in turn, can be supported by being observant. The creative software designer highlighted that not being observant could result in missed opportunities for serendipity:

> *"I could have easily been engrossed or not looking or turned when we walked by and then it wouldn't have happened."* – Creative software designer

The composer defined being observant as *"really having the ability to see and hear"* and explained that he, on a daily basis, stood still to observe aspects of his environment (such as the light, sounds and movement). A similar routine was described by the visual artist, who explained that alertness required the regular rehearsal of the senses:

> *"Every morning you need to remind yourself that you can smell and see and hear and touch things."* – Visual artist

Supporting observation skills by regularly rehearsing the senses is also encouraged in the creativity literature. Gaymer (1985) suggests that *"if our senses are to be used adequately as instruments to self-development, we should become more aware of the skills involved in applying them, and work on elevating them to higher levels of performance"* (p. 67).

The composer asserted that being observant could be supported by 'attuning' oneself to things of interest so as to notice triggers in the environment related to those interests:

> *"What gives rise to serendipity is a preparedness to be open to seeing conjunctions. Some conjunctions slap you in the face and you can't ignore them, but not all of them do. During that period, I was very attuned to*

certain images and certain themes. It's almost like my psyche was waiting for something it could pull in to attune itself." - Composer

The notion of being 'attuned' to things in the environment was also mentioned by the comedian, who stated that when he was performing he had a *"heightened awareness"* and *"kept looking out consciously for things that are funny"* and the installation artist, who stated that she often noticed things that nobody else would pay attention to because her *"brain at the time is slightly attuned to those things."*

Being observant was also noted to influence serendipity in an improvisation context; as explained by the improvisational choreographer:

"Improvisation is about observing your surroundings and changing what it is you're doing to fit in with them. By being both observant and flexible, I think it's possible to get more of what you want and to get the best out of what's available to you - which probably ultimately is what you want anyway!" – Improvisational choreographer

There are several existing digital environments that augment users' observation skills - helping them not to miss potentially unexpected and valuable information, as well as nearby people, places and events. These include the digital content and location-based recommendation environments described in our background section. Digital information environments can also augment users' observation skills in other ways. These include (but are not limited to) drawing users' attention to:

- New digital information sources or environments that provide information in their domains of interest (e.g. new Websites on gardening or a new academic journal in a particular specialist area).
- Information that is currently onscreen that they have previously or recently accessed (e.g. in a previous information search, browse or encountering session). This notion could be extended to drawing users' attention to information that other users with similar interests have previously or recently accessed.
- Information that is simultaneously related to more than one of their recent (but distinct) searches. For example, if a user conducts separate searches on factors influencing luck and factors influencing business success, the digital information environment might draw his or her attention to a Web article on the role of luck in business success.
- Information that has been recently changed, added or removed (e.g. on Web pages or other documents that are frequently updated). Property Bee (www.property-bee.com) for example, tracks when for-sale properties listed online change in price or come back on the market and displays this information to users (who may otherwise be unaware of the previous sale history of a property).
- Nearby people who have authored information that the user has previously read, downloaded, saved or printed (e.g. when the author of a blog that the user regularly follows or an academic paper they have read is nearby).

Digital information environments might also encourage users to become more observant by exposing them to important information literacy skills during the course of their information searching and browsing. For example, by explaining why particular search results were returned based on the query the user submitted or by highlighting the similarities and differences between visually similar versions of Web pages (e.g. different versions of a report, article or paper).

Drawing users' attention to unexpected things in their physical and digital environments they might not otherwise have noticed or examined thoroughly has the potential to result in valuable outcomes that might encourage users to be more observant when interacting with digital information.

Make mental space

Having sufficient mental space was also deemed important by the creatives for making potentially serendipitous connections. The composer stated that a busy lifestyle and 'full' mind meant he was *"less likely to have the space to pick up on things,"* whilst the amateur games designer asserted that being 'closed off' to serendipity (e.g. due to stress, a bad mood, or other pressures) made serendipity *"less likely to happen."* The importance of making mental space is discussed by the composer, who refers back to the connection he made in his 'serendipity story,' Fallen Angel:

"I think being fallow is very, very important. In my example, when I was going down the escalator at Angel I

wasn't ostensibly thinking about the piece, I was going to a rehearsal. So it was a sort of downtime really, even though I was thinking about it all the time. It's like you feed a load of stuff into your system and then you almost have to let go of it in order for it to speak. If you're investigating it too closely all the time there's too much brain stuff going on. It's almost like peripheral brain vision." – Composer

Csikzentmihalyi (1997) refers to the notion of 'being fallow' as 'idle time.' He describes how, in psychoanalytic terms, making mental space can involve conscious thoughts being replaced by subconscious ones – allowing mental connections to reveal themselves. He also describes how, in cognitive terms, making mental space can encourage the (almost random) association between unrelated ideas – with some of these associations resulting in the making of potentially valuable mental connections.

The creative professionals mentioned activities such as taking walks, meditation and yoga as being useful for making mental space. These reported activities support Csikzentmihalyi's assertion that rather than simply 'doing nothing,' making mental space involves doing something that is very different from our usual tasks (Csikzentmihalyi, 1997). As explained by Johnson (2010*), "the shower or stroll removes you from the task-based focus of modern life... and deposits you in more of an associative state"* (p. 110).

Technology can directly support users in making mental space (e.g. by helping them to relax) in the hope they will find inspiration as a result. Moodstream, for example, is a brainstorming tool *"designed to help take you in inspiring, unexpected directions"* (moodstream.gettyimages.com). It plays a music-accompanied slideshow of images and video, to reflect a particular mood. Similarly, Serenity plays audio and video of relaxing destinations to help users *"relax and let the solution for that problem you've been working on for weeks bubble up from your unconscious into that Eureka! moment"* (taptaptap.com/serenity). However pure their intentions, there is a tendency for tools like these to come across as gimmicky. Therefore, when designing to support making mental space in digital information environments, we suggest it may be more useful to support the strategy *indirectly*, for example by:

- Providing content that allows users to temporarily shift their focus away from the information task at hand. For example, by embedding videos or news articles alongside Web search results that are to some extent related to the search terms entered. The BBC News Website (www.bbc.co.uk/news), for example, provides links to television, radio programmes and blogs related to search terms entered. This could be extended to other types of digital information environments (e.g. digital libraries) and for content that is only loosely related to the search terms entered.
- Integrating sorting, categorisation and/or annotation functionality into digital information environments. This functionality can be used both whilst searching for, browsing for and encountering information and after information has been acquired. Mendeley (www.mendeley.com) currently provides integrated search and categorisation/annotation functionality within a desktop environment. Similar functionality could be integrated within online environments – allowing users to reflect on the information they acquire as they acquire it and also allowing them to return to their annotations some time later to potentially trigger new mental connections.
- Integrating brainstorming (e.g. mind-mapping) functionality into search and browse environments. Supporting users in relating Web pages and documents they have found to one another to help them gain a deeper understanding of a topic might also indirectly support making mental space. It may be particularly useful if mind-maps can be created that extend across information-seeking sessions – giving users the chance to reflect on their understanding of the topic in-between sessions.

Digital information environments also have the potential to support users in capturing and revisiting fleeting ideas that have come to them whilst making mental space.

By supporting users in shifting focus away from what they are currently working on and reflecting on it in order to 'see the wood from the trees,' technology has the potential to encourage users to incorporate making mental space as an integral part of their routines.

Relax your boundaries

As well as making mental space, the creatives also identified relaxing their physical and intellectual boundaries as important for being willing and able to make connections, as explained by the visual artist:

"If you have rigid boundaries between areas of knowledge, or areas of the world, whether intellectually or physically, you will cut off certain possibilities. Even literally, if you obey 'No entry' signs every time you see

them. Having a healthy disrespect for boundaries is a pretty important attitude for encouraging serendipity." – Visual artist

The filmmaker asserted that having relaxed boundaries not only demonstrated a willingness to be exposed to new experiences and environments, but also a *"lack of guard."* It was also suggested that relaxing boundaries between fields could result in inter-disciplinary connections of the sorts described by André & schraefel (André & schraefel, 2009) and Foster and Ford (Foster & Ford, 2003):

"Don't always look at things in your field. I can look at games all day, but it's more fun and more creative to look at things outside of games." – Amateur games designer

The importance of relaxing domain boundaries is supported by Csikzentmihalyi (1997), who points out important creative breakthroughs often occur when something that works well in one domain is transferred to another. The notion of relaxing boundaries is closely related to the importance of flexibility in information acquisition (as highlighted by McBirnie, 2008 and McCay-Peet and Toms, 2012) and in preparing the mind for serendipity (as highlighted by Cunha et al., 2010).

As with 'varying your routine,' existing location and non-location-based digital information environments support users in relaxing their boundaries by suggesting information to consume, people to meet, events to attend or places to visit. These should be related to users' existing interests, but not necessarily strongly-related. It is the partial relation to users' interests that has the potential to make these recommendations seem unexpected to users. Other ways digital information environments might encourage users to relax their boundaries include:

- Introducing users to unexpected and potentially valuable information from domains they were not previously familiar with (as suggested by André et al., 2009). This extends to new digital information sources or environments that users were not previously familiar with. Related to this suggestion is the possibility of illustrating some of the connections between topical areas that users have recently searched for or browsed Web pages or documents on, with the aim of helping users to understand the boundaries and fluidity between different areas. This might be achieved through harnessing semantic Web technologies, perhaps visually.
- Appending 'random' search terms to a user-specified search query (or subsequently as a means of filtering results). Bananaslug (www.bananaslug.com) already does the former by asking users to choose from a pre-defined set of categories (e.g. 'emotions' or 'archetypes') and appending a word from that category to the user's search query. It is also possible to append terms that are partially semantically-related to the existing terms entered, terms from words that appear in the (unaltered) search results or terms that appeared in information the user accessed earlier in the current search session.

By demonstrating the benefits of relaxing their boundaries, digital information environments can encourage users to be 'critical not cruel' (as the visual artist put it) – by absorbing information from the environment without being overly judgmental. Digital information environments have the potential to encourage users to value relaxed rather than rigid boundaries of knowledge when looking for information so that they gravitate towards new interests and experiences and make unexpected, insightful and valuable connections between pieces of information they had not previously thought were related.

Draw on previous experiences

Remembering and drawing on previous experiences was considered by the creatives to be an important way of making and projecting the value of connections, as explained by the visual artist:

"Serendipity is often meaningful because it aligns disparate elements, but you have to have access to those elements in some way and that's a function of memory, storage, sensitivity and self-archiving of memory." – Visual artist

The amateur games designer described drawing on his experience from other games by taking an existing idea and 'turning it on its head,' whilst the creative software designer described making a connection between the physicality of sound in his current project and "*as a kid, going over to a big bass speaker and being fascinated by its movement."* The installation artist explained she regarded previous experiences, even those she thought she had forgotten, as a potential resource for making connections:

"These things are always brewing in your head and slip in and connect, even though you didn't realise that you're thinking about them anymore." – Installation artist

Csikzentmihalyi (1997) suggests that creative professionals could write a diary or notes to support them in reflecting on previous experiences and in order to make these experiences *"less fleeting, so that the most memorable, interesting, and important events are not lost forever a few hours after they occurred"* (p. 347). Johnson (2010) describes keeping a personal digital archive of interesting quotations and periodically revisiting them and looking for associations between them.

Digital information environments can support users in drawing on previous experiences by allowing them to capture, store and revisit information. For example, Gimme Bar (gimmebar.com) is a browser add-on that allows users to save, organise and review content clipped from the Web. Hangal et al.'s 'experience-infused browser' (2012) archives users' e-mail and chat messages, then highlights terms on user-visited Web pages that match terms from the archive. Focused more specifically on serendipity, Sun et al.'s mobile 'serendipity diary' (2011) allows users to make notes and take/annotate photos to record and reflect on their potentially serendipitous experiences. More ambitiously, MyLifeBits (Gemmel et al., 2006) attempted to capture and facilitate searching of, among other things, users' online and offline communications, images seen, sounds heard and Websites visited. MyLifeBits highlights the challenge of capturing the richness of human experiences - not just the information we acquire and consume in the digital realm, but also the things we do in the physical world. An associated challenge involves supporting the revisiting of captured data in ways that might uncover unexpected, insightful and valuable connections. Digital information environments might also support users in drawing on previous experiences by:

- Suggesting potentially unexpected connections between information (or people, places) a user is currently paying attention to and information they have previously acquired. For example, suggesting that an article they are currently reading about innovation in organisations might interest a colleague who mentioned in a previous e-mail that he considering how best to reconfigure the office to increase collaboration opportunities.
- Supporting easy capture of digital information when searching or browsing for information or when encountering it (e.g. by allowing users to flag information they find interesting and by making and archiving an automatic digital copy). This could go beyond the content clipping functionality already supported by tools like Gimme Bar by supporting the capture and replaying of entire information-seeking or discovery sessions. A digital information environment might, for example, automatically capture a user's search session and allow them to flag Web pages or documents of interest. Then, at a later date, it might allow them to play the session back – skipping at will to pages or documents they flagged as interesting.
- Supporting the useful review of digital information. Information might be presented back to users in random order or by capture date, capture location or by semantic links between user-specified tags describing the content. Information might also be presented back to users *passively* - removing the need for them to actively search or browse for it. Users could also be provided with functionality that allows them to organise and categorise the information they have previously captured and to relate pieces of information to one another in order to facilitate the making of connections between different pieces of information.
- Reminding users of the previous occasions they have previously accessed, saved or printed the document or Web page they are currently viewing and/or the occasions they have previously conducted the same or similar searches to the one they are currently conducting. This could be combined with the capture and replay functionality described above to remind users of the context in which they last saw the document/page or conducted a similar search. It is also possible to remind users of previously accessed (and possibly forgotten) information that relates to information currently being viewed. Both of these suggestions aim to support users in making connections between their previous information interactions and the information they are currently seeking or viewing.

Supporting users in drawing on their previous experiences has the potential to encourage users to actively compare new experiences to previous ones in the hope of making insightful, valuable (and potentially unexpected) connections.

Look for patterns

Related to drawing on their previous experiences, the creatives also consciously looked for patterns in physical and digital environments to support them in making and projecting the value of connections. The filmmaker, for example, explained she had a 'tendency for wanting to find patterns in things':

"I have this tendency to want to find patterns in things. It could be patterns of meaning, or on a physical level,

just patterns in the way that people move around." – Filmmaker

The composer asserted that serendipity was fundamentally about being 'prepared to see alignments' and construct meaning from them:

"It's almost like one is prepared to see alignments. And it's not necessarily, for me, that those alignments are objectively meaningful, but that we can extract or construct something meaningful from them." – Composer

The participatory theatre maker stated that looking for patterns is not only a fundamental aspect of serendipity and creative practice, but also of humanity in general:

"There's a potter who I've worked with quite a lot. He's 90 now and tends to make big thematic statements. He said to me 'people think there's patterns in the world. There isn't; it's chaos. But what we're here to do is to look for patterns. That's our purpose.'" – Participatory theatre maker

The existing information visualisation environments discussed in our background section support users in looking for patterns. Future visualisation environments might not only present patterns to users but provide exploratory interfaces to support them in making their own connections between loosely or seemingly unconnected entities. Exploratory visualisation interfaces might 'nudge' users to discover patterns by suggesting potentially unexpected and valuable connections or displaying connections made by other users. These interfaces might also highlight breaks in patterns (i.e. anomalies, outliers or things that 'don't quite fit') that might warrant further investigation. Or they might shift agency further towards users and focus less on 'nudging' them to discover patterns and anomalies and more towards supporting exploration in general - in the hope that users will make these discoveries themselves.

Other (non-visualisation-based) digital information environments might also support users in looking for patterns, for example by:

- Highlighting when two or more results (from current, recent or previous search or browse sessions) are highly semantically-related. Also highlighting when Web pages or documents that seem similar actually differ in important ways and when pages or documents that seem very different actually share similarities. For example, two academic papers might report on the same study but focus on different aspects of it or they might report work from very different disciplines, but share complementary findings or follow similar methodologies.
- Highlighting connections between information a user is currently and has previously accessed. For example, informing users that a journal article in the issue they are browsing has been co-authored by someone whose papers they have previously bookmarked, downloaded or printed.
- Highlighting unusual (potentially 'anomalous') documents, Web pages or content. For example, when a user is browsing a particular journal issue, highlighting articles that have been cited much more (or much less) than others in the issue. Similarly, when a user submits a search query, highlighting Web pages that have been accessed much more (or much less) than others in the current search results list etc.

By using technology to discover interesting and surprising patterns, we hypothesise that users may become more used to noticing patterns in their physical and digital environments *without* technological support.

Seize opportunities

Finally, in order to exploit the value of connections made, the creatives discussed the importance of seizing (often risky) opportunities – such as by striking up a conversation with someone they met, walking into places they stumbled upon or using information they had come across. The filmmaker, for example, described deciding to accept the invitation of a man she had met in the sleeper carriage of a train in China to show her around a Chinese ethnic village (where she wanted to find a house suitable for filming in). She decided to seize the opportunity after noticing that the man's wife appeared jealous and thinking to herself *"this is genuine, I think we're safe."*

The installation artist described buying several figurines to act as a 'sculptural audience' for an exhibition piece she was developing after a visiting artist came to her studio and paid particular attention to a figurine of a cat on her windowsill. The artist suggested the need to be willing to invest a considerable amount of money in building prototype artworks in order to exploit the value of some serendipitous opportunities:

"I'm prepared to have a go and try things, so I'll build this, and you're looking at a room full of stuff that

probably cost me £1,500 over the last two months and there's nothing telling me I'm going to get any money back from that or, indeed, any satisfaction on any level." – Installation artist

Time was another resource discussed by the creatives as being important for seizing opportunities. Several creative professionals, including the installation artist, mentioned the need to invest often significant amounts of time in seizing opportunities. They recognised that these time investments were 'high-risk-high-reward' – they may not often result in valuable outcomes but, when they did, the time-saving benefits outweighed the time invested. In order to have sufficient time to invest in seizing opportunities whenever they present themselves, Csikzentmihalyi (1997) suggests the importance of being a *"master of one's own time"* (p.145).

Both Cunha et al. (2010) and Muller and Becker (2012) describe the importance of seizing opportunities as a means of influencing serendipity. Cunha et al. suggest the critical importance of seizing opportunities (which they call 'enactment') in order to avoid unexpected circumstances resulting in missed opportunities whilst Muller and Becker suggest the need for people to be able and prepared to initiate relationships that arise from unexpected circumstances and to route other peoples' requests to help facilitate serendipity.

Existing location-based mobile apps such as those discussed in our background section can support users in identifying often time-sensitive opportunities to seize (such as nearby events to attend, people to meet or places to visit) – in providing what André et al. term *"the infrastructure… to see that connection flourish"* (André et al., 2009, p. 312). Digital information environments might also support users in seizing opportunities by:

- Assisting users to follow up on potentially valuable opportunities (including those that arise from unexpected circumstances). These opportunities might be based on information users have consumed, people they have met or places they have visited. They might be supported by similar information capture, storage, organisation and annotation functionality to that discussed in relation to supporting 'draw on previous experiences.' Some digital libraries such as Westlaw (www.westlaw.com) already save a history of searches users have submitted and documents they have accessed. But there is also scope for them to allow users to mark searches and documents they would like to follow-up on and periodically remind users do so. Mobile apps could be developed to automatically share contact details when meeting a new person (e.g. by 'bumping' phones – see bu.mp) and then facilitate arranging a follow-up meeting. Apps could also be developed that use a user's location-based data (e.g. their check-in locations on Foursquare) to map places they have visited and who they have met there. These apps might then allow users to create and follow-up on activities arising from the visit. A conference delegate might, for example, want to read new research they heard about or contact people they met at the conference.
- Better integrating existing digital tools and information environments with one another. For example, a user who comes across a review of a restaurant they want to visit whilst browsing an online newspaper could be supported in booking the restaurant online, getting directions to the restaurant on his mobile device and adding the booking to his calendar – all from within the review itself. Online travel review site Tripadvisor (www.tripadvisor.com) already supports some of this functionality, by allowing users book hotels and restaurants directly from within the information environment.

We hypothesise that reaping the rewards of unexpected opportunities facilitated by technology might encourage users to seize more opportunities. It may also help them to decide which opportunities to seize in the future (such as those with high potential value and high likelihood of the value materialising).

Supporting serendipity strategies

Many of the existing digital information environments reviewed in this article implicitly attempt to support serendipity as a discrete phenomenon; they often incorporate the 'unexpected' aspects of the phenomenon (by trying to create unexpected or surprising circumstances, or opportunities for unanticipated outcomes) and the 'valuable' aspects (by attempting to ensure that the system results in important, meaningful, relevant or otherwise beneficial outcomes to users). However, they still tend to strive to offer users 'serendipity on a plate' – which cannot be readily achieved. We advocate a new approach – designing not to support serendipity itself, but to support 'serendipity strategies.' Rather than attempting to offer 'serendipity on a plate,' our approach empowers users to create their own 'recipes' for serendipity. It does this by supporting users in implementing strategies that people who frequently experience serendipity deemed to increase its likelihood - and by potentially exposing users to the benefits of serendipity as a result.

Designing to support 'serendipity strategies' rather than the phenomenon itself is a new way of thinking about how to support serendipity in digital information environments. Firstly, it allows designers to consider a broader

range of functionality than is currently supported by existing environments; asking 'how can I best help users make mental space or draw on previous experiences?' is likely to result in functionality that moves beyond recommendation, personalisation and visualisation. Secondly, designing to support serendipity strategies goes beyond creating individual opportunities for users to experience serendipity through technology – it has the potential to encourage users to integrate these strategies into their work and everyday lives and potentially experience serendipity more often as a result. Finally, designing to support serendipity provides a new, empirically-grounded 'lens' for considering what functionality to support when designing to create opportunities for serendipity. When designing to support serendipity, designers must make a 'creative leap' from the notion of serendipity to design. Designing to support 'serendipity strategies' rather than aspects of serendipity itself (such as 'unexpectedness' or 'value') can reduce the size of this leap by providing design suggestions that are at a practical level of abstraction for informing design. These suggestions are neither so broad as to require a big creative leap between the design suggestions and possible ways of implementing them, nor so narrow as to restrict creativity by suggesting that there are certain 'right' or 'preferred' ways of supporting the strategies we identified through design. Indeed, the design suggestions we made related to each strategy should not be regarded as 'desired' ways of supporting the strategy; they are intended to be illustrative rather than prescriptive. The framework formed by the strategies is not intended to prescribe 'off-the-shelf' design suggestions that should be blindly implemented with the aim of supporting or better supporting each strategy. It is intended as a means of stimulating design thinking in relation to each strategy and in relation to serendipity in general. We also suggest that designers consider each strategy in relation to the specific system they are developing or improving. They might ask themselves, for example, 'how can we support users in varying their routines when reading online news?' or 'how can time management tools support users in seizing opportunities?' and come up with design suggestions that differ considerably from the ones we have proposed.

Although we have focused on providing design suggestions for supporting 'serendipity strategies,' there are also several other possible 'lenses' that may be useful for supporting serendipity; for example, it is possible to design to support aspects of the process or essence of serendipity (see Maxwell et. al., 2012), such as making or exploiting the value of connections made. It is also possible to design to support aspects of digital environments that have been empirically identified to facilitate serendipity - such as 'presenting variety' and 'inducing curiosity' (see McCay-Peet & Toms, 2011). There is no single 'right' way to design to support serendipity. But empirically-grounded guidance can support designers in moving beyond existing design suggestions and implementations to find their own useful ways of supporting the phenomenon.

CONCLUSION

We have proposed a new way of thinking about how to design to support serendipity in digital information environments (and digital environments in general); by supporting strategies found to increase the likelihood of serendipity, designers can not only create opportunities for users to experience serendipity, but also encourage users to integrate these strategies into their work and everyday lives. This approach not only has the potential to result in users experiencing serendipity, but also to assist users in experiencing it more often – and not necessarily as the direct result of using technology. Further studies and design implementations are, however, needed to determine how technology can best realise this potential. A particularly useful set of future studies might determine whether users actually perceive to have experienced serendipity as a result of interacting with digital tools that have been designed to support our 'serendipity strategies' or other aspects of serendipity.

Our long-term aim is to encourage users to embrace serendipity as an important part of their lives by integrating 'serendipity strategies' into their work and everyday routines. We have taken important first steps towards achieving this aim. By supporting the strategies that increase its likelihood, digital environments not only have the potential to assist people in experiencing the phenomenon, but also to empower them to become their own 'kings' and 'queens' of serendipity.

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REFERENCES

André, P. & schrafel, m.c. (2009). Computing and Chance: Designing for (Un)Serendipity. The Biochemist E-

Volution, 31(6), 19-22.

André, P., schrafel, m.c., Teevan., J. & Dumais, S.T. (2009). Discovery is Never by Chance: Designing for (Un)Serendipity. In proc. Creativity and Cognition, 305-314. Berkley, CA. ACM.

Bawden, D. (2011). Encountering on the Road to Serendip? Browsing in New Information Environments. In Foster, A. & Rafferty, P. (eds.) Innovations in Information Retrieval: Perspectives for Theory and Practice. London, UK. Facet.

Beale, R. (2007). Supporting Serendipity: Using Ambient Intelligence to Augment User Exploration for Data Mining and Web Browsing. Int. J. Human-Computer Studies 65(5), 421-433.

Bellotti, V., Begole, J., Chi, E., Ducheneaut, N., Fang, J, Isaacs, E., King, T., Newman, M., Partridge, K., Price, R., Rasmussen, P., Roberts, M., Schiano, D. & Walendowski, A. (2008). Activity-Based Serendipitous Recommendations with the Magitti Mobile Leisure Guide. In proc. CHI'08, Florence, Italy, 1157-66. ACM.

Blumer, H. (1954). What is wrong with Social Theory? American Sociological Review, 19(1), 3-10.

Bogers, T., Rasmussen, R. & Jensen, L. (2013). Measuring Serendipity in the Lab: The Effects of Priming and Monitoring. In proc. iConference 2013, Fort Worth, TX, 703-706.

Burkell, J., Quan-Haase, A. & Rubin, V. (2012). Promoting Serendipity Online: Recommendations for Tool Design. In proc. 2012 iConference, Toronto, Canada, 525-526. ACM.

Campos, J. & de Figueiredo, A.D. (2001). Searching the Unsearchable: Inducing Serendipitous Insights. In proc. Workshop of Case-Based Reasoning (ICCBR), 159-164. Washington, DC.

Coombe, M., Hogan, P. & Tan, I.S. (2011). DistractMi – Discover Yourself. OZCHI Student Challenge. In proc. OZCHI'11, Canberra, Australia. ACM.

Corbin J. & Strauss, A. (2008). Basics of Qualitative Research (3rd Ed.): Techniques and Procedures for Developing Grounded Theory. London, UK. Sage.

Cunha, M.P., Clegg, S.R. & Mendonça' S. (2010). On Serendipity and Organizing. European Management Journal 28(5), 319-330.

Czikszentmihalyi, M. (1997). Creativity: Flow and the Psychology of Discovery and Invention. NY. Harper Collins.

Dantonio, L., Makri, S. & Blandford, A. (2012). Coming Across Social Media Content Serendipity. In proc. *75th* Annual Meeting of the American Society for Information Science and Technology. Available at www.asis.org/asist2012/proceedings/Submissions/2.pdf

Eagle, N. & Pentland, A. (2005). Social Serendipity: Mobilizing Social Software. Pervas. Comp., 4(2), 28-34.

Erdelez, S. (1995). Information Encountering: An Exploration beyond Information Seeking. Unpublished PhD Thesis. Syracuse University, NY.

Erdelez, S. (1999). Information Encountering: It's More Than Just Bumping into Information. Bulletin of the American Society for Information Science (Feb/Mar), 25-29.

Erdelez, S. (2004). Investigation of Information Encountering in the Controlled Research Environment. Information Processing & Management, 40(6), 1013-25.

Farrar, J. (2010). Google to end Serendipity (by Creating it). ZDNet.]zd.net/cQW0mJ].

Forsblom, A., Nurmi, P, Áman, P. & Liikkanen, L. (2012). Out of the Bubble – Serendipitous Event Recommendations at a Urban Culture Festival. In proc. Intelligent User Interfaces'12, Lisbon. 253-256. ACM.

Foster, A. & Ford, N. (2003). Serendipity and Information Seeking: An Empirical Study. Journal of Documentation, 59(3), 321-340.

Gaymer, R.D. (1985). You are a Camera… Some Aspects of Observation. Journal of Creative Behaviour 19(1), 67-75.

Gemmell, J., Bell, G. & Lueder, R. (2006). MyLifeBits: A Personal Database for Everything. Communications of the ACM 49(1), 88-95.

Hangal, S., Nagpal, A. & Lam, M.S. (2012). Effective Browsing and Serendipitous Discovery with an Experience-Infused Browser. In proc. Intelligent User Interfaces'12, 149-158. ACM.

Johnson, S. (2010). Where Good Ideas Come From. Allen Lane, London, UK.

Kirman, B., Linehan, C. & Lawson, S. (2012). Get Lost: Facilitating Serendipitous Exploration in Location-Sharing Services. In proc. CHI'12, Austin, TX, USA, 2303-2308. ACM.

Kleiner, E., Rädle, R. & Reiterer, H. (2013). Blended Shelf: Reality-based Presentation and Exploration of Library Collections. In proc. CHI 2013 Extended Abstracts, 577-582, Paris, France. ACM.

Lieberman, H. (1995). Letizia: An Agent that Assists Web Browsing. In proc. International Joint Conference on Artificial Intelligence, Montreal, Canada, 97-102.

Makri, S. & Blandford, A. (2012). Coming Across Information Serendipitously: Part 1 – A Process Model. Journal of Documentation, 68(5), 684-705.

Makri, S. & Blandford, A. (2012). Coming Across Information Serendipitously: Part 2 – A Classification Framework. Journal of Documentation, 68(5), 706-724.

Maxwell, D., Woods, M., Makri, S., Bental, D., Kefalidou, G. & Sharples, S. (2012). Designing a Semantic Sketchbook to Create Opportunities for Serendipity. In proc. BCS HCI 2012*,* 357-362. Birmingham, UK.

McBirnie, A. (2008). Seeking Serendipity: The Paradox of Control. Aslib Proceedings: New Information Perspectives, 60(6), 600-618.

McCay-Peet, L. & Toms, E.G. (2010). The Process of Serendipity in Knowledge Work. In proc. 3rd Symposium on Information Interaction in Context, 377-382. New Brunswick, NJ. ACM.

McCay-Peet, L. & Toms, E.G. (2011). Uses and Gratifications: Measuring the Dimensions of Serendipity in Digital Environments. Information Research, 16(3), paper 483.

Muller, T. & Becker, L. (2012). Get Lucky: How to Put Planned Serendipity to Work for You and Your Business. Jossey-Bass, San Francisco, CA.

Oxford Concise English Dictionary (11th Ed.). (2009). Oxford University Press, NY.

Pariser, E. (2012). The Filter Bubble: What the Internet is Hiding from You. Penguin.

Roberts, R. (1989). Serendipity: Accidental Discoveries in Science. NY. Wiley.

Rubin, V., Burkell, J. & Quan-Haase, A. (2010). Facets of Serendipity in Everyday Chance Encounters: A Grounded Theory Approach to Blog Analysis. Information Research 16(3), paper 488.

Sun, X., Sharples, S. & Makri, S. (2011). A User-Centred Mobile Diary Study Approach to Understanding Serendipity in Information Research. Information Research, 16(3), paper 492.

Thudt, A., Hinrichs, U. & Carpendale, S. (2012). The Bohemian Bookshelf: Supporting Serendipitous Book Discoveries through Information Visualization. In proc. CHI'12, Austin, Texas, 1461-1470. ACM.

Toms, E.G. (2000). Understanding and Facilitating the Browsing of Electronic Text. International Journal of Human-Computer Studies, 52(3), pp. 423-452.

Toms, E.G. & McCay-Peet, L. (2009). Chance Encounters in the Digital Library. Lecture Notes in Computer Science 5714, 192-202.

Watson, E.A. (2008). Going Fishing: Serendipity in Library and Information Science. Unpublished Masters Thesis. University of North Carolina, Chapel Hill, NC.