The Serendipitous Pattern in Interaction Design

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Abstract

Serendipity is increasingly becoming a concern in the design of interactive systems as an alternative to the echo chamber effects being felt in the medium. However, the concept of serendipity is one shrouded in ambiguity, which limits our abilities to regard it as an achievable goal in interaction design. Based upon literature review, as well as empirical research, we propose a Serendipitous Pattern that identifies the core moments of serendipity, as well as the role of the human agent. Through this pattern, we are able to lay the groundwork for establishing a framework that enables the design of serendipitous systems.

Keywords

Serendipity, Information, Discovery, Interaction Design, Digital Medium.

Introduction

Serendipity, according to Walpole who coined the term in 1754 (Merton and Barber 2006, 1), is the result of accidental discovery and human sagacity. Considering the contemporary world and its richness and variety of information, there is a growing need to design systems that encourage serendipitous discoveries, especially those that are able to counter the growing signs of the balkanisation (Van Alstyne & Brynjolfsson, 1996) resulting from the catering of information and creation of echo chambers and feedback loops (Pariser, 2011). Through designing for valuable unpredictability—serendipity—we are able to introduce divergence experiences into our daily interactions within the digital medium. However, in order to be able to design systems that enable serendipity discoveries, we need to identify the distinct moments that constitute the serendipitous experience.

A Model for Serendipity

Acknowledging serendipity's relationship with information discovery, we began our approach by establishing a serendipity model by looking into information behaviour literature for theoretical constructs and models that could be applied to the experience of serendipity, such as with T.D. Wilson's information-seeking model.

Figure 1. Model for Information-Seeking Behaviour ©T.D. Wilson 1995

T.D. Wilson's model suggests four distinct methods that describe information-seeking behaviour: *Passive attention*, *passive search*, *active search*, and *ongoing search*. Of these, one may argue that the moment that begins the serendipitous process occurs during a process of passive attention. However, this would ignore the cases in which the discovery that triggers serendipity occurs in moments where there is no attention of search being paid, passive or otherwise.

As such, traditional representations of information-seeking behaviour do not apply in the case of serendipity, as serendipity does not begin with human intention (a conscious act as a response to an identified need), even if the position towards information seeking is a passive one, as Wilson's model foresees. Serendipity is the result of a change in the world—an unexpected encounter, henceforth described as *trigger*—that begets the serendipist[1] attention. Information seeking models do not contemplate this trigger.

[1] The one that experiences serendipity.

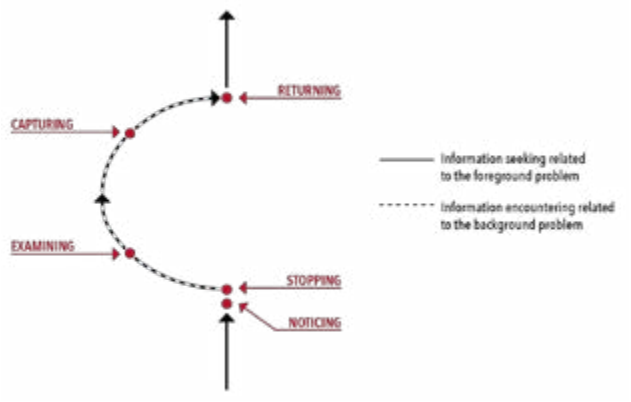

Figure 2. Graphical representation of an event of information encountering within an activity of information seeking © S. Erdelez 2004

Within the subject of information, Erdelez (2004) model of information encountering captures the noticing aspect of serendipity, however it ignores the potential of the human actor, as well as the unpredictability aspect, focusing instead around the concept of finding something while looking for something else, or when engaged on a different activity.

Erdelez's model, while relevant, does not represent the entirety of serendipity as we believe it. Lawley and Tompkins's model (2008), on the other hand, is more encompassing and representative of serendipity, as well as identifying a necessary pre-stage: *Prepared Mind.*

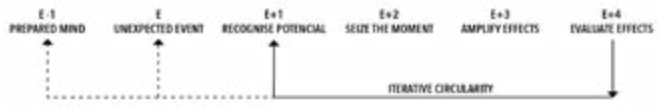

Figure 3. Lawley and Tompkins' perceptual model of serendipity © Lawley and Tompkins 2008

E-1: Prepared Mind is followed by an act of noticing by the observer, such as with Erdelez's model for information encountering. However, in Lawley and Tompkins this act of noticing is explicitly the result of an "unexpected event". These are followed by a moment of *Recognise Potential*, in which there is a "forward-facing" evaluation of the event, recognising a serendipitous potential. This is followed by an event to *Seize the Moment*, in which there is an action to "to preserve and amplify the potential", followed by a possible a moment of *Amplify Effects* wherein other events can occur to "turn an event from an interesting anomaly into serendipity", finally followed by a final moment of *Evaluate Effects*, in which there is a "backward-facing" reflection upon the events, adding to it judgement and evaluating the possible effects that resulted from the event on the one experiencing it.

Lawley and Tompkins's model (2008) shares common ground with Rubin et al.'s four facets of serendipity (Rubin, Burkell, & Quan Haase, 2011): *Prepared Mind, Act of Noticing, Chance*, and *Fortuitous Outcome*, identified in their study of serendipity in everyday encounters accounted in personal blogs.

Facet A: Prepared Mind builds upon Walpole's original concept of sagacity and reflects Lawley and Tompkins's E-1. According to Rubin et al., prepared mind is the result of a prior concern—"a pre-existing problem"—that is linked with a previous experience—"a personal accumulated knowledge or expertise"—that shed light towards a particular find, defining its importance, as well as influence the actual act of noticing "making it more likely that some types of finds (those related to prior concerns) will be noticed." (2011)

Facet B: Act of Noticing describes a need "to be able to notice the find and shift the attention from a primary activity to a clue in the environment". Rubin et al. cites Erdelez's term of "trigger" as an example of this act of noticing.

The act of noticing is followed by *Facet C: Chance*, a "necessary pre-condition of serendipity" that "captures the accidental nature of the encounter and underlines the perceived lack of control" (Rubin et al., 2011).

While Rubin et al. utilise the term "chance" to describe the third facet, they define it as both possibly accidental as well as unplanned and is characterised as the perception of lack of control. The key issue here is that the experience was not motivated by the one experiencing it but comes unexpectedly. It mirrors Laweley and Tompkin's "unexpected event".

Lastly, *Facet D: The Fortuitous Outcome* describes the necessity of the "chance encounter" to provide "unexpected benefits linked to the find", wherein the experience of serendipity is framed as a valuable experience with tangible, beneficial, results. This mirrors Lawley and Tompkins *Recognised Potential* that is the result of an evaluation of the effects.

Building upon both Rubin as well as Lawley and Tompkins models, Makri and Blandford empirically-grounded process model of serendipity chooses to focus not on events but on the mental *connections* (2012).

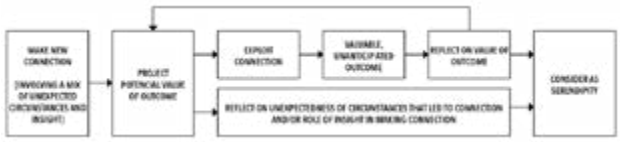

Figure 4. Makri and Blandford's empirically-grounded process model of serendipity © Makri and Blandford 2012

Makri and Blandford's (2012) model reinforces that serendipity is the result of a reflection on the perceived value of the outcome that begins with "making a new connection". It is the result of 28 semi-structured interviews to graduate students and research and academic staff as previous studies "had suggested that serendipity is often an important part of research". While Makri and Blandford's model is of particular interest to the mental processes of deriving insight from unexpected connections in the process of research (what we define as "Serendipity as Knowledge"), it largely ignores other possible serendipitous outcomes (values) of serendipity, such as Experience and Creativity.

As this research is encompassed within the subject of interaction research, we attempted to situate the serendipitous moment within interaction itself. Don Norman's action cycle is well suited for this since, as he himself explains, it can be motivated not only by the establishment of a new goal, but also from an event that triggered it, which Normal refers to as "data-driver or event-driven behaviour" (Norman 2013, p. 43).

As such, the interaction action cycle is able to accommodate the encounters and unexpected events previously identified. This occurs following a change in the world (trigger), starting the *Bridge of Evaluation*, which consists by first a moment of perceiving (which corresponds with Erdelez's moment of noticing), followed by a moment of interpretation (Lawley and Tompkins's recognise potential) that leads to a moment of comparison, whereas there is a reflection on the possible value (comparing the change in the world with an underlying necessity). If, following a reflection of value, that value is recognised, there is a moment of epiphany that generates said value.

However, in the case of serendipity, not every change in the world requires a completion of the action cycle, as the moment of serendipity exists before the possible formation of a goal. In the cases that the moment of serendipity begets further action, Norman's action cycle is completed, if not, there is a moment of capture (Erdelez, 2004), followed by returning.[2]

As such, building upon previous models, as well as Norman's action cycle for interaction, we identify three specific stages that are key for the definition of serendipity.

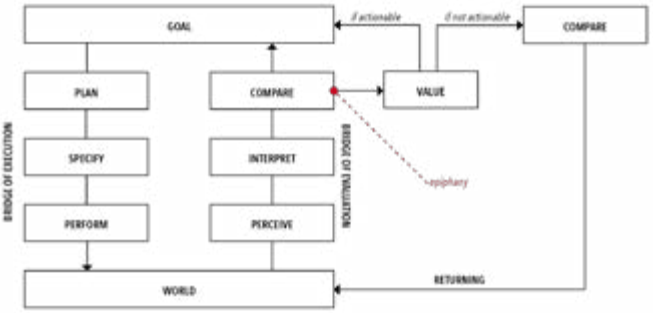

Figure 5. Norman's action cycle with our three stages of the serendipitous pattern.

These stages are common both within Merton's pattern as well as following models of serendipity. We can consider them core stages of serendipity. Here we refer to them as *trigger*, *epiphany*, and *value*.

The observer notices an event that acts as trigger (by connecting that event with some previously established data), leading to a moment of epiphany and the creation of value.

[2] As it relates to "serendipitous" web browsing, De Bruin and Spence identify a third possibility: forgetting, which occurs if there is moment of recognised serendipitous value as well as no immediate action (De Bruijn and Spence).

These stages do not replace other models, but encompass them and encircle them within Norman's cycle, identifying key moments that are relevant for the development of serendipitous systems.

A Serendipitous Pattern

Stage 0: Prepared Mind

Preceding any experience of serendipity, and as we've seen in Lawley and Tompkins (2008), Rubin et al. (2011), Makri and Blandford (2012), as well as in Walpole's original definition, there is a stage (to which we refer to as *Stage 0: Prepared Mind*[3]) that concerns the human actor that experiences the serendipitous pattern and describes the required openness in order to allow for the serendipitous pattern to occur.

This pre-required stage of the serendipitous pattern correlates to E-1 of Lawley and Tompkins's model: "a mind that is prepared to recognise unexpected potential and then seize the moment", encompassing both prior study as well as knowing one's self-bias.

There is an argument to be made regarding the necessity of a mind-set that can be cultivated and incentivised, in order to encourage serendipitous experiences, as Rosenman (1988, p. 137 in Foster and Ford, 2003): "By realising that discovery involves a dynamic interplay between conventional scientific methods and chance in all of its forms, and by cultivating an aptitude for serendipity, scientists can greatly enhance their investigative powers". This argument puts forward the notion that serendipity is less the outcome of chance and more of what the serendipist brings to the experience.

The idea that there is precondition that influences the experience of serendipity is corroborated by Makri and Blandford, that suggest that "being open to new connections could be influenced by their mood and by exposing themselves to new situations and experiences — particularly those outside their confort zones" (2012)

Likewise, this notion was reflected on our own studies, through the observations and exercises realised with first-year design students, wherein those that were receptive to the concepts related to serendipitous discoveries produced the richest results. (REDACTED)

Stage 1: Trigger

The first stage of the serendipitous pattern starts with a moment of noticing a trigger (Erdelez 2004; McCay-Peet and Toms 2010). This act of noticing can be the result of a casual observation done by the human actor, or by an action done by a system that demanded her attention.

[3] The term "prepared mind" is based on both Lawley and Tompkins and Rubin et al.'s utilisation of the expression, which in turn reckons back to Louis Pasteur famous aphorism "Dans les champs de l'observation le hasard ne favorise que les esprits préparés".

This stage corresponds to Lawley and Tompkins's *Unexpected Event* as well as both facets B and C of Rubin's facets of serendipity, although sequential and reversed (first there is a moment of chance/accident/event that occurs outside human control (facet C), followed by a moment of observation and attention (facet B). These two moments are interlinked and cannot be disassociated. An unobserved event is an irrelevant event (therefore it cannot act as a trigger) and a without an unexpected event, there is no observation to be made.

Van Andel and Bourcier (1997, in Campos and Figueiredo, 2002) offer a distinction between triggers that are a result of an external event, and those that are the result of some sort of mental activity, classifying them in two sets: ad oculus stimuli (produced externally, mostly in tangible means); and "mental" stimuli (proceeding from some sort of mental activity) (Campos and Figueiredo 2002).

As observed in Stage 0, every serendipitous pattern requires a mental, internalised process that leads to a 'aha' moment. However internal triggers are those that do not require any external event to kickstart the mental processes that lead to the moment of insight. It is not within our objectives to explore the possibilities to *design* the necessary mental processes that could lead to an internal trigger,[4] as opposed to external triggers.

Makri and Blandford (2012) propose that triggers can be based on a memory, being that it is not absolutely necessary to experience the trigger in real time for serendipity to occur. While apparently similar these differ from internal triggers in the sense as these are remembered external triggers. The triggers can be well-defined or vague, through *things*, such as a "person", an "event", a "place", "information" or an "(non-informational) object".

Building upon Makri and Blandford collection of *things* that address an explicit or implicit necessity that the serendipitous experience address, we've identified three broader categories of external triggers—*Things*, *Places*, *Events*, and *Agents*—that encompass Makri and Blandford's examples along with others that were identified in our research.

Things

Our usage of the term *things* differs from Makri and Blandford (2012) as we do not contemplate persons, places or events in it. Instead, we consider things as inanimate material objects, natural or artificial (when artificial, we shall refer to things as artefacts). *Things* can, likewise, be both physical or digital (it also follows that all digital things are artefacts, hereby mentioned as digital artefacts when necessary), and need to be perceptible in some fashion in order to act as triggers. A notification on a smartphone, a book, an informative flyer, a rock, a pop-up window, both a song or a single note on a piano, all of these are things.

While Makri and Blandford distinguish between informational and non-informational objects, we adopt Buckland's approach of information as *things* (1991), although we prefer the term *meaning* instead of information to differentiate from things that are designed to communicate and those that aren't but aren't.[5]

As such, anything can have implicit or projected meaning. Things with implicit meaning are those with encoded information, such as data and documents (Buckland, 1991). Things with projected meaning are those that, nevertheless, communicate and are meaningful to the observer, but their meaning is projected upon the thing by the person noticing and experiencing it, based on the person's thoughts, experiences, and feelings.

Take, for instance, a paper-clip found in a pocket while grocery shopping. This paper-clip could act as a trigger, remembering the shopper to buy office supplies as well. Or a cold gush of wind when stepping outside, remembering the person to wear a jacket. There is no implicit meaning on this thing but, nonetheless, they communicate.

As such, anything can communicate meaning and, as such, act as a trigger in the serendipitous pattern.

Places

Triggers can occur as the result of specific places. These can be physical (towns, streets, buildings, as in (Makri and Blandford's own examples), as well as virtual (websites, software, virtual reality), or the combination of both (such as augmented reality or location-aware software). The key component of these triggers is the interaction between who experiences serendipity and the space where it happens.

The design of physical spaces in order to encourage serendipity can be described as what Cooper describes as *environmental serendipity* (Cooper 2014, 421)

In the case of *places*, serendipity is not triggered by interaction with a particular *thing*, as in the previous example, but through the interaction where these things are encountered. The classical example is an unexpected book being discovered while browsing through a bookcase in a library. The trigger here is not the book (which would be a *thing*), but the library itself (a place).

These spaces can be traversed three-dimensionally, as in the aforementioned example or in a virtual environment (such as in a 3D video game). It may also occur in 2D environments that are able to be such as a website, but also the pages of a particular book, as long as the navigation and interaction are non-linear.

[4] Beyond the identification of the particular qualities that encourage serendipitous experiences, such as was introduced in Stage 0, qualities that can, nonetheless, be actively developed. These internal factors, however, differ from those described by van Andel and Bourcier that can lead to an internal trigger. While there is an argument to be made that practices such as psychoanalysis could have a visible impact on encouraging internal triggers, they lie outside the scope of this research.

[5] As it relates to this research, and to avoid ambiguity, we adopt Raya Fidel's definition of information as "a strung of symbols that 1. Has meaning, 2. Is Communicated, 3. Has an effect, and 4. Is used for decision making." (Fidel, 2012, p.6)

Both Björneborn (2017) and Dörk et al. (2011) consider the concept of explorability a "key guiding principle for design of urban or digital environments" (Björneborn, 2017) that may trigger serendipitous experiences, encouraging "information flâneurs" (Dörk, 2011).

Taking inspiration of the artistic urban movement of psychogeography and the *dérive*, the intention is to enable an exploration of space that encourages the stumbling and unexpected encountering of information.

Besides *explorability* Björneborn (2017) identifies as well *sensoriability*, *traversability*, and *diversifiability* as key components that enable serendipity to be triggered in physical spaces. However, he argues that while *sensoriability* is rich in physical spaces, the same is not true in digital ones where "typically only sight and hearing are activated" (2017). On the other hand, *traversability* may be richer in digital environments, where mobility is not encumbered by the limitations that exist in physical spaces for the "transportation of people and resources". Finally, Björneborn suggests equal level of *diversifiability* both in physical and digital spaces.

Lastly, *places* can trigger serendipity through the experience of an *aporia* (Aarseth, 1997, p. 3)—where the environment (or *place*) itself is designed in order to prevent the reader[6] to make sense of the whole. The moment that there is a realisation—an insight—that allows the reader a "link out" (Aarseth, 1997, p. 91) that permits the reader to understand the whole of the place, an epiphany replaces the aporia.

Events

Events, as suggested by Makri and Blandford (2012), can be triggers for the serendipitous pattern (as well as information themselves (Buckland 1991)). These are happenings that exist at a particular time and may, or may not, exist at a specific place.

While the examples Makri and Blandford offer for events relate to a particular place (conferences, meetings, and parties (2012)), this is not a requirement. In fact, and more-so with modern communication technologies, events can be decentralised, defined only by a particular time.

Consider, for example, a memory triggered by the fact that it is nightfall. The defining factor of the event is the sunset itself, not where the sunset is experienced.

Events can be experienced on an individual level (as the aforementioned example) or collectively, where something occurs at different places and spaces but are characterised by a common time and action (as, for example, Earth Hour, where lights are turned off during an hour at various different places). Naturally, serendipity only occurs individually, but the trigger that begets it can be the result of a collective event.

Agents

We we've also identified other agents (such as human beings) as possible triggers for the serendipitous pattern, through interaction with said agents (through, for example, communication, which "is instrumental to accidental discovery" (Race and Makri 2016, 20)).

Here we choose the term *agents* in order to represent actors besides the one that experiences serendipity (the serendipist actor) but actors that have, nonetheless, agency as defined by Murray (2012). This means that agents are actors that can "initiate behaviors autonomously" (Murray 2012, 410) and whose behaviour is, in practicality, unpredictable to the human actor.

For the sake of simplicity, when referring to agents we shall refer mainly to human agents or those that are equally complex (such as a hypothetical advanced AI), while other non-human agents shall be understood as things.

In this sense, agents are *undesignable* triggers. However, we are able to design *things*, *places*, and *events* that act as a medium between agents and encourage interaction. These could be done through encouraging awareness between agents (Jeffrey 2000), mediating intimacy (Gibbs 2005) collaborating creatively (Bryan-Kinns 2004), or through the design of a building, such as the example of the design of the Pixar building, that shared a common entrance where common facilities which "resulted in cross-traffic—people encountered each other all day long, inadvertently, which meant a better flow of communication and increased the possibility of chance encounters (Catmull and Wallace 2014, 365)

Here, there is a thin line that separates serendipity through interaction with places or with other agents: if the serendipitous experience ends with the discovery of another agent in a particular space, the trigger is the space, while if the serendipitous pattern is the result of the interaction with said agent, the trigger was a pattern. In both cases, the space can be a designed medium to facilitate serendipity.

Stage 2: Epiphany

Following the trigger that sets the serendipitous pattern and emotion, and the sub-sequent act of noticing, interpreting, and comparing (described in Norman's "Gulf of Evaluation" (Norman 2013, p. 39)) where the investigator is stimulated to "make sense of the datum" (Merton, 1968, p. 158) the second stage of the serendipitous pattern corresponds to the moment in which the connection is made between the serendipist need and the trigger event observed.

This stage, here called epiphany, is where there is a recognised potential from the trigger (corresponding to Lawley and Tomkins' "E+1: Recognise Potential"). At that moment there is a "projection" of the "potential value of the outcome" (Makri and Blandford 2012).

While the term conjures images of a heavenly light shining around Saul on the road to Damascus, this creative moment is not a gift from the gods but the moment where the subconscious work of incubation bursts into the surface of consciousness.

This moment is described by Boden as a flash of insight, according to Poincaré's four phases of creativity (named by Hadamard as *preparation*, *incubation*, *illumination*, and

[6] In the particular case of hypertext.

verification), in which there is an unexpected moment of creativity following a phase of subconscious incubation (Boden 2004).

Next comes the flash of insight, to which— despite its unexpectedness as a conscious experience—Poincaré ascribed a significant mental history: "sudden illumination [is] a manifest sign of long, unconscious prior work" (Boden 2004, 30).

Epiphanies, minor or larger, are prevalent throughout all human experience, and not all epiphanies are the result of an unpredicted external trigger, thus not all epiphanies are the result of serendipity. However, all experiences of serendipity do require a moment of epiphany.

Just as Archimedes' famed proclamation following the observation of the water level on the bath, epiphany is the result of what McCay-Peet and Toms (2010), citing Koestler, refer to as a bisociation (a surprising association between disparate, previously unconnected pieces of information), or what Makri and Blandford (2012) refer to as a connection.

As it is the result of a mental process, it is difficult to describe (Makri and Blandford 2012). It can answer an underlying query or need, such as Makri and Blandford's example of "to find love", but as they demonstrate in the example of one of the interviewees realising that he needed a bicycle the moment his neighbour gave him one, the need being addressed by the serendipitous moment is only realised "at the time the connection is made" (2012).

Stage 3: Value

To be considered as serendipity, the epiphany that results from the process must be valuable to the human actor.

Your discovery may well be interesting and informative, but it will not be truly serendipitous unless it helps you fill in a piece of a puzzle you've been poring over (Johnson 2010, 109).

As such, the final stage of the serendipity process is the identification of value from the experience. This value is a key element of serendipity what distinguishes it from coincidence (Bogers & Björneborn, 2013).

Corresponding to Lawley and Tompkins E+4 moment of serendipity "Evaluate Effects", as well as Facet D of Rubin: "Fortuitous Outcome—in which there is a perceived gain/happy ending—value is recognised looking backwards to the experience and reflecting upon it. According to Cunha's definition of serendipity (2010, 320) as "the accidental discovery of something that, post hoc, turns out to be valuable", value is only considered upon reflection (immediately following the moment or afterwards in, what Rubin et al. call's a "reframing of events (2011).

Although already considered valuable to some extent, the full extent of the value of the outcome becomes apparent over time – through an iterative process of projecting further value to be gained from the connection, continuing to exploit the connection and *reflecting on the value of the outcome.*

After reflecting on both the value of the outcome and the involvement of unexpectedness/insight, the experience can be considered as serendipity (Makri and Blandford 2012).

Also, as observed by Makri and Blandford, future events can increase or decrease the perceived value of the serendipitous experiences (what Lawley and Tompkins refer to as an "Amplification of Effects"), based on following subjective experiences and the relative impact of that value had in the subject's life. Although the long-lasting impact of the value derived by the serendipitous experience can only express itself over time, there is still a necessity, at the moment of the serendipitous experience, to recognise a certain value and, if necessary, act upon it (completing Norman's action cycle) or, if no further action is required (no goal is established), then there is a moment of capturing (as per Erdelez's model of Information Encountering) and a return to the World.

The value of serendipity, however, can manifest itself in different fashions, each of it with different implications on the experience. We have identified three ways in which serendipitous value can be expressed: through the acquisitions of knowledge, through experience, and through a creative act.[7]

Serendipity as Knowledge

Perhaps the most researched aspect of serendipity, and the most commonly associated with the term itself, is the creation and production of new knowledge as a consequence of the serendipitous experience. A new insight that follows a connection with information (Makri and Blandford 2012) regarding an underlying question or necessity, commonly illustrated by the examples of Archimedes or Alexander Fleming in which an unexpected (and unpredicted) event triggers a deduction.

This may be the result of new (relevant) information, as well as previously known information that it is presented at an opportune time.

Described by Fine and Deegan as "analytical", this manifestation of serendipitous value "involves the ability to establish connections between data and theory (1996).

It is the assumption in Merton's pattern of serendipity, where the insight that is generated "stimulates the investigator" to "fit it into a broader frame of knowledge" (1968, pp. 158–159), which leads to an abduction and the production of knowledge.

In order for knowledge to be created, in the context of qualitative research, Fine and Deegan identify a series of possible processes that allow for an insight to occur: The first is a previous exposure to previous knowledge (such as relevant literature on the matter) allowing for one to see

[7] These correlate, to some extent, with Fine and Deegan's three potential opportunities that "chance provides": temporal serendipity, serendipity relations, and analytic serendipity" (Fine and Deegan). While Deegan's serendipitous opportunities are in regard to qualitative research, those identified here are in regards to interaction design. Nonetheless, the possible correlations between shall be appropriately identified.

"relevance where none was noticed before", perhaps as the result of interdisciplinary interests and influences. Secondly, the data needs to "speak to the researcher". Thirdly, the problem needs to be conceptualised in a novel form that reframes the problem (as, perhaps, a dramatic metaphor or narrative strategy); Finally, the researcher "may be influenced by being part of a scholarly world", in the sense that the social ties that connect researchers can influence the work being developed.

By knowledge, however, we do not necessarily mean historically and scientifically significant knowledge that is required to be produced. It can be pedestrian, such as Raya Fidel's example for information encountering: "Finding a telephone number one will need tomorrow while surfing the web, or happening upon a nice toy store when going to a new movie theater, after unsuccessfully searching for a toy shop, or finding information when reading for pleasure." (Fidel 2012). This is knowledge, even if only individually significant.

Serendipity as Experience

Serendipitous value can be found not only through the discovery of new and meaningful knowledge, but also through an unexpected and meaningful experience, where one does not necessarily discover a particular bit of information that may or may not produce insight, but where one finds oneself the subject of a particular experience with unexpected and unsought results. Research in serendipity as experience has been developed as it relates to listening digital music (Levy, 2006), as well as when interacting with personal media collections (Bentley et al., 2006; Helmes et al., 2011).

One example of how serendipity can be a valuable user experience is Leong, Vetere, and Howard's empirical studies with random-led listening to digital music (2008). Leong's argument is that the necessity of having to choose what to listen to within a large musical library can be "unpleasant and even paralysing", particularly when the user doesn't have a particular preference. As such, abdicating of their ability to choose what to listen to, can lead to an enriched listening experience and even encourage "encounters with serendipity".

Their findings reported that "the surrender to a random process coloured participants' listening experience with unpredictability". By experiencing music through this shuffle functionality, individual listener perception was increased for not only each track but also of for those that preceded and followed, creating the necessary conditions for "intense experiences such as serendipity". Some examples of these experiences of serendipity could be observed with the listener having a desired track start to play randomly, at the right moment; when a track meaningfully resonates with a particular sentiment the listener was experiencing or simply as a freak coincidence (Leong et al., 2008).

As Leong et al. conclude, there is a great deal of value to be discovered if we explore alternative methods of interaction (random and abdicating choice in this particular example), that are capable of creating meaningful experiences.

Serendipity as Experience accommodates, as well, the "temporal" and "relations" examples of serendipity described by Fine and Deegan (1996).

"Temporal serendipity" refers to "being exposed to a particularly dramatic event can, at times, transform a mundane ethnography into a classic", where who experiences serendipity will recognise it "as significant when they occur and will be shaped into powerful narratives", while by "serendipity relations", Fine and Deegan refer to the establishment of personal connections through acts of "good fortune" that still require the ability of the serendipist to "capitalize on this contact" (1996), leading to serendipity.

In both cases, there is the experienced value, while there isn't, necessarily, identifiable knowledge or creation that resulted from the serendipitous moment. Regardless, this value should not be ignored from the development of serendipitous systems.

Serendipity as Creativity

Serendipity is intrinsically connected with creativity. To experience serendipity is to experience a moment of creativity that results from a moment of unpredictability. As with creativity, while one cannot systematically provoke serendipitous moments, we can create the necessary conditions that have proved to be conducive to serendipity.

Boden's own definition of creativity—"the ability to come up with ideas or artefacts that are new, surprising and valuable" (2004, p. 1)—is reminiscent of many definitions of serendipity. In fact, we may even consider that, while not every creative moment is necessarily serendipitous, all serendipitous moments are creative ones.

To experience serendipity is to experience what Boden defines as psychological (or personal) creativity, as in, a personal discovery. That is not to say that it cannot lead to a historical, or absolute-creativity, as the eventual outcome (in fact, the history of inventions and creativity are filled with anecdotes of such events), but the process is circumscribed to a P-creative one.

Value in serendipity is found in creative outcome, but the act of serendipity is, in itself, a moment of combinatorial creativity, as it is the result of a connection, done unconsciously and after a particular input or signal that triggers that moment. When describing creative value in a serendipitous finding, we are referring to the utilisation—and expectation—of serendipity within the creative process, deployed knowingly and purposefully.

This particular intentionally can be observed in Philip Galanter's definition for generative art, in which artists use systems with a certain degree of autonomy to create a work of art (2003). Through the use of autonomous or semi-autonomous systems (such as, for example, an algorithm), the artist knowingly expects to be serendipitously surprised by a particular result.

Systems and creative tools could be designed in order to further explore accidents in the creative process in order to

turn them into serendipitous moments, as Boden suggests: "If knowledgeable agents were developed to help us make the best of our mistakes (not just avoid them), they could lead to some real surprises" (2010, p. 171).

Conclusion and Future work

In order to be able to design interactive systems that afford serendipitous experiences, we must first understand the specificities of the experience of serendipity itself.

Based upon a review of the literature, we established a model for serendipity within Norman's Action Cycle, establishing a based within interaction design for the experience of serendipity, followed by an exploration of the three core stages necessary for serendipity to be experienced—*Trigger*, *Epiphany*, and *Value*—as well as a necessary required stage—*Prepared Mind*—regarding the human component in recognising serendipity.

In future work we expect to continue to explore the intrinsic qualities of serendipity—particularly the role of chance in it—, as well how it can be encouraged through design.

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