Heteroscalar Serendipity and the Importance of Accidents

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Luck is problematic when it comes to moral or epistemic virtues such as creativity. Interviews with creative people (Csikszentmihalyi, 1996; Sawyer, 2018) point to its undoubted importance to both career trajectories and creative moments. Indeed, Csikszentmihalyi writes (p. 46).

> When we asked creative persons what explains their success, one of the most frequent answers—perhaps the most frequent one—was that they were lucky. Being in the right place at the right time is an almost universal explanation.

We value creativity and so displaying it is a socially desirable act. The role of luck in creativity undermines the notion that creativity is a character virtue; character virtues require the agent to know what she is doing, to

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make an active choice and for this to stem from her fixed disposition (Kieran, 2017). In the case of creative success generated by luck, these criteria cannot be met. However, as argued by Gaut and Kieran (2018), creative success also seems to be more reliant on luck than other forms of success.

So, the question becomes how to reconcile the seeming contingent nature of creative success with its personal and scientific import. In the past we have invoked the muses or other supernatural explanatory factors (see Le Hunte, this volume) to explain this or allowed it to rest on the shoulders of great creative geniuses who rise above the flux of chance (Montuori & Purser, 1997). I have argued elsewhere that the answer to this is to move from considering the relationship with chance as one of luck and rather to consider it as a manifestation of serendipity; that is, as *enacted luck* (Ross & Vallée-Tourangeau, 2021c). Serendipity is the combination of accident and sagacity—it requires both luck (in the form of accident) and, crucially, the exploitation of that luck by a skilled agent (Merton & Barber, 2004). In this respect, serendipity allows us to negotiate the narrow path between uncontrolled accident and agential intent and attribute a form of distributed epistemic credit across agent and environment.

There is a danger in equating serendipity with creativity. Definitions of both creativity and serendipity are volatile. Both tend to centre on two characteristics—novelty and value in the case of creativity; accident and sagacity in the case of serendipity—and then seek further stability with a variety of additions which suit the situation (see Simonton, this volume). In a way, this definitional instability is inevitable—both concepts suffer from the same problems of contingency, unpredictability, and a conceptual spread that includes both the mundane and the extraordinary. For both, the list of necessary conditions gets ever longer without looking like reaching sufficiency; a list which threatens to engulf all human action. After all, a broad enough definition of novelty can include almost any act (Martindale, 1990) and all human activity takes place against a background of environmental flux or chance. A definition which is broad enough to cover every eventuality that could be labelled either serendipity or creativity is weak and meaningless, yet threshold definitions are also vexingly unsatisfactory.

In addition, definitions of creativity which have tried to cast the interdisciplinary concept as something worthy of academic study have struggled with the tension between the mundane and the mysterious implied by the idea of "bringing into existence" at the heart of what it means to be creative. On the one hand, "to bring into existence" is an everyday act—moving through life, each experience is novel; on the other hand, generating something from nothing is conceptually and practically problematic. To counter this and avoid crediting the "schizophrenic word salad" (Weisberg, 2010, p. 237) by attributing it the label of "creative", most definitions agree that creativity has to have some level of value whether that is personal or social value. This value further complicates the concept of creativity, given that "creative" status can be awarded and taken away with an alarming level of arbitrariness (see also Simonton, this volume). In the same way, serendipity as well only occurs in retrospective sense making (Solomon, 2016) and can also be changed depending on the standpoint of the observer. So, for both, the definitions require taking into account the extended network (Copeland, 2019; Csikszentmihalyi, 1998, 2014). These extended networks decide whether an act is either creative or serendipitous, or both, and the collective can also change its mind. It is because of these vexing complexities, I wish to move away from a conceptual definition to a focus on descriptions of process.

This conceptual dissipation in the case of serendipitous creativity is particularly a risk if we argue—as I have elsewhere (Ross & Arfini, forthcoming; Ross & Vallée-Tourangeau, 2021c)—for a materially engaged form of creativity which requires an open system to generate novelty. Novel existence presupposes a tangible form and so a full study of creativity cannot limit itself to the study of sequestered psychological functions. It is impossible to be creative in abstract. The notion that a mental blueprint is drawn up and imposed on inert matter—so called hylomorphism (Ingold, 2010)—is not upheld by any observational or qualitative data of which I am aware and so reflects creativity as we wish it were rather than as it actually is. Rather, it seems creativity unfolds incrementally and recursively along multiple timescales and in coordination with the material (Glăveanu, 2020; Glăveanu et al., 2013). The nature of the form changes with the nature of the creative action but

similarly the nature of the creative action changes with the nature of the form.

Creativity in this view consists of actions on objects and this material engagement (Malafouris, 2013) is part of a constant interaction with things beyond the closeted agent. Creative action requires a dissipation of agency and familiarity with an uncomfortable uncertainty (Beghetto, 2020; Glăveanu et al., 2013; March, 2019). If this is the case, then at first glance the relational nature of serendipity seems to permeate all aspects of the creative process. Environmental flux and material affordances shape and direct the flow of creativity and what emerges is not reducible to either artist or material, process or final product. However, I will argue that serendipity goes beyond a simple connection between agent and chance. Such a binary definition of serendipity dissipates it to such an extent that all creativity—and perhaps even all human activity—can be seen as serendipitous. This is unhelpful.

This chapter will explore a way of understanding serendipity which casts it as more disruptive in nature than this. I will suggest that serendipity requires a break in a flow state, and it forces a reassessment of the artistic intent. We can trace this by three things: first, an accident stemming from unintentional action or an external source, second, the noticing of the accident (indicated by surprise) and third, a change in creative action. These are similar to the elements picked out by Arfini et al. (2018) who identify both the accidental and "game changing" nature of serendipity. Where I depart from them is by not attributing a value to the accident; the aim of the analysis outlined here is to assess the accident without the post-event value judgement. This means that the accident becomes ontologically unstable with regards to serendipity, but I suggest these three stabilising characteristics outlined above (and in more detail later) will go some way to mitigate this. Furthermore, the arbitrariness of social judgements mean that serendipitous events are necessarily *always* ontologically unstable, as that label can be removed as easily as bestowed.

However, it is important to begin by situating the argument for serendipity as a single surprising event in more extended understandings of serendipity. I agree with the wider literature (e.g., Copeland, 2019)

that it is these broader understandings—personal and socio-cultural—which shape whether or not an event is understood as serendipitous. This retrospective coronation is the very thing which makes serendipity "slippery" (Makri & Blandford, 2012). In this respect serendipity closely resembles creativity in terms of its heteroscalar composition. The argument laid out here with regards to serendipity draws on similar discussions around value attribution and definition in the creativity literature, which is also rooted in the tension between the moment of "insight" and the broader structural causes of creative products. However, I also agree with Baumeister et al. (2010) that it is only the accident that differentiates a serendipitous from a non-serendipitous discovery because "sagacity" is required for all discovery. Therefore, a theory of serendipitous discovery which does not pay serious attention to the accident risks blurring the line between the two. I therefore suggest that becoming comfortable with the ontological instability may be necessary.

Heteroscalar Serendipity

What follows is a necessarily brief description of how the different temporal levels of serendipity interact when it comes to creativity and discovery. This is captured by the notion of heteroscalarity, that is the importance of taking account of the simultaneous different time scales over which a phenomenon can occur to fully understand it (this is similar to multiscalar approaches as described in Steffensen & Vallée-Tourangeau, 2018). I do not intend this as an exhaustive account of how serendipity plays out in the generation of a creative product. As I have already indicated, an exhaustive account of serendipity or creativity is perhaps unobtainable or at least useless when obtained. Rather, I offer an illustrative one to situate the argument I shall make for the understanding of the accidental event to generate a clearer view of what serendipity means and how it can help us understand creativity.

The narrative scale of serendipity has been highlighted by others (see for example Solomon, 2016). Yaqub (2018, p. 176) calls this the "window of analysis" and points to the difficulty of pinpointing temporal start and end points for a serendipitous incident, suggesting rather that

we speak of a serendipitous "phase". As well as start and end points, I also suggest that we have a problem of heteroscalarity—that is that serendipity can take place across multiple time scales each with an attached level of granularity. Take the story of the discovery of penicillin: Fleming's discovery was serendipitous in different ways yet each necessary in the overall story. It was serendipitous that Fleming was in a time when the scientific networks existed to cement his initial observation, as well as being serendipitous that he personally was equipped with a mind prepared to understand the implications of what he saw and finally it was a serendipitous accident that generated the triggering observation. The final discovery emerges from all three and is irreducible to any one of them.

Figure 1 describes the complex nature of the temporal rhythm when it relates to both creativity and serendipity. Understanding this requires
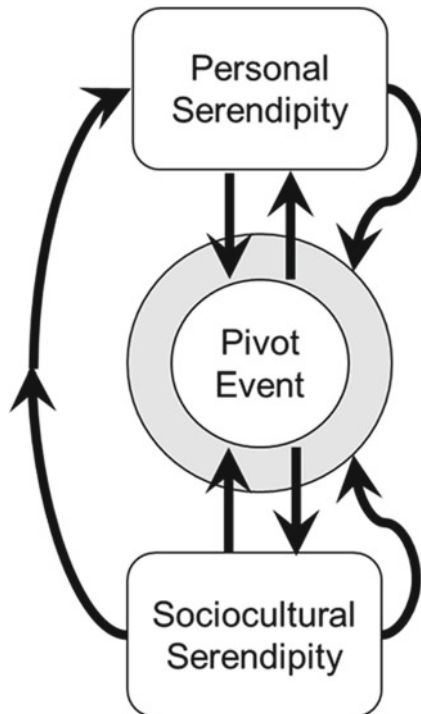

Fig. 1 The Heteroscalar model of serendipity

a comfort with plurality and the contradiction occasioned by different yet interconnected levels of analysis. The event shapes the surrounding personal and socio-historic environments, which then also shape and change the event as well as both interacting with each other, leading to a form of backwards causation (Latour, 1999). However, what lies beneath these shifting time scales is necessarily the exploitation of an accident. This accident is the pivot event, a threshold moment when something changes which is reflected in a change in the creative trajectory. Whilst the accident is not serendipitous in itself, it is a prerequisite for distinguishing specifically serendipitous discoveries.

A creative act is nested within a person and that person is nested within a wider social and cultural context. Each of these shapes and constrains the other dynamically. Serendipity can intervene at any level: The "place" and "time" in "being in the right place at the right time" are multiple and connected. Let us start with the broadest level: Socio-historic serendipity. This is the historical backdrop which both generates and constrains the nascent creative act (Ross et al., 2020). There is a thread of inevitability to this form of historically situated serendipity. Simonton (2004, p. 10) argues that it (in the form of zeitgeist) is "strikingly incompatible" with the chance perspective. He suggests that viewing cultural ages in this way makes creativity inevitable. I concur and I view the idea of a golden age of multiple discoveries (Lamb & Easton, 1984) as clear evidence for the inevitability of social change and discovery, thus categorising characteristics of wider socio-historic background as serendipitous needs to be done with care.

However, I also suggest that, for some forms of serendipitous discovery, the socio-historic background can be better understood as an extended prepared mind (in the tradition of the prepared mind, Clark & Chalmers, 1998) which provides the ground which is fertile enough for creativity and innovation to take hold from incidental observations (a similar argument is made by Muthukrishna & Henrich, 2016). In the simplest form, discoveries require the correct tools to exploit and sediment the discovery. Some inventions such as Leonardo's helicopter have survived but it is likely that many others have been lost. If the right time is almost guaranteed to generate a certain idea, an idea out of time

is almost guaranteed to not be followed up. On a very basic level, the exploitation of an accident is constrained, not by the sagacity of the individual agent, but by the abilities and resources of wider society and social networks.

The idea of an extended prepared mind is further embedded in the systems model of creativity introduced by Csikszentmihalyi (1998, 2014). He argues that the creative actions are only creative once publically recognised as such, even if that public recognition is as mundane as the scoring of judges on a consensual assessment task. In this model creativity is seen as "a phenomenon that is constructed through an *interaction* between producer and audience" (Csikszentmihalyi, 1998, p. 314, emphasis in the original). Creativity requires transmission and sedimentation from a broader domain, which in turn requires selection and acceptance by a field that can be surprisingly narrow. Thus, there is an inherent paradox at the heart of creativity (which I discuss further below in relation to the notion of the adjacent possible). An idea must be novel but not so novel that it is rejected by the field. The field must be prepared to accept it. As we shall see, this tension is repeated on a microscale when we come to the role of the accident. Both creativity and accident require rupture and diversion, but if too extreme then they are disregarded or the skills necessary to exploit them are not available. Thus, they walk an uncomfortable tightrope between disruption and continuity which is constrained by the surrounding socio-historic environment. This is something Glăveanu (2019) describes as immersed detachment.

There are many tales of a scientific discovery that lay unexploited because it was not recognised by the field until much later. Take Boris Pavlovich Belousov's discovery of the foundations of the Belousov-Zhabotinsky Oscillator (Winfree, 1984). A surprising observation was followed up by the scientist but lay unpublished because it was not at that time considered possible—it failed to find sympathetic reviewers and so languished for many years. The occasional and regular rediscovery of past discoveries suggests that there cannot be a strict inevitability to a particular scientific discovery being exploited by an extended prepared mind even if certain features of a society make a scientific discovery inevitable. Survivorship bias means that we are aware of those things which are eventually accepted by a field, but we should be very wary of assuming that

this process picks up all great discoveries simply because we could never know if recognition did not happen.

Therefore, for an accidental observation to take hold and change long-term trajectories then socio-historic serendipity is required to intervene in two ways. First when the accident happens, the broader extended societal mind needs to possess adequate resources to exploit and cement this and second, broader social judgements are required to coronate the person, product or thought (Copeland, 2018). That the accident takes place in a time and culture which possesses these two qualities is serendipitous. Furthermore, a momentous enough event will change the surrounding socio-cultural environment which will then produce a narrative which supports the event and yet this impact can also only be understood in relation to that environment. It is important to note that the *same* event can be therefore either serendipitous or not serendipitous depending on what happens after.

Personal serendipity refers to the next level, one that is often reported by those who have assessed the long-term careers of creative people (Csikszentmihalyi, 1996; Getzels & Csikszentmihalyi, 1976; Sawyer, 2018) and is also that referred to by Gaut and Kieran above. It describes the idea of contingency in a personal life trajectory. The role of chance in this case takes on a more finely grained aspect than in socio-historic serendipity where it is often smoothed out of the narrative, and so the role of an accident comes into a sharper relief, although viewed through the eyes of the person who experiences it and so already understood in retrospect. The inevitability which seems apparent in the longer timescales is less so when the necessary skills for the exploitation of an accident fall more contingently—a discovery may be driven by zeitgeist but that it falls to the particular person to add the final piece often seems a tale of improbable connections.

The third scale on which serendipity can happen is the focus of the rest of this chapter. That is the momentary "accident" which is the trigger for a change in creative or innovative trajectory. I argue that it is at this moment that serendipity occurs as an *event* and accident meets sagacity; later in the narrative arc of serendipity it becomes an *experience*, which is how it is more commonly understood. The accident is experienced by a person and is often reported and understood as an experience, but I

argue that it can also be seen as a single event which can be observed in detail. This is important to develop an empirical research programme examining precipitating causes and the best actions to take. It in important to recognise that in itself this event is not serendipity but is rather ontologically unstable until after it is complete and has been enacted. At this stage when there is a clear outcome it is classed as either valuable or not. This means it is intimately reliant on both socio-cultural and personal serendipity both at the moment it is recognised and afterwards. The shifting ontological status of the event poses a challenge for a systemic examination which is why it requries isolation.

Microserendipity

Socio-historical and personal serendipity are structuring causes. They are necessary for the enactment of serendipity, but they are not triggering causes (Dretske, 2010). All discovery, innovation and creativity take place in networks and they are secured by individuals who have certain skills and talents. This is a trivial observation. What sets serendipity apart is that the triggering cause is an accident which arises from outside the system. This is a radical understanding of serendipity which constrains the conceptual dissipation outlined above but which may end up overly reducing the number of events we label as serendipitous. It does not deny the importance of other temporal levels but rather suggests that these are important for *all* elements of creativity. What makes the accident important is that it is not inevitable. This is why not all discovery and creativity are serendipitous. Serendipity on this time scale I call microserendipity to emphasise its narrower focus. Microserendipity aims to move away from the wider timescales (Ross, forthcoming; Ross & Vallée-Tourangeau, 2021c, 2021a) to focus on a single event.

Elements of socio-historical serendipity and personal serendipity have been explored in the literature, but the moment of accident is perhaps under explored. This is not surprising. The accident can only be recognised as serendipitous after it has occurred, indeed only becomes serendipitous after it has occurred. This is then problematic; short of recording and following people who we suspect of having the potential

for a creative act (and a researcher would have to be lucky even then) by the time that accident is identified as serendipitous we no longer have access to that moment to observe it. Furthermore, it is necessarily filtered through the levels of socio-cultural and personal retelling identified above to be identified as important. However, research on serendipity deals with complexity and contingency as a matter of course so it needs to embrace this most contingent of elements.

It is also problematic because it points towards a reductionist view of a phenomenon which is intrinsically emergent. A focus on the accident as the primary driver in serendipitous discovery threatens to undermine the arguments laid out above for serendipity's heteroscalar nature. After all, serendipity requires recognition and a retrospective coronation, and so an accident cannot be either serendipitous or not serendipitous without this. However, I suggest that a focus on the nature and characteristics of the accident is as important as the focus on individual sagacity in respect to serendipity as a skill which is already sustained (de Rond, 2014); indeed, often even those who focus on this skill also include the triggering moment (Makri & Blandford, 2012; McCay-Peet et al., 2015). Emergent phenomena require plurality of analysis to understand their complexity. Multiple levels of analysis can co-exist and indeed do (Giere, 2006).

I therefore suggest there are three characteristics of the serendipitous accident which can help us understand how that accident occurs and how it can further lead to novel thoughts or things. First, the accident arises from either object-actions (that is pure "accident" in the folk understanding) or non-directed actions on and with objects. Second, while unintended, the results of the actions are both noticed and generate surprise. Third, it represents a change in the creative trajectory and occasions the forming of a novel creative system with a different intention. A serendipitous accident is necessarily contextualised which prevents the focus becoming too severely reductionist; a serendipitous accident is also a situated accident. It cannot be understood without a reference to the state of the broader surrounding system before it occurred, and it is only serendipitous if it is later enacted. This means we keep the sequential nature of human action whilst still maintaining that some aspects are

unexpected and unpredictable. Paradoxically, a focus on the accident as an event may help underline the importance of the surrounding system.

I argue that an accident characterised in these ways will not only support us to identify serendipity outside of an experiential narrative account but also stop the spread of serendipity as a description suitable for any and all human action. A serendipitous accident is not a sufficient condition for serendipity to arise, the subsequent retrospective coronation that has been picked out above is also necessary. Consequently, I offer these three characteristics as a starting point to build a theory of serendipitous accidents.

Non-Directed Action

Serendipity and creativity require action: Creative thoughts become manifest through action (Glăveanu & Beghetto, 2020). It is this that separates creativity from imagination. In taking on a form whether that is subvocal murmuring, a written score or the premier of a full orchestral piece, the creative thought shifts and moulds the underlying nature of that form while also being shifted and moulded by it (Malafouris, 2020). The practical implementation of the imagined plan cannot be detached from that plan and so plan and creative objects are co-created. Thought and form are collapsed. Intention arises in action and is created by soft assembled creative systems at the centre of which are the artist and the material, but around which are many different things both proximal and distal which sediment the process until finally something is created. In short, creativity is a dynamic process which resists static analysis. Serendipity is similar in structure. The agent responds to an event in the environment and that response shifts and shapes the event, turning it from something which the person could just have passed by to something "serendipitous". At the centre of the soft assembled system is the event and the agent's response to it but that event is anchored and tailored by networks which sustain and support it.

Initially, it seems that a difference between serendipitous and non-serendipitous creativity is the point in the creative timeline the action takes place. In non-serendipitous creativity, the action and the creative

things co- create and there is no easily identifiable trigger event (March & Vallée-Tourangeau, this volume), whereas in serendipity, the creative action is a response to an event which is outside of the agent's control. Post-event action is required to enact and generate that which stems from the event, but it is not a generative action in itself. This aspect of serendipity leads to profiling of environmental affordances that can maximise these forms of actions. I call these object-actions to empha- sise the lack of direct human agency. These object-actions are what are commonly considered to be pure "accidents", that is they are movements in the world which are not generated in any way by the human agent that they affect. These, however, are perhaps the rarest forms of actions leading to serendipity and also those for which there is the least evidence beyond the anecdotal.

However, at other times, actions with and through objects generate these accidents so the divide between action and accident is less clear and attribution of intential agency murky. This is something that Austin (1979) has labelled the Kettering principle (see also Copeland, this volume), that serendipity and discovery are more likely to arise from something which is in motion. Actions on objects like this are more common in the serendipity literature. These serendipitous actions can be divided into those which occur prior to the pivotal event and are a trig- gering cause and those which occur afterwards and have a sedimenting effect. Sometimes the preparatory actions leading up the event lead the event to be labelled as pseudoserendipity (Roberts, 1989) but the divide between the serendipity and pseudoserendipity is hard to sustain and has been frequently challenged (Arfini et al., 2018; see also Simonton, this volume). However, by allowing accident generated by intentional actions into the class of serendipitous triggers, we return to the problem of conceptual elision, where all human actions are seen as serendipitous so I suggest that the idea of accidents generated by human action needs further refinement.

Rather than categorising the action by where it occurs in the creative trajectory, I suggest that this division should not be a temporal one but rather one of intention. Post-event action is marked by an intention to build on the effects of the accident, pre-event actions (whether object- actions or actions on objects) which generate the accident should be

marked by a lack of planning and the unexpectedness of the result. That is, the results of the actions were unanticipated. This is at the heart of the notion of an "unsought finding" (van Andel, 1994).

Intentional action has a representative and an attitudinal aspect. Intention in this respect requires a plan (the representational aspect) and a belief that that plan can be carried out and will yield results. It is for this reason that an action with the plan of generating random events will not be serendipitous. If I believe that by scrambling letters, I can generate a moment of randomness that will trigger a creative moment then I am carrying out an intentional action and whilst the results may be unplanned in their detail, they are not unplanned in their overall structure. To be an accident, the trigger action must generate something different to the initial representative aspects. Equally, while the intention can be to solve a problem, some serendipitous tales demonstrate unintentional action where the plan has been carried out without a concomitant attitudinal aspect. That is, actions can be carried out ostensibly with the intention of solving a problem but with no belief that those actions will be successful. Such quasi-desperate actions only become serendipitous through attitudinal change.

Whilst environmental and personal triggers have been investigated, there has been less attention paid to the types of actions that might generate serendipity. Kirsh and Maglio (1994) introduced two different motivations for action: Epistemic and pragmatic. Whilst a pragmatic action has as its intention progression towards a concrete goal, an epistemic action is one which does not advance or change the practical landscape but does yield more information about the situation. Epistemic actions are those which aim at manipulating information bearing structures to reveal the information and increase understanding (Rowlands, 2018). For example, an epistemic action would be to turn a jigsaw puzzle piece so it was clear where it would fit in the overall picture, a pragmatic action would place it there. Neither of these actions are useful to our understanding of action and serendipity because they reflect both a representational and an attitudinal aspect. This indicates intentionality from the agent (see also March and Vallée-Tourangeau, this volume, for a discussion on extended intentionality).

On this view, serendipity is generated by unintentional actions. Such forms of action I suggest can be labelled exaptative actions (Ross & Vallée-Tourangeau, 2021b). The notion of exaptation is borrowed from innovation (Andriani et al., 2017) to signal something which is repurposed. Exaptative actions start with one representational aspect but expose information contained in the object of interest unrelated to that initial plan. I call these actions exaptative to emphasis the change of direction that occurs once their initial results are observed. These actions may be skilled and intentional, but they do not have within their representational or attitudinal aspect the plan or the belief that they will generate the knowledge that they end up generating. When the epistemic state of the system is shifted through these unintentional actions, they then change recursively to secure the knowledge revealed. Their purpose becomes different and pre-serendipitous actions become post-serendipitous actions.

Exaptative actions are important to understand serendipity. Not only are they often reported in anecdotal tales, but they allow serendipity to resist falling into an unhelpful binary of agent on one side and accident on another. The important aspect of an exaptative action is that it generates an unintentional change in the epistemic state of the system which in turn updates the representational aspect of the action. It is not that the change is not generated by the agent but rather that is does not map onto the change intended by the initial action. However, systems are always changing and intentionality is sometimes hard to infer or recall. In which case, we risk returning to the dissipated nature of serendipity where all actions over objects are in some way considered serendipitous. For this reason, we need to add another aspect to the notion of a serendipitous accident: the element of surprise.

The Element of Surprise

The etymological roots of accident imply something entering from outside the system. It comes from the latin *accidere* meaning "to fall down, impinge on, be heard, happen" (Merriam-Webster) and serendipity is firmly tied to the "act of noticing" (Rubin et al., 2011). At

the heart then of the notion of a serendipitous accident is that it comes from outside the system, involves a disruption and is noticed. These aspects can be collapsed into one: A serendipitous accident is surprising (see Glăveanu, Simonton, this volume). I suggest that the element of surprise is key to resisting the conceptual dissipation outlined above. In this case, a bland definition of serendipity that threatens to engulf all encounters with environmental chance ignores the disruptive nature of the phenomenon (see Copeland, this volume). For serendipity to have the effect with which it is credited then it is necessarily disruptive because it forces a change in epistemic field and (as we shall see) requires a change in action. This disruption is marked by surprise.

Surprise connects both creativity and serendipity. Whilst it is not part of the core bipartite definition for either, it is regularly attached to creativity. Boden (2004, p. 4) defines creativity as "the ability to come up with ideas or artefacts that are new, surprising and valuable" and Simonton includes it in his calculation for creativity (see Simonton, this volume). However, surprise is also situated and relational; something is surprising for someone and something which may be surprising in one situation passes unnoticed in another (Ross & Webb, forthcoming). It is an epistemic judgement related to prior expectations and the likelihood of an event. It has both affective and cognitive dimensions which make it hard to classify (Celle et al., 2017).

What marks a difference in the theoretical analysis of creative surprise and serendipitous surprise is the proposed origin of the surprise. Current cognitive research on creativity focuses on the moment of "insight" as a key factor. Historically, this derives from a combination of Gestaltist psychology (Köhler, 1925) and Wallas's (1926) four stage theory of creativity. This affective and cognitive mechanism is regularly linked to creative inspiration and is examined by presenting participants with initially intractable problems. It is theorised to consist in the alleviation of a feeling of being stuck, a feeling of certainty in the proposed solution, a feeling that this solution came suddenly, a feeling of "aha" and, importantly, a feeling of surprise in the answer. Thus, it is marked by a similar lack of agency to serendipitous surprise but differs in two fundamental ways. First, insight is theorised to be an internal mechanism which comes

from a (disputed) mental process whereas serendipity is necessarily occasioned by something which comes from outside the system. Insight theorises a novel representation of existing information whereas serendipitous surprise is more radical—it is not surprise at discovering what you already knew framed differently, but surprise at new knowledge.

For new knowledge to be recognised and incorporated into the system, a particular state of the system is required. This state relates to a prepared mind state, reminding us that surprise is a situated emotion. As Arfini and colleagues (2018, p. 5) write:

> Fleming's "Oh!" reaction was when he managed to frame and understand the antibiotic effect of a mold. He did not enter his laboratory to find a moldy culture singing the chorus of Mamma mia!: that would have sparked another kind of reaction.

In other words, serendipitous surprise relies on the adjacent possible (Björneborn, 2020)—the event has to be close enough to what the system views as possible even if the knowledge is not there before, and the boundaries of the system have to be flexible and dynamic in order to assimilate this new knowledge. This is a quasi-liminal knowledge state which requires both expertise (to recognise and assimilate) and ignorance (to experience surprise). In this way, we are redirected to a relational and contingent phenomenon because the boundaries of the adjacent possible are necessarily dynamic. This is why surprise and noticing do not necessarily follow directly after the event but can occur far further along the narrative arc of the event when the adjacent possible changes in such a way to create understanding and the space for the knowledge to be recognised.

This aspect of the adjacent possible echoes the argument that Yaqub (2018) makes of the relationship between theoretical expectations and serendipity. The accident forces a deviation from theoretical expectations, but this presupposes that these expectations already exist. Surprise requires an existing backdrop. An observation can only be incongruent if the relevant theoretical knowledge is there to offer a contrast. Many stories of scientific innovation surrounding serendipity describe a change

in a theoretical field which is impossible to enact unless you are inti-mately aware of that theoretical field. It is in this way that the prepared mind is situated. If Fleming's culture could sing and dance it would not be serendipitously surprising because it would not require a disruption of theoretical expectations so much as an entire set of new ones; there is a level of continuity in the experience of serendipitous disruption.

As discussed above, this is also true of creativity. Creativity requires rupture but that rupture cannot be too severe or else it is not creative because it is not able to be fully valued by the field. There has to be both continuity and rupture. So, both serendipity and creativity sit in a liminal space, the in-between both disrupting and simultaneously relying on and supporting the status quo (see also Le Hunte, this volume). This is where the complexity of situated value clouds even processual accounts. It is not yet clear how to disentangle this.

The second difference between insightful surprise and serendipitous surprise is that insight is theorised to be an end state. The problem is solved and epistemic closure is attained. This is marked by the emphasis on high certainty in the answer. Serendipitous surprise is rather the start of knowledge exploration and ignorance reduction. Rather than epis-temic closure, it represents an epistemic opening and thus is linked to curiosity rather than certainty. The new knowledge is not sedimented until it is enacted and explored. The re-representation and reframing of the theoretical situation requires verification. The importance of assim-ilation and exploration of the novel epistemic landscape is discussed in the next section.

The Importance of Enactment and Change

It is not enough that the accident happens nor is it enough to generate a feeling of surprise, the accident must also lead to further action. Indeed, serendipity can be most properly located not in the person nor the acci-dent but rather in the actions that combine both. This time this action takes an intentional form which is marked by a change in the system. If the accident is discarded by the agent and does not generate a change

in cognitive or creative trajectory then it is not relevant to an understanding of that process. For example, Barber and Fox (1958) tell the story of two scientists who both made the same surprising observation (that rabbits ears droop when injected with palpain) and for one this led to a change in actions and a discovery whereas for the other this was an interesting but dropped diversion. The moment of accident and noticing and surprise was the same in both, the changes were not. For an accident to be a serendipitous one it must also be reified through action. A prepared mind must not only be prepared to notice but also be prepared to enact the accident and its implications. This is the true value of pinpointing exaptative actions. The action surrounds the event, generating and securing it. The idea of exaptation relies on the idea of change and the change is marked by a change in intention sparked by the noticing of an opportunity.

This change may be delayed along with the act of noticing but noticing must lead to action; the novel information yielded by the accident must be reified in further action otherwise the accident remains inert. Indeed, the accident often triggers the formation of a new creative system in which the accident forms a part. This is supported by the argument made by Arfini et al. (2018) that discovery through environmental change is ubiquitous in science so to demarcate serendipitous discovery requires a game changing perspectival shift which takes place at the level of the system. The same is true of materially engaged creativity. It is not enough to be surprised by an unintended act, the surprise must lead to action and change in the creative system. As Glăveanu et al. (2013, p. 5) note, material undergoing is marked by accidents and objects which "change the original plan".

This change from unintentional to intentional action requires either a change in the representational aspect of the action—it now proceeds according to a novel plan—or also a change in attitudinal aspects—the increased likelihood of success marks a change in the attitudinal aspect of the intentionality. Unplanned success sparks the feeling that success is inevitable and so attitudinal intentionality sets in even if the way ahead is unclear (see also Lock et al., this volume).

The Benefits of a Focus on Accident

I have been careful to hedge my claims for the importance of the single event as I lay out the preliminary basis for a theory of serendipitous accidents in creativity and discovery. It is important to resist a reductionist approach for something inherently emergent but I also hold accident is a necessary condition of serendipity to avoid a bland conceptual dissipation which is equally important to resist. The accident exists alongside and within a focus on social, cultural or personal aspects which are important for all creative action; it is the accident which makes it a serendipitous action. However, the accident is not a fixed point, rather it can only be understood as part of a liminal space. Its ontological instability is a necessary discomforting and this discomfort is one which sits with researchers in both creativity and serendipity.

I suggest that there are three interlinked benefits to a focus on accidents which can help advance our understanding of serendipity. First, it forces the recognition that the existence of serendipity requires moments of failure; that is, when it is a poor choice to follow up the information yielded by the accident and while all the pieces were in place, serendipity nonetheless did not occur. A fuller understanding of this will support practical efforts to increase serendipity. Second, that this acknowledgement of failure from the same initial trigger will paradoxically strengthen the argument for both the arbitrary nature of the accident and the necessary nature of serendipitous networks and post-event sedimentation. Additionally, removing the human generated notion of post-event value from the accident and accepting its ontological instability allows us to move towards a systematic investigation of serendipity as a feature of extended cognitive systems (for a longer discussion of this aspect see Ross, forthcoming).

A complex human phenomenon such as serendipity which is at once an event, an experience and a rhetorical device, and which spans multiple time scales, requires a complexity of analysis and plurality of focus. The danger of a concentration on the wider aspects of the system is that this can lead to a conceptual dissipation as the skills necessary for chance discovery to be enacted are the same as the skills necessary for any

discovery to be enacted. Focusing on accidents requires being comfortable with a dynamic situation and an unstable event but, I suggest, it will restrict conceptual spread and allow us to make clearer inferences about the relative importance of that moment.

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