The Time of Our Lives: Understanding Irreversible Complex User Experiences

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Abstract. The science of complexity [6], [12], [20, 21], [31, 32] has been introduced to Information Systems (IS) but thus far with seemingly little impact. This paper argues that its application can be located in the burgeoning field of User Experience (UX) in digital business practice [23], [38]. Both these developments are looking at *time* in a new way, specifically at the irreversibility of many living processes, whilst simultaneously involving, including, and relying upon very scientific and computational data. The paper introduces a forthcoming research project with a UX company seeking to discover more.

Keywords: Complexity, UX.

1 Introduction

There has, historically, been a broadly positivist bias in Information Systems (IS) literature, [2, 3], [5], [10, 11], [24, 25, 26], [28, 29]. More recently, however, there has been something of a shift in the conceptualisation of success in information systems from a focus on technical factors to a focus on human factors [30]. One might usefully quote Ray Paul from his editorial piece in the European Journal of Information Systems in 2007, where he offered a definition of information systems and its relationship with information technology (IT) that reflects this shift:

- "The IS *is not* the IT and the formal processes being used.
- The IS *is not* the people using the IT and the formal and informal processes
- The IS is what emerges from the usage and adaptation of the IT and the formal and informal processes by all of its users." [28]

IS research has evolved, then, from what might be deemed rather technologically determinist approaches, which investigate the effects of technologies on societies, to research which focuses on the human and the social [9], and addresses the increasing part technological artefacts play within the social. The positivist and interpretive methodologies used by various camps in the past, moreover, have increasingly become combined by IS researchers. Mixed methods approaches in IS, indeed, have a long pedigree, and have gained ground in both popularity and usage [15, 16], [19].

In this paper, I wish to focus on two parallel developments. The first promises a much more profound theoretical basis upon which such mixed methodology and human

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usage can be studied. It has been growing over the last few decades in the worlds of environmental biology, chemistry, and other life sciences, and greatly advanced by the introduction of powerful computing tools to their study: it is the science of complexity [12], [20, 21, 22], [31, 32]. Some attention has been paid to this development, in the field of information systems, including a Special Issue in *Information Technology and People* in 2006 [4],[18] which included some internal debate. The second parallel development is the User Experience, (UX) approach that is rapidly superseding usability practice, responding to the legitimate business need to attend to the personal experiences of the human parts of information systems [38]. This is a popular area of focus for Human Factors scholars in IS.

Crucially, both developments are taking a new look at *time*, and the irreversibility of processes in systems that operate in far-from-equilibrium conditions: which includes all living systems. Irreversibility is proving to be the profoundest break from the traditional mechanical or reductionist tradition favoured by much of physics, mechanical dynamics, and the mindset of the hard sciences that prompted the positivist bias in IS for so much of its history as a field of enquiry.

As Paul said in his 2007 editorial, immediately following the above definition of IS. “Note therefore that the IS is constantly adapting to need as the users change their usage and the IT is updated or extended.” [28] In other words, this paper seeks to stress, the IS is dynamic, subject to continual change - in ways even faster and more profound than perhaps Paul was implying in his editorial - and theoretical understandings and methodologies that incorporate this dynamism and the nature of its nonlinearity and irreversibility need to be explored and adopted by IS researchers.

So, this paper is about research towards achieving a better understanding of information systems as things which incorporate, rather than merely being used by humans, and what the impact of such a better understanding may be upon issues of design, usability, and success. The aim of the research is to find ways that might improve User Experience (UX), not simply by feeding these results back into a traditional requirements capture / design process, but towards the creation of learning systems that incorporate developers and end users in a continuous conversation with continually evolving information technology artefacts as the process language of that conversation.

I begin with a section outlining the most relevant ideas of complexity theory. I then move on to a consideration of the User Experience (UX) approach in web development businesses. I conclude with a brief review of the consideration of complexity in IS thus far, by way of an introduction to a research project due to begin with a UX small-medium sized enterprise (SME) in the North West of England, UK.

2 Complexity

Contemporary computational evolutionary biology has been one of the principle sites for the development of the sciences of complexity, in the latter part of the twentieth century. This development was greatly accelerated by the enormous advances in computing in the late 1980s and 1990s, and complexity science has spread to multiple sites and down multiple avenues, with the results disseminated from its multiple sources to equally multiple audiences during the 1990s and the first decade of the 21st century. The work of Ilya Prigogine [31, 32], Brian Goodwin [12], and Stuart Kauffman [20, 21], among others, is a view of evolution from chemistry and biology, and yet reaching out far beyond it, challenging the reductionist neo-Darwinian orthodoxy of the likes of Richard Dawkins [8], presenting a new understanding of evolutionary theory that places natural selection as a secondary, rather than primary force. The primary force behind evolution, for these complexity theorists, is self-organisation.

For Kauffman, “Life and its evolution have always depended on the mutual embrace of spontaneous order and selection’s crafting of that order” [20]. Yet these insights into how patterns in the branching of evolution reveal a lawful ordering, how the complexity of teeming variety harbours principles of self-organisation, he also extends beyond the self-organisation of flora and fauna. “The natural history of life may harbour a new and unifying intellectual underpinning for our economic, cultural, and social life,” he asserts [20]. He suspects that “the fate of all complex adapting systems in the biosphere - from single cells to economies - is to evolve to a natural state between order and chaos, a grand compromise between structure and surprise.” [20]. One might say something very similar about most information systems.

Acknowledging the march of physics towards a final theory of everything, Kauffman nonetheless reminds us that though it may end up explaining how the building blocks of the universe operate, it “almost certainly will not predict in detail” [20]. This failure to predict is down to two fundamental branches of physics itself: quantum mechanics, “which assures a fundamental indeterminism at the quantum level” with all its attendant macroscopic consequences, and chaos theory, neatly captured in the famous so-called ‘butterfly effect’ that can see the flapping of a butterfly’s wings in Australia cause a Hurricane in the Atlantic [20].

But not knowing the details does not preclude us from building theories that “seek to explain the generic properties” - for example, “when water freezes, one does not know where every water molecule is, but a lot can be said about your typical lump of ice.” [20]. Kauffman attempts to develop, through his work, “classes of properties of systems that ... are typical or generic and do not depend on the details” [20]. Giving numerous examples, from the origin of life “as a collective emergent property of complex systems of chemicals” through to “the behaviour of coevolving species in ecosystems that generates small and large avalanches of extinction and speciation”, Kauffman finds that the “order that emerges depends on robust and typical properties of the systems, not on the details of structure and function” [20]. In this way the theory of complexity - and its attendant principles of self-organisation - is not tied to the world of biology, but capable of evincing patterns in all manner of complex adaptive systems - including information systems.

Complexity has been introduced and lauded as an important development in the social sciences, notably with Paul Cilliers’, *Complexity and Postmodernism* [6] and more recently a Special Issue of *Theory, Culture and Society* given over to consideration of the Complexity Turn in sociological thought [36]. Cilliers lucidly points out a fundamental issue that must be grasped about complexity:

It is useful to distinguish between the notions of ‘complex’ and ‘complicated’. If a system – despite the fact that it may consist of a huge number of components – can be given a complete description in terms of its individual constituents, such a system is merely complicated. Things like jumbo jets or computers are complicated. In a complex system on the other hand, the interaction among constituents of the system, and *the interactions between the system and its environment, are of such a nature that the system as a whole cannot be fully understood by analysing its components. Moreover, these relationships are not fixed, but shift and change, often as a result of self-organisation. This can result in novel features, usually referred to in terms of emergent properties. The brain, natural language and social systems are complex. [6]*

In other words, although the computer may be complicated, add human usage and the information system becomes complex.

There are important differences in approach that must be undertaken between studying something which is complicated, and something which is complex. The analytical method, whilst useful for complicated systems, is counterproductive when trying to understand complex systems. Complexity focuses on the shifting and evolving "intricate relationships" between components. "In 'cutting up' a system, the analytical method destroys what it seeks to understand." [6] Furthermore, interactions are not restricted to being physical - they can also be described as a "transference of information" [6]. These interactions are both rich – "any element in the system influences, and is influenced by, quite a few other ones", and non-linear - "small causes can have large results, and vice versa," [6].

Most complex systems "are usually open systems, i.e. they interact with their environment." By contrast, "closed systems are usually merely complicated" [6]. This is of crucial significance in environmental theory, where for much of the twentieth century - at least since Tansley [35]- a nineteenth century organicist metaphor of natural equilibrium has been the defining characteristic of the term Tansley coined, 'ecosystem.' Yet, as many ecologists in the last decade or so of the twentieth century found through painstaking study (see [13]), the natural world in fact displays no such equilibrium at all, and the notion of ecosystems has undergone a radical rethink. As Cilliers notes, "Complex systems operate under conditions far from equilibrium. There has to be a constant flow of energy to maintain the organisation of the system and to ensure its survival. Equilibrium is another word for death." [6].

Small causes, moreover, can include forces as weak as gravitational fields. Prigogine outlines how 'bifurcation points' arise when systems are pushed further and further from their stable equilibrium states, points where "an irreducible random element" enters the equation. There is no recourse to a "macroscopic equation" to "predict the path the system will take. Turning to a microscopic description will not help. There is also no distinction between left and right. We are faced with chance events very similar to the fall of dice," [31]. Sometimes it is the environmental fields in which the system sits - such as the gravitational field of the earth - which seem to be the only influence that might tip the dice one way or the other. The results are the common - and otherwise unexplained - left-handed turns of the DNA helix and most seashells.

The essential point here is that pre-existing conditions cannot be used to predict outcomes. Bifurcation points can come in clusters producing landslides of change through which there is little or any hope of even deriving an outcome from a previous state. Yet - extraordinarily - when these bifurcated, far-from-equilibrium states are reached, spontaneous order seems to arise, stable and yet kept moving in the stream of dynamic forces that propel the system along. Prigogine coined the term 'dissipative structure' to describe systems that are sustained by the persistent dissipation of matter and energy. As Kauffman tells us, "in dissipative systems, the flux of matter and energy through the system is a driving force generating order," [20]. The science of hydrodynamics has been very instructive here, and the image of a whirlpool of water at the plug-hole in a bathtub is a useful illustration. If the tap is left running, the whirlpool persists, bringing order to the constant flow of water. It is here, in this inherently unstable nonequilibrium, where, according to Kauffman, "life exists at the very edge of chaos" [20]. Living cells are themselves "nonequilibrium dissipative structures", and the very nature of evolution - and especially of the coevolution of many systems, such as species in an environment - is to attain the "edge of chaos, a web of compromises where each species prospers as well as possible but where none can be sure if its best next step will set off a trickle or a landslide," [20].

But as Cilliers is at pains to underline, for all this chaos and flux, these remain discernible systems, with pattern and order. As he asserts, "complex systems have a history. Not only do they evolve through time, but their past is co-responsible for their present behaviour," [6]. Unlike merely complicated systems, susceptible to analysis, this order does not arise through the control of one part of the system over another, or the predictable unfolding of one state towards a resulting state. "Each element of the system is ignorant of the behaviour of the system as a whole, it responds only to information that is available to it locally. This point is vitally important. If each element 'knew' what was happening to the system as a whole, all of the complexity would have to be present in that element," [6].

But as Kauffman asserts, the fundamental problem with reductionist, mechanistic thought, when applied to complex systems, is that to *represent* a complex system one must, of necessity, reproduce the system in its entirety. The representation, usually something like an algorithm - the "shortest description" which can capture the essential elements of a system - can only capture the *entirety* of a complex system, because a complex system is already its own shortest description. In computation this is known as an "incompressible algorithm," [20].

Perhaps the most important aspect of all this, is the introduction into scientific thinking of the arrow of time - of processes which, unlike simple dynamics, and mechanical processes, cannot be reversed. As Prigogine enthuses in his book, *Order out of Chaos,* citing 19th century thermodynamics as the beginning of such thinking, "far from being an illusion, irreversibility plays an essential role in nature and lies at the origin of most processes of self-organisation. We find ourselves in a world in which reversibility and determinism apply only to limiting, simple cases, while irreversibility and randomness are the rules……interest is shifting from substance to relation, to communication, to time," [31].

3 User Experience (UX)

Turning our attention back to contemporary information systems, we find that standard industry usability practice has, in recent years, become downgraded, and finds itself distinguished from the more novel User Experience approaches, the former being conceived as either completely separate, or at the very best subsumed within the latter [23]. The key differentiation between these two approaches is in what is regarded as the far more subjective concerns of UX with look, feel, and satisfaction, in comparison to the more operational, concrete concerns of usability with task execution times and clicks and error numbers. “A user’s motivation and expectations play a much stronger role in UX than in traditional usability,” [38].

Of course, mixed methodology is also crucial to UX. Mirroring the way in which information systems (as conceived, above, by Ray Paul) is, by nature, inevitably multi-disciplinary, calling as it must upon both sociology and computer science, the new approaches of UX, in addressing such human factors as satisfaction, cannot ignore the more numerical concerns of usability. But in the business world of web and app development, the realization has dawned upon those formerly wedded to the mathematical certainties of computer science that life just isn’t like that. The retreat of the World Wide Web Consortium (W3C) from eXtensible Markup Language (XHTML) is a case in point. Paving the cowpaths, Hypertext Markup Language 5 (HTML5) walks where the real world has gone while the theoretical purity of XHTML was consigned to history. Equally illustrative is the failure of the semantic web, making room for the possibility of developments in cognition-as-a-service, whereby apps begin to make use of such Artificial Intelligence (AI) tools as Siri, Wolfram Alpha, etc, to provide a more human and interactive experience to the users of information systems [14], [34]. Matching the predictable, mechanical, certain equilibrium systems of our complicated machines, therefore, with the dynamic, far-from-equilibrium spontaneous order of living beings and our complex personal behaviour and social systems, is necessarily a very multi-disciplinary endeavour. The simple recognition that humans don’t behave rationally is just the start [27]. The IT artefact may be complicated, but the information system, open to its environment, driven by and incorporating rich information flows with potential – and often all-too-human - bifurcation avalanches, are complex.

With the development of UX in mind, then, it may be that the locating of academic IS departments in Business Schools is no mistake, for it is bottom-line business drivers that have shifted attention beyond mere usability practice to attend to the more subjective concerns of the personal experience of the users – or should I say, the human parts - of information systems, just as it is business concerns that left the computational purity of XHTML, Web Ontology Language (OWL) and Resource Description Framework (RDF) to the history books, in favour of HTML5, JavaScript Object Notation (JSON), and apps with access to cloud-based ‘intelligent’ systems one can have a conversation with [34]. The stress in Web 2.0 upon user-generated content was exemplary of how core the human part of contemporary information systems can be - and often is. In the context of what many are calling Web 3.0 and its world of multi-device, multi-channel and multi-directional throughput of information, information communication technologies (ICTs) are all the more clearly revolving around us, our information, our needs, and in real time: the web 3.0 that some are beginning to call, ‘the Stream’ [34].

Here, the crucial break with the mechanical approaches of the past arrives with the realisation that these more experiential complex systems are most frequently not reversible. Time is an arrow in these instances and no amount of cookies, server-side accounts, or wish lists can make up for the loss of that most amorphous, context and moment-dependent quality of human behaviour upon which so many businesses depend: impulse. This is not even yet in the foothills, moreover, of that other crucial element of success in business: emotional intelligence. So in the field of UX, what has in the past been intellectually grasped as spatial, measured, and objective, is today by contrast increasingly being apprehended as durational, experiential, and subjective.

4 Further Research

Now, complexity and information systems are certainly not strange bedfellows, and this paper is not the first to suggest a confluence. Following a Special Issue in *Communications of the ACM* (2005) there was another in *Information Technology and People (ITP)* on Complexity and IS in 2006. In their introductory paper to the ITP Special Issue, Jacucci, Hanseth and Lyytinen argue that complexity needs to be taken seriously in IS research [16]. Benbya & McKelvey's core paper of this special issue, which we shall take as exemplary, inferred in the preamble that information systems development projects are complex not only because they deal with complex technological issues, "but also because of organisational factors beyond a project team's control." [4]. More substantively, the authors argued, Van Aardt [37] had asserted that any information system displays the characteristics of a complex adaptive system. Van Aardt concentrates on the emergence of order as opposed to causal predetermination, and the irreversibility of a system's history and unpredictability of its future. He focuses on open source software as the best example of IS as a complex adaptive system. Benbya & McKelvey, however, in their paper, go further, suggesting that all information systems act as complex adaptive systems [4].

But it is in a note by Kallinikos, another contributor to the ITP Special Issue, who furthers the debate with a critique of the Benbya & McKelvey paper [18], that my concerns with the meeting of complexity and information systems, thus far, are raised. Essentially, Kallinikos points to Benbya & McKelvey's continued embrace of what he describes as a *"representational* view of information and coding as mapping of an exogenous reality that is reflected on what we call 'user requirements,' considered both as independent and the starting point for coding," [18]. This, as Kallinikos asserts, "bypasses one of the major, contemporary sources of instability in organisations, which is no other than the changing organisational conditions (and user requirements) created by the very development of information systems themselves. In other words, the ghost is not simply outside but inside the house as well," [18]. The human parts of the information system, in short, cannot be abstracted from the information technology such that the IT project team can then safely proceed without them. Given the insights into complexity explored in this paper, it seems extraordinary that such a notion could be entertained. But how could it come about - how could IS scholars brave enough to embrace the ideas of complexity nonetheless find a way to cling on to the safety of the predictable and discrete?

Herbert Simon's seminal paper from 1962 on the 'Architecture of Complexity', cited by both Benbya & McKelvey and by Kallinikos, includes the notion of *near decomposability:* the notion that complex systems have a hierarchical structure, that they are built up of inter-related subsystems, and that the intra-relationships within subsystems are stronger than the inter-relationships between components of different subsystems, such that the subsystems might easily be pried apart, and considered separately. For Simon, the distinction between a *decomposable* system and a *nearly decomposable* system is that in the latter "the interactions among the subsystems are weak, but not negligible." [33]. Moreover, for Simon, in nature, systems where the hierarchy is interdependent, and which are therefore less decomposable, "are far rarer and less typical," [33]. For Benbya & McKelvey it seems that the human and non-human 'subsystems' of an information system might be pried apart for the more predictable information technology project to get underway. For Kallinikos this notion is regarded as supportive of modular architecture wherein a "loose coupling of processes and agents" is enabled, [18]. Yet, as Agre points out, "hierarchy is a somewhat more diverse phenomenon than the universal ambitions of Simon's theory require,"[1]. Indeed the ambition of Simon to subsume everything under his notion of hierarchy manages to ignore a great variety of instances where the modular approach simply does not hold, and his argument is "a product of its time…: [the] high-water mark of the classical hierarchical organization"[1].

Self-organisation, in fact - the favoured notion of the general systems theory of the time, and championed, as we have seen, by Prigogine and Kauffman, among others - turns out to be a much better description, certainly of the reality of contemporary information systems, than *hierarchy*. As Agre asserts, "Precisely because Simon's image of hierarchy is spatial, it does not fit well with the networked world, which collapses many types of distance," [1]. A more durational view is required, and, as Cilliers [6] reminds us, the intricate - and often sensitive - relationships between components, both within and between 'subsystems,' are often – for all that they may be considered 'weak' – nonetheless the most important aspects of complex systems, capable of bringing both sweeping and fundamental changes.

In this paper I have tried to show that in fact, given the involvement of humans as parts of information systems - the ghost both outside and inside - the characteristics of complexity must *inevitably* apply to IS, and its aspects of irreversibility, its durational rather than spatial characteristics, are of growing significance. Success in today's information systems development, then, infers durational complexity, and though Benbya & McKelvey make a brave attempt at a framework for considering complexity in information systems, I consider that Kallinikos' criticisms - and my own - hold.

So what answers can I offer in a brief position paper for a conference? Well, the worlds of theory and practical application are sometimes difficult to bridge, but the opportunity is there to find in a Knowledge Transfer Partnership (KTP) between University of Salford and UX specialists Sigma Ltd, in the UK, which began in March 2014, real-world examples that may help to flesh out an understanding of how non-reversible experiences in information systems unfold, how they operate, what guidelines we might adopt in approaching their 'design', and how the experience of the human parts of those systems might be enhanced. The partnership will seek to explore how the concerns raised in this paper translate into concrete activities, with live clients and their digital presence, and what can be learnt from studying the data accrued by user research for future understanding of this mixed method approach, and, crucially, how the element of time and irreversibility impacts upon issues of design, usability, complexity, and success.

5 Conclusion

In this paper, I have tried to introduce IS scholars to what I believe may be the next step in the trend away from reductionist, mechanical positivism, through an interest in social and human studies, towards a more complex, and durational understanding of information systems, as exemplified by the approach of the User Experience professionals. The novel understandings of the sciences of complexity, giving us insight into the irreversibility of living systems, gives pause for thought when considering the processes most information systems incorporate. As Paul [28] stressed, information systems are "constantly adapting," and this continual adaptation - and the flexibility that it requires - needs to be built into our designs for the future.

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