Context Sensitive Health Informatics: Human and Sociotechnical Approaches
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Stasis and Adaptation

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Abstract. Many of our most pressing societal challenges arise from our inability to move on from present practices and structures and do what is needed. Healthcare struggles to improve safety and quality. It resists adoption of best practices and persists in high levels of unwarranted variation in care delivery, and clings to financially unsustainable models of care. One explanation for this state of affairs is not a lack of will, but that we are experiencing *system inertia* - a consequence of the increasing complexity of our human systems. In this paper I explore three possible system level interventions that may help design systems that are less likely to approach inertia, as well as help change our current systems so that they again become adaptive, and move to the outcomes we desire. Firstly, I question our religious belief in the power of standards, an intervention designed to minimise adaptation and almost from first principles designed to lead to inertia. Next I explore the power of apoptosis, a process that sees existing structures and practices programmatically removed to free up resource for adaptation. Finally I explore a flexible but controversial approach to system management called market-based control. Whether any of these, together or in tandem, are a way out of inertia is an open question. However, it is time for us to engage with the challenge of system inertia, and find a way out.

Keywords. System inertia, apoptosis, standards, market-based control

Introduction

It is a profound paradox that in a world so rapidly changing around us, some of our biggest problems arise because we cannot change rapidly enough. Humanity is currently struggling with many large-scale system problems, apparently all of our own making. Globally, health systems of developed nations are financially unsustainable. Yet we cling to failing models, baulking at the major changes needed, apparently hostage to vested professional and commercial interests. Similarly, we have yet to find a way of adapting global governance to deal with climate change. Our collective desire to alter nothing, and pay no price, makes us behave like moths to the global warming flame. Even as the monumental failure in governance that led to the global financial crisis has yet to play out, the push to return to past practices and ideologies has been swift. It appears that we have built human systems that often fiercely resist the very response required to adapt to new and unanticipated external shocks and challenges. When we do attempt system change, unanticipated negative consequences, sometimes perceived as ‘fightback’ [1], often swamp the positive impact of what is attempted.

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1. A frozen health system

Many of our most pressing challenges as a society seem to arise from our inability to move on from present structures to what is needed next. As a prime exemplar, the importance of developing a healthcare system that is not stuck in past structures, but is capable of responding rapidly, is unarguable and pressing. In healthcare, developed nations know that investment in preventative and primary health care is far more cost effective than supporting the hospital system, yet shifting investment from one to the other is politically unsalable in most countries. Safety and quality initiatives struggle to make care safer [2]. Errors and adverse events affect millions across the world [3], and are present in 10% of hospital admissions [4-8]. Two percent of admissions result in major disability or death, a shocking figure [9]. In 1999, the US Institute of Medicine published a landmark report 'To Err is Human' which outlined a strategy to reduce preventable medical error by 50% in five years [10]. A decade later, we have yet to approach that target, despite substantial effort and cost [11].

In 2003 a US study of variations in clinical practice found that only 50% of the adult population receive medical care that meets minimum recommended standards [12]. One decade on and another Australian study found very similar levels of care, with just 57% of the population receiving care in line with best practice indicators, and with wide variation in the delivery of care across conditions, and between care providers [13]. Evidence-based recommendations and standards for treatment that are created by expert committees thus often simply pile up, unheeded or poorly enacted [14].

It is also unclear how we will respond as a society to new urgent challenges such as global pandemics, or the impact of climate change on healthcare, which will not just create new health problems, but degrade our capability to respond to them. More worryingly, by 2020, because of demographic changes, our health system will have to treat proportionately more people, with more illness and higher expectations, using more expensive technologies, and relatively fewer tax dollars and workers [15]. Given that commentators are alarmed at the present strains on the health system, we have to assume that by 2020, the healthcare systems of most nations will either have somehow substantially transformed, or failed. If healthcare systems are to flourish in the coming setting of uncertain resources and increased demand, then it will need explicitly designed and implemented new systems that are fundamentally adaptive and sustainable. Given the enormity of the task, this may require nothing less than the re-invention of healthcare [16].

2. System inertia

One explanation for this state of events is not a lack of will, but that we are experiencing a consequence of the increasing complexity of our human systems – that in some shapes they end up resisting change. I have elsewhere informally defined such system inertia as "*a failure by a human organization to initiate, or to achieve, a sustained change in behavior despite clear evidence indicating that change is essential [17].*" Clearly this empirical definition tells us nothing about causation, and it is likely that underlying this definition are a number of different phenomena, all of which has inertia as the final common and emergent behavior.

Inertia at the organizational level has been studied for many decades [18]. There is a small literature on *clinical inertia* [19]- the failure to modify treatment despite evidence indicating change is needed [20, 21]. One compelling explanation is that clinicians make the best decisions they can in the face of multiple *competing demands* [22-24]. Decisions are constrained by time, uncertain or absent data [25], and the need to prioritize multiple problems [26]. Making a sub-optimal decision to satisfy competing demands is called *satisficing* [27]. When resources are limited, humans choose a 'good enough' solution that meets multiple goals. This notion of satisficing, that 'better' is sometimes best, does not fit easily with healthcare quality strategies that target particular behaviors, failing to notice that resources are simply being withdrawn from elsewhere to meet new targets [28]. As demands increase, it obviously becomes harder for any single initiative to get the attention and resources it needs.

All systems that are understood to be complex – living cells, the Internet, social and economic systems, consist of extraordinarily large numbers of components that interact via intricate networks, and which converge on similar topologies and behaviors [29]. Complexity analyses are a promising approach to modeling and explaining system inertia, and have a clear pedigree in the study of biology, ecosystems, economics, and organizational science. We have in the last decade made huge inroads in developing systems science approaches to natural systems including planetary climate and systems biology. It is now clear the same leap forward is needed in human systems design. While early attempts to develop a general systems theory last century faltered, there is now a pressing need for pragmatic systems theory that helps us understand why human systems behave the way they do, and that assists us in designing systems that quickly adapt to systemic challenge.

What has been much less explored is how such theoretical insights can translate into mechanisms that unfreeze systems. For example, recent work by Barabasi and colleagues on the controllability of networks points the way, showing that certain network configurations are in principle 'controllable' – as long as the levers within the network can be identified [30]. Some theorists have noted that organizational inertia is sometimes path dependent, leading them to the conclusion that we are witnessing an example of a widely known behavior in many physical systems – hysteresis [31]. This means that the path that takes us to inertia cannot be retraced backwards, and that unfreezing requires new pathways, new strategies, to open up a system for change.

In the remainder of this paper I explore three ideas that may help us guide system behavior, either insulating them from moving into inertial states, or helping unfreeze them if they find themselves in such a place. For a complex system to move to new kinds of behaviour will probably require old elements to be retired, new elements to be designed, and in some settings, forcing functions and control systems to guide the process.

3. From standards to stasis?

A common strategy for structuring complex human systems is to demand that everything be standards-based. The standards movement has taken hold in education and healthcare, and technical standards are seen as a prerequisite for information technology. In healthcare, standards are visible in three critical areas, typical of many sectors: 1/ Evidence-based practice, where synthesis of the latest research generates best-practice recommendations; 2/ Safety, where performance indicators flag when processes are sub-optimal; and 3/ Technical standards, especially in information systems, which are designed to ensure different technical systems can interoperate with each other, or comply with minimum standards required for safe operation. There is a belief that 'standardisation' will be a forcing function, with compliance ensuring the "system" moves to the desired goal – whether that be safe care, appropriate adoption of recommended practices, or technology that actually works once implemented.

In the world of healthcare information systems, the mantra of standards and intra-operability is near a religion. Standards bodies proclaim them, governments mandate them, and as much as they can without being noticed, industry pays lip service to them, satisficing wherever they can. For such a pervasive technology, and we should see technical standards as exactly that – another technical artifact – it is surprising that there appears to be no evidence base that supports the case for their use. There seem to be no scientific trials to show that working with standards is better than not. Commonsense, communities of practice, vested interests and sunk costs, all along with the weight of belief, sustain the standards enterprise.

For those who advocate standards as a solution to system change, I believe the growing challenge of systems inertia has one a disturbing consequence. The inevitable result of an ever growing supply of standards meeting scarce human attention and resource should from first principles reasoning lead to a new 'Malthus' law of standards - that *the fraction of standards produced that are actually complied with, will with time asymptote toward zero* [17]. To paraphrase Nobelist Herb Simon's famous quip on information and attention, a wealth of standards leads to a poverty of their implementation [17].

It should come as no surprise then that standardisation is widely resisted, except perhaps by standards makers. Even then they tend to aggregate in competing tribes pushing one version of a standard over another. Unsurprisingly, safety goals remain elusive and evidence-based practice to many clinicians seems an academic fantasy. Given that clinical standards are often not evidence-based, such resistance may not be inappropriate [32, 33]. In IT, standards committees sit for years arguing over what the 'right' standard is, only to find that once published, there are competing standards in the marketplace, and that technology vendors resist because of the cost of upgrading their systems to meet the new standard. Pragmatic experience in healthcare indicates standards can stifle local innovation and expertise [34]. In resource-constrained settings, trying to become standards compliant simply moves crucial resources away from front-line service provision.

There is a growing recognition that standards are a worthy and critical research topic [35]. Most standards research is empirical and case based. An important but small literature examines the 'standardisation problem' [36] – the decision to choose amongst a set of standards. Economists have used agent-based modelling in a limited way to study the rate and extent of standards adoption [37]. Crucially, standards adoption is seen as an end in itself with current research, and there seems little work examining the *effect of standardisation* on system behaviour. Are standards always a good thing? There seems to be no work on the core questions of *when* to standardise, *what* to standardise, and *how much* of any standard one should comply with.

Clearly, some standardisation may be needed to allow the different elements of a complex human system to work together, but it is not clear how much 'standard' is enough, or what goes into such a standard. My theoretical work on the continuum between information and communication system design provides some guidance on when formalisation of information processes makes sense, and when things are best left fluid [38]. That framework showed that in dynamic settings where there is task uncertainty, standardisation is not a great idea. Further information system design can be shaped by understanding the dynamics of the 'conversation' between IT system and user, and by the task specific costs and benefits associated with technology choice [39, 40].

It is remarkable that these questions are not being asked more widely. What is now needed is a rigorous analysis of how system behaviour is shaped and constrained by the act of standardisation, and whether we can develop more adaptive, dynamic approaches to standardisation that avoid system inertia and deliver flexible and sustainable human systems.

4. Designing for obsolescence

Why is it that human systems appear to become more complex over time, in the sense of having more interacting elements and interdependent behaviors? The first reasons may be the statistical tendency of all physical systems to accumulate random variation. Diversity and complexity arise by simple accumulation of random accidents, much like a painted fence will over time crack and peel, becoming more complex. In biology, a 'first law' holds that evolutionary systems by definition accumulate such diversity and complexity over time, independent of natural selection [41]. It seems there must also be a "first law of organizations", which also accumulate diversity and complexity over time, independent of directed action [17]. Another explanation is a *pro-innovation bias,* where the act of innovating is "heavily laden with positive value" [42]. We are rewarded for introducing new or improved processes, not for dismantling old ones. Humans value gain over loss, and this may partly explain why relinquishing old processes appears more risky than adopting new ones [43]. For many individuals and organizations, there are also substantial sunk costs in existing structures and processes, and change threatens that investment. This may also explain why the rate of adoption of positive evidence (that something works), appears to be much higher than the rate of negative evidence (that tells us we should stop what we are doing).

The process of relinquishing old processes while introducing new ones is not well understood in human systems research. Restructuring health services appears to achieve little [44] and there is little theoretical basis to help decide which parts of the system are the best candidates to 'restructure'. Biology however provides us many examples of complex organisms undergoing extra-ordinary changes. The journey from tadpole to frog, or the development of a limb stub into a hand, all depend upon a biological process called *apoptosis*, or programmed cell death - a prerequisite for complex living organisms to develop [45]. Developing methods that allow complex human organizations to reliably undergo the same degree of change, by design, is a tantalizing prospect. For example, large organizations struggle with older "legacy" information systems, which remain in operation but become increasingly out-of-date. Legacy systems constrain innovation by absorbing scarce resources, and limit the choice of new systems to those that interoperate with the old. I recently suggested that if we could define a process of *information apoptosis,* there would be clear rules to manage growth in software complexity, or information system implementation [17].

Understanding which elements of a system to remove for a specific change in behavior is non-trivial. Simple 'cash for clunkers' programs will not do in a complex system. Mathematical modeling shows that for some complex systems, the selective removal of individual elements can lead to a very significantly change in system behavior [46]. Inspired by cellular apoptosis, it should however be possible to develop mechanisms to safely and programmatically retire unneeded processes or structures before new ones are implemented. Developing the rules and procedures for graceful, timely and controlled system apoptosis will be a major new research endeavor.

5. Designing for adaptation

It is tempting to manage system inertia by fine level control of structure. Yet it is unlikely that we can know all the elements in a given 'system'. Consequently, rather than always prescribing specific changes, part of the answer lies in developing feedback-control structures that specify targets, and forcing functions that drive structural change. For example, attempts to reform the health system are typically top-down, with central control of new initiatives, or bottom up where local practices aggregate with global impact. Top down strategies have a poor record in achieving change, often at the mercy of local fight-back and unanticipated problems. Bottom up reform does not suffer these problems [47], but struggles with co-ordination and failure to develop public goods like shared infrastructure.

For nation-scale health information systems, I recently advocated the adoption of an alternative *middle-out* approach in an article that suggested abandoning traditional top-down and bottom-up approaches [34]. This sees government and local providers instead mutually agree on goals, and then each controls the things for which they are best suited. Simulation studies of organizational structure supports this view. An intermediate form of coordination, equivalent to middle-out reform, gives agents exclusive control of only some elements (their "patch"). Patching often outperforms bottom up processes and leads to better optima than centralized processes, along with a reduction in search time and cost [48].

There are some precedents to help us exploit middle-out approaches to dynamic system control. One model I find compelling is market-based control (MBC), the mechanism underlying 'cap and trade' [49]. MBC was inspired by economic marketplaces, but is now understood to be a general approach to controlling systems, and not to be confused with ideological stances like 'the free market'. MBC has been used in settings beyond the Kyoto Protocol, with much success. The US Federal Clean Air Acts of 1970 and 1990 successfully set pollution reduction targets, but did not mandate how they were to be met. MBC has been used as a feedback controller to allocate resources in communication networks [50] and structural control of buildings during earthquakes [51]. Indeed, market theory is used in many unexpected ways e.g. the prediction of avian influenza outbreaks and vaccine effectiveness [52].

In 2009 I controversially suggested MBC could improve patient safety by setting a *safety price*, given that all other approaches seemed to have stalled [53, 54]. To "cap and trade" a regulator would establish organisation specific safety targets, based on the cost of adverse events, and create a market for trading safety credits. Organisations are given a clear policy signal to reduce adverse event rates, are told by how much, but are free to choose mechanisms suited to local needs. The incentive to sell rather than buy credits provides a mixture of incentive and penalty, without the regulator specifying behaviours or solutions – leaving locals to manage their 'patch'.

What does MBC have to do with inertia? In the context of systems inertia, a well-designed MBC system may circumvent some of the sources of inertia to change typically found in top down and bottom up reform. MBC is a general approach to governing complex systems, and supports local bottom-up innovation, top-down goal setting, and puts a control system in the middle. One of the biggest problems MBC faces is its name – the word 'market' conjures up reaction both from those who want the 'market' out of the public health system, or resist new regulation in the private. Yet MBC is nothing more than a more adaptive pay for performance scheme. The other major problem that MBC faces is that it has struggled to work in the fiercely contested world of climate change politics – one of our classic examples of systems inertia. Unlike Kyoto, in the healthcare setting MBC may not have to navigate international *realpolitik*, but could more comfortably sit within a predefined organisational system, one that is familiar with targets and rewards for meeting target.

Conclusion

How stasis emerges from adaptation is a classic systems question, and is one we need to answer. In this paper all I have done is to again ask that we think about this question. It is equally important that we move away from mere describing, to understanding, to action.

We do desperately need to engage with new models of system governance and control, no matter how odd they might feel, or strange their operation. Just because standards are everywhere and unchallenged does not mean we should not challenge them, or imagine a world in which we think about conformance to common practice in a different, more adaptive way. Just because we find it hard to let go of old practices and structures does not mean we continue to find excuses to hang on to them. With a better understanding of organisational apoptosis, we may find that we arrive at a world where every new practice or policy comes at its birth with its use-by date inscribed upon it. With something like MBC, it is clear that we need to explore, research and experiment, rather than rush to implement. Even if MBC is only a starting point, by exploring the effects of this class of system control on overall properties of a system, like inertia, will teach us much. Above all, we must recall that if nothing changes, then nothing can change.

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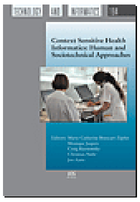
Ebook: Context Sensitive Health Informatics: Human and Sociotechnical Approaches



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Description

Healthcare information technologies are now routinely deployed in a variety of healthcare contexts. These contexts differ widely, but the smooth integration of IT systems is crucial, so the design, implementation, and evaluation of safe, effective, efficient and easy to adopt health informatics involves careful consideration of both human and organizational factors.

This book presents the proceedings of the Context Sensitive Health Informatics (CSHI) conference, held in Copenhagen, Denmark, in August 2013. The theme of this year's conference is human and sociotechnical approaches. The Human Factors approach is distinctly design-driven and aims to optimize performance, safety and users' sense of well-being associated with their use of a system through the application of user-centered systems design and evaluation. The papers and presentations included here are grouped under the topics: patients and IT; usability test and evaluation; work tasks and related contexts; human factors and simulation; and context and systems design, and outline theories and models for studying contextual issues and insights related to how health information technologies can be better designed to accommodate different healthcare contexts.

Healthcare organizations, health policy makers and regulatory bodies globally are starting to acknowledge this essential role of human and organizational factors for safe and effective health information technology. This book will be of interest to all those involved in improving the quality of healthcare worldwide.

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Preface

This volume presents the papers of the International Conference on "Context Sensitive Health Informatics, Human and Sociotechnical approaches" held at Herlev Hospital in Copenhagen, Denmark in August 2013.

Context Sensitive Health Informatics is about health information technologies and their environments. Environments may be people in different roles such as users,

↓ more

Context Sensitive Health Informatics: Concepts, Methods and Tools

Authors Craig Kuziemsky, Christian Nøhr, Jos Aarts, Monique Jaspers, Marie-Catherine Beuscart-Zephir
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Abstract

Context is a key consideration when designing and evaluating health information technology (HIT) and cannot be overstated. Unintended consequences are common

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Stasis and Adaptation

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Abstract

Many of our most pressing societal challenges arise from our inability to move on from present practices and structures and do what is needed. Healthcare struggles to