Theoretical Issues in Ergonomics Science
Vol. 9, No. 1, January–February 2008, 1–24

Taylor & Francis
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Human factors engineering that makes a difference: leveraging a science of societal change

KIM J. VICENTE*

Cognitive Engineering Laboratory, Department of Mechanical and Industrial Engineering, Department of Computer Science, Edward S. Rogers, Sr. Department of Electrical and Computer Engineering, Institute of Biomaterials and Biomedical Engineering, University of Toronto, Ontario, Canada

The over-arching purpose of human factors engineering is to improve the quality of human life, but our discipline has not been as successful as we would like in effecting societal change, whether it be at the political or corporate level. The current paper addresses this problem, first by identifying a set of general challenges to change, and second by reviewing three illustrative theories of the processes behind large-scale societal change. Kingdon's (1984/2003) work on agenda setting explains how ideas get onto the political radar. Birkland's (1997) research on focusing events shows how accidents can be exploited to foster policy change. Tushman and Romanelli's (1985) work on punctuated equilibrium theory illustrates how market forces and environmental disruptions can be manipulated to encourage radical corporate change. These research programs have largely unappreciated 'design' implications that human factors engineers can adopt to increase the likelihood of improving the fit between people and technology in the service of humankind.

Keywords: Societal change; Public policy; Political science; Management; Corporate change

1. Introduction

> 'To better the quality of human life through the discipline of human factors/ergonomics.' Statement of Purpose (Human Factors and Ergonomics Society 2004, p. 361)

> 'People who are trying to advocate change are like surfers waiting for the big wave. You get out there, you have to be ready to go, you have to be ready to paddle. If you're not ready to paddle when the big wave comes along, you're not going to ride it in.' A policy analyst for an interest group (Kingdon 1984/2003, p. 165)

Human factors engineering is an inherently activist discipline because its over-arching aim is to affect societal change. Some recent and salient examples that begged for our input and leadership include: risk management of the NASA space shuttle program (Columbia Accident Investigation Board 2003), patient safety (Kohn *et al*. 1999), the voting ballots in the 2000 US Presidential Election (Sinclair *et al*. 2000) and the proposed Occupational Safety and Health Administration ergonomics standard (Anonymous 2000). All of these issues reached the level of Congressional or Presidential politics in the US, and they all could have benefited

*Email: vicente@mie.utoronto.ca

Theoretical Issues in Ergonomics Science
ISSN 1463-922X print/ISSN 1464-536X online © 2008 Taylor & Francis
http://www.tandf.co.uk/journals
DOI: 10.1080/14639220600723484

from very strong attention to human factors, but a human factors voice was consistently not as forthcoming as it could have been. Have we really made a difference in changing the way government and corporations think about the relationship between people and technology, thereby making the most of the knowledge base that our discipline has worked so hard to develop over the last 60 or so years?

Our discipline has had significant impact on some high-profile issues. Improving airline safety through cockpit resource management (Weiner *et al.* 1993) and the aviation safety reporting system (Billings 1998) are among the best known examples. For the most part, however, we have not been nearly as successful as we would like in effecting significant societal change (Hansen 2000, Howell 2000, 2001). This limited practical impact has been consistently noted for decades (e.g., Chapanis 1967, Perrow 1983, Rouse 1985, Simon 1987, Meister 1989, Vicente 2000), suggesting that there are endemic reasons for the unsatisfactory progress achieved to date. If we are to have any hope of ever fully realizing our discipline's ambitions of improving the quality of human life, then we need to address this persistent and over-arching problem, preferably systematically. Yet, there appears to be very little human factors engineering literature on how best to facilitate societal change.

A seemingly obvious path in filling this critical gap would be to borrow from other disciplines that have systematically studied processes of large-scale societal change (e.g. management, political science, public policy), especially how to facilitate such change to achieve a particular set of policy objectives. There is a vast body of scholarship on this subject, with many theories and results (e.g. Birkland 2001, Christensen 1997, Collins 2001, Senge 1990, Weimer and Vining 1999). Given the centrality of effecting change, whether it be at the political or corporate level, to our discipline's mission, it might be thought that human factors researchers would have frequently and heavily tapped into this knowledge base to increase the practical impact of our work. It appears that this has not happened; articles that use the wealth of systematic knowledge about large-scale political or corporate change to derive implications for the practice of human factors engineering are exceedingly rare. The purpose of the current paper is to address this gap, first by identifying some of the major obstacles to change, and second by reviewing several theories describing how change can occur at the political or corporate level.

Three caveats are in order. First, even though the topic of this article—encouraging societal change—is highly pragmatic, the approach being adopted is not to abdicate the rigor of scientific research, but on the contrary, to make the most of academic scholarship so that this topic can be tackled in a systematic and principled manner. Second, given the immense scope of research on this topic, it is not possible to provide a comprehensive review of the literature on political or corporate change. Instead, just a few examples are highlighted to illustrate the value of this body of work for our discipline. Finally, the literature on societal change is not, and never will be, sufficiently mature to allow any policy activists consistently to achieve their objectives. Societal change is intrinsically a very complex, uncertain and, therefore, risky process. Nevertheless, the existing literature does give us many principled insights into how to 'tilt the playing field' to our advantage, thereby increasing the chances of achieving our activist aims.

2. Challenges to change

This section begins by briefly analysing the problem of societal change, and then goes on to identify 11 general obstacles that make change difficult to achieve.

2.1. *Morphological analysis of change*

Table 1 illustrates a very simple morphological analysis of societal change. Along the top, there are two states: there is a societal problem requiring a change in action, or there is no such problem. Along the left, there are two responses: act to resolve a perceived problem, or do not act. This formulation leads to four types of situations.

(1) In the upper left corner, there is the case of change: there was a problem, and action was taken. An example was the swift passage of oil pollution liability legislation shortly after the 1989 Exxon Valdez accident in Prince William Sound, Alaska (Birkland 1997).
(2) In the upper right corner, there is the case of a false positive: there was no problem but action was nevertheless taken. This situation is more complex because resources were unnecessarily invested—an overly aggressive reaction. Interestingly, it appears that it is very difficult to find real-world examples of this type of situation (European Environment Agency 2001), suggesting that industry and government do not adopt an aggressive attitude toward change. The possible exception is the Y2K phenomenon (Story and Crawford 2001). However, that example illustrates one of the difficulties with identifying a false positive: was Y2K a successful change to address a real problem, or an unnecessary, overly aggressive change? In the absence of a control group of inaction, it is difficult to discriminate between cases of successful change and those of false positives because the intervention may or may not have led to the outcome.
(3) In the lower right corner, there is the null case when there was no problem and no action was taken. This is the simplest case of all.
(4) In the lower left corner, there is the case of a false negative: there was a problem, but no action was taken. This is the most interesting and important case because it deals with situations where there is strong resistance to change or lack of awareness: the problem demands action, but intervention is not forthcoming. As we will see, there are many examples of this type, but to understand their nature, we need to identify some sources of resistance to change.

Table 1. Morphological analysis of societal change.

	Problem	No problem
Act	Change	False positive
Don't act	False negative	Null case

2.2. *Eleven challenges to change*

There are eleven challenges to change that have been inductively identified from the 14 case studies reviewed by the European Environment Agency (2001) in its aptly titled report *Late Lessons From Early Warnings*.

(1) Very long lag between cause and effect.
(2) Uncertainty or ignorance in information.
(3) Transboundary problems.
(4) Large short-term costs in the face of economic pressures.
(5) Costs are externalized onto environment, government and public.
(6) Difficult cost-benefit trade-offs.
(7) Legal liability for corporations.
(8) Public accountability for governments.
(9) Conflicting organizational roles.
(10) No evidence of harm $\neq$ evidence of no harm.
(11) Shoot the messenger.

The topics covered by the cases, described in Table 2, include substances or activities that have eventually been deemed harmful to people, animals, or the environment—but only after a great deal of resistance to change (thus, the title of the report). These cases represent an invaluable resource because each one comprehensively describes the initial evidence of harm, the reaction to that evidence, the reasons for resistance to change, and the policy changes that were eventually adopted. As far as is known, there is no comparable analysis for a human factors case of large-scale change, let alone for 14 of them. Therefore, these cases provide a fruitful database for identifying challenges to large-scale change.

The list of challenges to change is not intended to be comprehensive, and not all factors will be found in any one case. Nevertheless, the factors are useful because they are not tied to the idiosyncratic details of any one case, and are thus potentially generalizable across a diverse array of settings.

2.2.1. Very long lag between cause and effect. In some cases, change is difficult simply because the problem to be solved has slow dynamics, creating a very long lag between cause and effect. Asbestos provides a case in point. Typically, the time between exposure to asbestos fibers and the onset of cancer can be on the order of 10 to 40 years. It is difficult to assess risk during this 'incubation period' in which the symptoms of disease—evidence that there is a problem—are not visible. During this time, those that benefit from the status quo (e.g. asbestos producers) will argue that there is no evidence of harm so that they can justify not acting (e.g. not setting exposure limits). Even when the effects do become visible, it may be difficult to discern their cause because more immediate factors may be more obvious candidates. Given these conditions, it will take a long time before action is taken to address the problem. Indeed, in the case of asbestos, 100 years passed between the first warning sign of potential harm (1898) and the ban of all forms of asbestos by the European Union (1998). Acting to set limits for radiation also took decades because of the long lag between exposure and cancer.

Some environmental problems also tend to have slow dynamics that present a challenge to change. The impact of halocarbons first on the ozone layer and eventually on human health provides an example. The average time between the

Table 2. Fourteen case studies of societal change.

Case study #	Subject	Description
1	Fisheries	Overfishing owing to short-term economic pressures causes collapse of stock, leading to lost sales, unemployment, and financial bailouts
2	Radiation	Exposure to radioactivity leads to cancers and death
3	Benzene	Powerful bone marrow poison used in many, diverse industrial settings causes fatal leukemia and lymphatic cancer
4	Asbestos	Mineral with many industrial applications; inhalation of dust causes fatal mesothelioma cancer
5	PCBs (polychlorinated biphenyls)	Synthetic organic chemicals with many industrial uses; environmental pollutant as well as danger to animals and humans
6	Halocarbons	'Green house' gases that lead to deterioration of ozone layer, contributing to global warming and skin cancer
7	DES (diethylstilboestrol)	Synthetic estrogen used, among other things, to prevent miscarriage; prenatal exposure leads to rare but fatal vaginal cancer
8	Antimicrobials	Bacteria-killing drugs also used as growth promoters in food animals; lead to antimicrobial resistance in humans and animals
9	Sulphur dioxide	Air pollutant that causes fatal lung disease as well as 'acid rain', leading to contaminated lakes, dead fish, and dying forests
10	MTBE (methyl tert-butyl ether)	Engine anti-knocking agent used in gasoline as substitute for lead; may lead to groundwater contamination, cancer, and asthma
11	Great Lakes	Chemical pollutants cause contamination of Great Lakes and threat to human and animal health
12	TBT (tributyltin)	Chemical compound found in paint for ships and boats; leads to sexual deformities in marine life causing collapse of stock
13	Hormones	Used as growth promoters in food animals; cause cancer in humans and harmful to wildlife
14	BSE (bovine spongiform encephalopathy)	'Mad cow' disease caused by cattle eating feed with remains of sheep, cattle, and other animals; can lead to fatal disease in human beef consumers

release of these emissions and a concomitant increase in the prevalence of skin cancer is 30 to 40 years. Under these circumstances, it should not be surprising to find that, for many years, industry's attitude toward the use of halocarbons was not one of pre-emptive change, but rather, of 'wait and see'.

2.2.2. Uncertainty or ignorance in information. Sometimes, change is not forthcoming because the quality of information is less than ideal. There are several

versions of this obstacle. In one case, there is a great deal of intrinsic variability in the data, so it is difficult to make a convincing case for the need to act. For example, the stock of herring and sardines in the oceans can fluctuate dramatically over decades. Against this backdrop, it is difficult convincingly to isolate the unique contribution of overfishing on stock depletion. In another version of this obstacle, the problem is not variability but rather multiple potential causes, making the attribution of cause difficult. Asbestos provides an excellent example. In the 1930s, when the prevalence of lung cancer was quite low, it was easier to establish a direct link between asbestos exposure and cancer. However, decades later, when the prevalence of lung cancer owing to smoking increased significantly, it became more difficult to argue that asbestos was a carcinogen. Consequently, those in the tobacco industry could argue that people were dying from asbestos, and those in the asbestos industry could argue that people were dying from smoking instead, creating a paralyzing gridlock for policy change.

2.2.3. Transboundary problems. A system is an artificial construction created by a modeller and, as such, the lines defining the system boundary can be drawn in different ways with varying consequences. In the case of MTBE (methyl tert-butyl ether), government agencies were carved up according to media, such as land, air and water. This seems to be a reasonable way to allocate regulatory responsibilities, but in the case of MTBE, it had the undesirable effect that environmental impact assessments were fragmented and incomplete. MTBE crosses the land/air/water parsing, and so the damage it creates is severely underestimated unless a holistic view is adopted. In the absence of such an integrated perspective, change will be difficult to justify because the costs of the status quo are perceived to be much lower than they really are.

An analogous issue can be found when problems cross jurisdictional boundaries, as environmental problems are likely to do. For instance, restrictions on the use of TBT (tributyltin) in paint for seagoing vessels have been adopted by many, but not all, countries. It took a great deal of effort to effect these changes because there were many obstacles to change. Despite this apparent success, however, there are still TBT-induced problems on the coastal waters of Japan. Only world-wide restrictions would address the TBT problem and achieve environmental standards in all coastal systems. Clearly, this requirement substantially raises the bar for successful change.

2.2.4. Large short-term costs in the face of economic pressures. Change is also difficult because it frequently demands large short-term costs. As the EAA (2001) put it, 'Being wise before it is too late is not easy, especially when the environmental or health impacts may be far into the future and the real, or perceived, costs on averting them are large and immediate' (EEA 2001, p. 13). This situation creates a significant obstacle, especially for a corporation who is responsible to its shareholders for maximizing profits and whose 'legally defined mandate is to pursue, relentlessly and without exception, its own self-interest, regardless of the often harmful consequences it might cause to others' (Bakan 2004, pp. 1, 2). Naturally, there will be great resistance to take costly action under these circumstances. Indeed, the case studies frequently bear this out. There are several examples where those who benefit from the status quo try to avoid action by stating that there is no 'clear-cut or convincing evidence' of a problem. This leads to a

protracted debate about the quality of evidence, which benefits the status quo by delaying action, thereby averting a large short-term cost associated with change. The case of benzene is the most clearly documented: 'Manufacturers began to hire consultants to downplay the importance of the scientific observations related to the toxicity of benzene and to introduce unresolvable arguments about dose-response analyses, which had an impact in delaying much needed government regulations that sought to reduce benzene exposure in the workplace' (EEA 2001, p. 43). Monsanto adopted a similar tactic in its defence of PCBs (polychlorinated biphenyls), as did the pharmaceutical industry in defending the use of antimicrobials as growth promoters and Shell Chemical Company in defending the use of chemicals that contaminated the Great Lakes.

2.2.5. Costs are externalized onto environment, government and public. Economists use the term 'externalities' to refer to the effects of a transaction on a third party who did not play any role in that transaction (Bakan 2004). An example would be the decision by a pulp and paper company to dump its effluents into a river, polluting the water supply of a town downstream. The pollution is an externality because (barring any regulatory fines) the entity that made the decision—the company—does not suffer any of the negative consequences of its actions, whereas the entity that was not involved in the decision—the town—experiences the negative effects. Externalities are ways of shifting the burden of doing business from a corporation to the general public, environment or government. In cases such as this, there is no incentive for a company to modify its behaviour because it is not suffering the harmful costs of its actions, making change less likely to occur.

Unfortunately, many of the societal problems that are in need of change arise from externalities. For example, the health care costs associated with harm from asbestos exposure may not be paid by the company who manufactures the asbestos, but by the patients themselves or by government insurance programs. The company can then sell asbestos at a relatively low price because it is not shouldering the full costs of its product, making it difficult for asbestos to be replaced by a less hazardous material.

2.2.6. Difficult cost-benefit trade-offs. It is a truism that financial resources are always limited, which means that the benefits of change must be weighed against the costs. It is difficult to assess this trade-off because 'The cost of preventive actions are usually tangible, clearly allocated and often short term, whereas the costs of failing to act are less tangible, less clearly distributed and usually longer term' (EEA 2001, p. 3). Therefore, cost-benefit analyses usually argue against change, unless a precautionary perspective is adopted.

When there was strong scientific evidence about the harm caused by sulphur dioxide, some still resisted change by arguing that acid rain was a million dollar problem with a billion dollar solution. This may seem like a utilitarian argument that puts a price tag on human life and environmental devastation, but it must be taken seriously because the same amount of money could potentially be invested elsewhere with a greater impact on human health and the natural ecology. In the case of sulphur dioxide, researchers argued that the original cost-benefit analysis was incomplete because it did not fully take into account damages to health, agriculture,

materials and natural ecosystems. Once all of these costs were included in the analysis, then the balance sheet was clearly in favour of change.

Sometimes, the cost-benefit analysis seems to argue against change because the status quo has several desirable qualities. For instance, the use of MTBE as a replacement for lead in gasoline has the following advantages: it is inexpensive and easily produced with desirable chemical characteristics; it is produced at the refinery as opposed to at a more remote location; it blends easily without separation from gasoline; and it can be transferred easily through existing pipelines. Therefore, the harm caused by MTBE must be weighed against this non-trivial set of benefits. Change can be justified if a safer and equally beneficial replacement for MTBE can be found. It is not always easy to find a viable alternative, in which case we may have to live with an irreducible amount of risk—an unappealing, but inevitable prospect.

2.2.7. Legal liability for corporations. Legal liability can also be an obstacle to change, especially for corporations. In some cases, the fact that a company makes a good will change to improve one of its products is exploited by its detractors—in the media or in a lawsuit—as evidence that there must have been something harmful about the previous product, putting the company in a double bind situation. The PCBs case study provides an example of this dysfunctional reward structure. Monsanto stated that 'stopping the production of PCBs was not an option as it would cause "profits to cease and liability to soar because we would be admitting guilt by our actions" (EEA 2001, p. 65). In the absence of some offsetting benefit, companies would be loathe to adopt changes that would hurt them financially.

2.2.8. Public accountability for governments. Just as admitting that there is a problem can lead to law suits for an organization, admitting that there is a problem can lead to unfavourable public opinion for a government. Thus, the need to save face can lead to resistance to change. The BSE (bovine spongiform encephalopathy) case study provides a clear example of this phenomenon. First, the British Ministry of Agriculture, Fisheries and Food (MAFF) chose to hide the existence of the outbreak for 17 months for fear that citizens would panic. As one official put it, informing the public of the outbreak 'might imply to the general public we know something they don't, like the meat or milk is a source of danger for humans' (EEA 2001, p. 159). Meanwhile, unbeknownst to the public, the outbreak continued to escalate, increasing the threat to public health. Second, the MAFF also refrained from taking any action to curb the outbreak early on for fear that the resulting 'irresponsible or ill-informed publicity . . . might lead to hysterical demands for immediate, draconian Government measures' (EEA 2001, p. 159). Third, later in the outbreak—once the existence of BSE had finally become public—the MAFF offered the public the optimistic and reassuring message that the presence of BSE in British cattle did not pose a threat to human health, even though the available scientific evidence showed that it was impossible to be sure that consuming meat, dairy, and milk from BSE-infected animals posed no risk. The perceived need to save face was so strong that the government stuck to this initially indefensible position, even in the face of accumulating contradictory evidence. Consequently, many precautionary measures that could have diminished the impact of the outbreak were not adopted because they would undermine the government's position. This attitude of adopting, and sticking to, a palatable but increasingly distorted message may temporarily help

the government save face in the eyes of the public, but it is a clear challenge to policy change and a threat to public health.

2.2.9. Conflicting organizational roles. Change is also difficult to effect when an organization has conflicting roles. There are at least two versions of this challenge, one more explicit and another more implicit. In the implicit case, the conflicting roles are not immediately obvious. A good example can be found in the benzene case study, where scientists employed by benzene producers participated on the Threshold Limit Value Committee of the American Conference of Governmental Industrial Hygienists. These scientists were in a position of conflict of interest because, on the one hand, they had to represent their employers' concerns which would involve setting benzene limits at values that were easily achievable in the workplace, but on the other hand, they should protect public health which would involve setting limits according to the best available scientific evidence. In the end, the former role beat out the latter and limits of 100 ppm were recommended, even though there were known cases of benzene poisoning associated with levels of 10 ppm.

In the explicit case, an organization officially has responsibilities that are in intrinsic conflict with one another. In the BSE case, the MAFF was responsible for protecting the public from food-borne hazards while also promoting the economic interest of farmers and the food industry. There are situations in which these two mandates are in direct opposition, and the BSE outbreak was an example. Early on, the MAFF chose not to make information about the outbreak public or take any remedial action to safeguard public health, in part because doing so might lead other countries to reject UK exports of cattle, bovine embryos and semen. In fact, the Agriculture Minister did 'not see how [he] could proceed without being clear where the offsetting savings are coming from .... Action along the lines recommended now would make the export position much worse' (EEA 2001, p. 159). The tremendous resistance to change exhibited by the MAFF in the BSE case shows that when an organization is put in a conflict of interest, it can be very difficult for change to occur.

2.2.10. No evidence of harm $\neq$ evidence of no harm. The propensity to equate no evidence of harm with evidence of no harm is a logical fallacy that has repeatedly been an obstacle to change. Just because there is no evidence to show that a substance is dangerous does not mean that it is safe. The appropriate studies may not have been conducted yet. This is very likely to be the case in substances that have slow dynamics, such as asbestos, because, even though it is a harmful substance, evidence of its effects will not be visible for many years. For this reason, it is important to interpret 'negative' cancer studies with caution. Unless participants have been studied over 20 to 30 years, such studies are unlikely to detect lung cancer in people exposed to asbestos. Indeed, in an early asbestos study, the increase in cancer incidence was seven times normal but it did not become statistically significant until 25 years after the exposure.

2.2.11. Shoot the messenger. Finally, change is also difficult to achieve because sometimes the person bringing attention to a problem is not received with welcome arms. By definition, change threatens the status quo, so those who have a vested

interest in keeping things as they are typically have a great deal of power and may choose to use it to attack the messenger. There are many examples of the price paid by whistleblowers, including a penetrating account in Ibsen's (1882) play, *A Public Enemy*, which describes how a whistleblower goes from applauded public hero to outcast public enemy once the mayor, the media, and the public learn of the dire economic implications of his public health warnings. When Rachel Carson's (1962) seminal book, *Silent Spring*, linked pesticides with increased incidence of cancer and environmental devastation, the National Agricultural Chemicals Association wrote to editors of magazines and newspapers threatening that advertising revenues could be affected if the book were to receive positive reviews. And when the *New Yorker* published parts of the book in a serial fashion, Houghton Mifflin (the publisher of *Silent Spring*) received a letter from the general counsel of the Velsicol Chemical Company threatening legal action unless the last *New Yorker* article was cancelled. More forceful attacks with more devastating personal consequences have been documented in detail (Boisjoly *et al*. 1989, Brenner 1996, Thompson *et al*. 2001). The possibility of such a forceful backlash can serve as a strong deterrent, discouraging those with the requisite skills and information to come forward and spur change.

2.3. *Discussion*

There is much to be learnt from history, and the 14 case studies listed in Table 2 shed a great deal of light on why large-scale societal change can be so difficult to achieve. The challenges to change that emerged from these cases have been summarized above. The number and strength of these challenges show why change is so slow. Based on this corpus of cases, change seldom occurs in less than 25 years as measured by the time between the early warnings and the corresponding regulatory, judicial or administrative actions of reform.

However, there is another, perhaps less obvious, lesson buried in the list of challenges to change. Advocates for change frequently complain that a 'lack of political will' is the reason why change does not occur. But this phrase explains nothing. It is equivalent to the concept of 'caloric' that was once used by physicists many years ago to explain why objects give off heat (Einstein and Infeld 1938/1966). Why is an object warm? Because it has caloric. Eventually, physicists realized that the caloric was not useful because it merely shifted the burden of explanation—there is no account of the factors responsible for the phenomenon, nor of how they interact. The same could be said for political will. It allocates blame, but it does not elucidate the basis on which decisions are being made, whereas the factors given in the list of challenges to change represent an attempt at doing precisely that.

This difference has important practical implications. If you think change does not occur because of a lack of political will, you will tend to think that people who disagree with you are stupid, evil or, at the very best, misguided, so you will think that the remedy lies in trying to pressure them, or failing that, replacing them. But you do not really know where the levers for change are. If you put different people in the same roles and leave the design of the system intact, then it is unlikely that the undesirable behaviours will change. As Hartmann (2002) put it (in a different context), 'Nobody thought to examine the structure of the . . . institutions as a source of problems. Instead, the cause was laid at the feet of individual people . . . . But there is no use trying to find villains, because the problem is in the structure of the

situation' (p. 22). In other words, people may be engaging in behaviours we do not like or understand but they may be resistant to change for what they believe are very good reasons (e.g. a company has an obligation to its shareholders, a government agency has conflicting missions). A few of the factors given in the list of challenges to change—long lags, uncertain information—may be immutable, but the vast majority of the factors let us see some of the rationale behind resistance to change and therefore identifies where we need to focus our efforts (e.g. offering a company financial incentives for change, splitting a government agency into two independent units). Rather than pursue the usually futile course of blaming individuals, we can identify powerful and useful levers that can encourage the kind of change we want to achieve.

Knowledge of obstacles is important but not enough because it does not tell us when it is likely that obstacles can be removed or overcome. We also need to be savvy about when change is likely to occur so that we can invest our limited energies wisely. There are times when trying to change certain policies is tantamount to tilting at windmills. Trying to pass gun control legislation today in the US is an example. Yet, as the examples below will show, there are other times where windows of opportunity appear and comparatively small investments can lead to tremendous societal change. In the remainder of the present paper, three theories of the mechanisms behind change—two at the political level and one at the corporate level—are reviewed to show when change tends to occur. This knowledge has important practical implications for how to improve the likelihood of achieving human factors policy objectives.

3. Political change

3.1. *Agenda setting: how does an idea's time come?*

The phrase, 'an idea whose time has come', is frequently used to refer to a political or social movement that suddenly takes hold—seemingly everywhere at once—knocking down barriers to change that had persisted for decades or centuries. The civil rights movement of the 1960s in the US is a prototypical example. We would all like to think that human factors engineering will soon be an idea whose time has come because its potential impact for improving the quality of human life is tremendous (Vicente 2003a). But how does an idea's time come? What causes politicians, civil servants, lobbyists, the media, corporate executives, and the general public to embrace an idea simultaneously, and effect widespread change? Any insight into this issue is worth its weight in gold because it would provide guidance on what we could do as a discipline to make it more likely that our time will come, sooner rather than later—or not at all.

Kingdon's (1984/2003) landmark work on agenda setting is a political science classic that addressed this profound question. Public policy can be broadly divided into four activities: agenda setting which is the process by which subjects or problems receive serious political attention; the generation of policy alternatives which is the process by which particular proposals for action are formed; the moment of choice which is the process by which a particular policy is adopted; and finally, policy implementation which is the process by which chosen policies are realized. Kingdon's

work focuses primarily on agenda setting activities, a topic that had received very little attention in the literature. In four annual waves from 1976 to 1979, he conducted 247 comprehensive interviews with opinion makers, both inside and outside of the US federal government, who were concerned with policy initiatives in two areas: health and transportation. In addition, 23 case studies of successful and unsuccessful policy change were identified and studied in detail, resulting in a representative and broad data set. These findings led to a novel and influential theory that explains why some subjects receive a great deal of attention at particular times but not others, and why some subjects never make it onto the political agenda.

Kingdon's (1984/2003) theory consists of three parallel streams—problems, policies and politics—that have relatively independent dynamics, but that occasionally become coupled at critical moments that are more likely to result in broad social change. In the problem recognition stream, different social problems capture the attention of decision makers in and around government. The list of key problems is highly fluid; problems are constantly appearing on and falling off the political radar. In the policies stream, people from different backgrounds and varied interests are continually generating proposals to achieve their political interests, frequently independently of what problems are currently on the political agenda. These varied, and frequently conflicting, proposals are constantly competing for the attention of lawmakers through a process akin to natural selection. In the politics stream, events such as changes in public opinion, changes in administration, and interest group campaigns provide a shifting context that can facilitate or inhibit particular types of societal change. In Kingdon's theory, these three streams are 'largely separate from one another, largely governed by different forces, different considerations, and different styles' (p. 88). However, there are critical times when the three streams come together—a policy proposal nicely fits a recognized problem and the ideology of the current political landscape—and it is precisely at these times that the likelihood of societal change is greatest. But since the three streams work in different ways, it is important to understand the unique factors that influence each of them.

3.1.1. Problems. Problems come to the attention of lawmakers in several ways. First, systematic indicators—preferably quantitative—such as unemployment rate, gross domestic product, or disease rates can push a problem onto the political radar. For example, the widespread publication of medical error mortality statistics—44 000 to 98 000 annual preventable deaths in US hospitals—catapulted the problem of patient safety to the level of Presidential politics, making it the most influential health policy issue of 1999 (Kaiser/Harvard Program on Public and Health Policy 1999). In addition, focusing events such as an airplane crash or an oil spill can quickly put a previously unknown or ignored problem at the very front and center of politicians' attention. The Three Mile Island (TMI) nuclear accident is a well-known example that briefly raised the profile of human factors engineering into the national spotlight. Third, feedback about the efficacy or efficiency of existing government programs provide another mechanism for problem recognition. Complaints from local citizens to their congressional representatives about deteriorating road conditions are an example.

Perhaps surprisingly, the media does not play a strong role in creating new agenda items. Instead, its role seems to be primarily in magnifying items that were already on the government agenda. In other words, the media does not create, but rather reacts to or advances, change.

Just as important as how problems get the attention of government is how they fade from view. If legislation is passed, then problems drop off the agenda because something has been done about them, regardless of whether the desired impact has been achieved. Conversely, if attempts to effect change fail or take too long, then lawmakers frequently drop the problem and turn their attention to more promising issues because they conclude that the time is just not right. It takes a tremendous amount of energy to 'work' a problem and keep it on the government agenda, and because resources are limited, that effort can only be kept up for so long. As a result, specific efforts toward societal change tend to have a limited lifetime because advocacy can only be sustained in relatively discrete pushes. Hot ideas are on the agenda for, at most, four or five years and then go cold and are replaced by other hot problems that have risen to the agenda. But even while a problem is on the agenda, change is not guaranteed because of the influence of the other two streams.

3.1.2. Policies. At any one time, there is a very large number of proposed policy alternatives that government can choose from. Many of these are not directed at a particular problem, but instead represent the ideological concerns of a particular person or community; they are solutions looking for problems. For example, mass transit has been advanced by various policy communities as a solution to a diverse range of problems, including pollution, traffic congestion, and energy consumption. The fit can be entirely opportunistic. Indeed, it is common for government agencies to develop policies to protect or enhance their turf, or for politicians to develop policies to increase their public visibility.

Policy communities can differ tremendously, with some being fragmented and others being more tightly knit. A fragmented community leads to policy fragmentation, which in turn, makes change more difficult to achieve. A community that adopts a common paradigm, uses the same terminology, and is conceptually integrated maximizes its impact.

Perhaps surprisingly, researchers and academics are important players in the generation of policy alternatives, ranking just below the top tier occupied by the administration, Congress, and interest groups. However, to be influential, they must know what is on the mind of the people in government, which is not a typical preoccupation of many academics.

Ideas are put into a conceptual marketplace that results in uncontrollable recombination and selection, leading to unexpected revised or hybrid policy proposals that differ from the original, sometimes in significant ways. To gain currency and attention, advocates spend a great deal of time explaining their ideas to other communities and to the public to build up awareness, understanding, and acceptance—a diffusion process known as 'softening up'. Kingdon's research shows that this persuasion activity is essential to change; policy alternatives that are unfamiliar have virtually no chance of being selected. Moreover, the softening up process is very time-consuming, taking as long as six years by some estimates. During this time, the goal may simply be to keep the issue alive, while waiting for a more propitious time for action. There are several criteria for the survival of policy

proposals, including: technical feasibility, value acceptability within the policy community, tolerable cost and acceptance to the public and to politicians. Because there are so many proposals and the criteria for survival are so diverse, policy alternatives tend to exhibit a non-linear, 'tipping point' effect. For years, an idea will be on the back burner and discussed by only a few self-interested advocates, but then suddenly, it catches on and there is widespread acceptance of it, vastly increasing the likelihood of change. In short, the policy stream is very complex, slow, effortful, competitive and discontinuous.

3.1.3. Political. There are many political events that occur in parallel and independently from the problems and policy streams. Some of these are predictable and even regular. For example, legislation expires on known dates, creating a window of opportunity for change. Similarly, changes in administration after elections can create significant changes that alter the political landscape, allowing policies that had no chance of succeeding to come forward and be passed very quickly (and vice-versa). Well-known examples include the New Deal under Roosevelt, and the Great Society under Johnson.

Some political events are more difficult to anticipate, but have an equally strong effect, such as changes in public opinion that promote some policies and restrain others. Growing concern amongst the public for a sustainable environment would be an example. Jurisdictional turf battles can also encourage and impede change. As an example of the latter, some Congressmen are more likely to try to push legislation through quickly in an attempt to get credit for societal change if they know that one of their opponents is working on the same issue. Usually, the balance of power operates to sustain the status quo. Whereas persuasion dominates in the policy stream, bargaining dominates in the political stream. Coalitions are built and trades and compromises are made to build a critical mass of support to open a policy window that greases the wheels for change.

3.1.4. Coupling. This description clearly shows that agenda setting is a highly distributed and exceedingly complex phenomenon. Usually, the three streams operate relatively independently of each other and work to impede change, but once in a while, a policy window can open, either because of a change in the political stream or the problem stream. However, experience shows that policy windows open quite infrequently and do not remain open for very long. Thus, it is critical that advocates recognize these opportune moments and act quickly and strategically.

When a window is open because of a pressing problem, decision makers survey the policy stream to see if there is a relevant proposal that can serve as a solution. When a window is open owing to a political change, decision makers survey the policy stream to see if there is a relevant proposal that can advance their ideological agenda. Decision makers are usually quite skilled at detecting these changes, which means that there will be a fury of activity from competing interest groups to couple policies to agenda items when windows are perceived to open. Once these events are set in motion, it will be very difficult to predict and control the course of events, which is why societal change is so uncertain and fraught with risk. Moreover, change is not guaranteed to occur because, like any information processing system, the political bureaucracy only has a finite capacity, in this case for passing legislation.

The likelihood of change is greatly enhanced, however, when all three streams become coupled, creating a highly fertile confluence of events. It is the job of policy entrepreneurs to build on the foundation created by the long softening up process and seize on these critical opportunities by linking a policy proposal to a recognized problem (or vice versa) and by amassing (or leveraging) the required coalition of political support. When the 'stars are aligned' through this three-way coupling process, change that was impossible to achieve before can now happen with astonishing speed. Kingdon (1984/2003) discusses an example from health care policy during the Nixon era: 'The proposal grew from a conversation to a memo, then from a very thick document to the status of a major presidential health initiative, all in a matter of a few weeks' (p. 6).

3.2. *Focusing events: how to capitalize on disasters?*

Birkland (1997) investigated a particular aspect of agenda setting, namely the potential impact of disasters on policy change. Since the relevance of human factors engineering to the quality of human life is—in principle, at least—most convincingly and vividly illustrated by nuclear, aviation, petrochemical, aerospace, and other such accidents, this research program can help us learn how to turn these tragic disasters into societal changes that can reduce the likelihood of more deaths, destruction or environmental damage.

Birkland (1997) analysed a number of diverse events—earthquakes, hurricanes, oil spills and nuclear disasters—over a long time period (ranging from 13 to 30 years). For each problem area, he searched government sources to identify the amount and type of policy activity, and media sources to identify the amount and type of publicity. The time periods before and after an accident were compared so that the dynamic impact of the event could be understood. By investigating several different sectors, Birkland was able to generalize results that were common across cases as well as identifying mediating factors that inhibited or facilitated the impact of the disaster on societal change.

The central construct in Birkland's work is the *focusing event:* a sudden, vivid, unpredictable event that stimulates tremendous interest in a societal problem and that greatly increases the likelihood of policy change on that problem. The prototypical example he discusses is the 1989 Exxon Valdez accident, which created enormous environmental damage after an oil tanker ran aground off the Alaskan coast and spilled over 11 million gallons of crude. For 14 years, environmental policy analysts had been unsuccessfully advocating comprehensive oil spill liability legislation to protect the natural ecology. After the Exxon Valdez spill, the Oil Pollution Act of 1990 was pushed through Congress within 18 months.

Interestingly, however, not all disasters become focusing events. For example, the 1966 Fermi accident in Michigan, the 1975 Browns Ferry accident in Alabama, and the 1979 TMI accident in Pennsylvania were all significant nuclear disasters, but only the latter received widespread international attention. Therefore, a disaster—an objective physical event—is, by itself, not enough to cause a focusing event—a socially constructed political outcome. A number of other factors, some of which are described next, mediate the likely impact on policy change.

3.2.1. Advocacy coalition. The most obvious pre-requisite for turning a disaster into a focusing event is the existence of an advocacy community. In the early days of

nuclear energy, the overwhelming public perception was that nuclear power was positive and would lead to remarkable innovations with clear societal benefits, such as 'electricity that was too cheap to meter'. In the absence of a significant community of advocates, disasters will not be linked to the need for policy change and this is indeed what Birkland's research on the early days of nuclear power demonstrates.

More importantly, even when there is a significant group of advocates, the likelihood of change is dependent on the degree to which they are organized. There must be a community of core policy entrepreneurs that is constantly active, not just after disasters. Birkland's (1997) contrast between the earthquake and hurricane policy communities illustrates this point:

> The earthquake domain has an active policy community that is mobilized during postevent periods and continues activity between such events. The hurricane community has no coherent scientific community that participates in congressional hearings between hurricanes. Without the participation of the scientific community, interest in the hurricane problem does increase in the wake of events, but this interest is centered almost solely on disaster relief and virtually disappears as the memory of the storm fades. (p. 64)

Thus, it appears that the softening up process identified by Kingdon (1984/2003) is also critical to focusing events. The groundwork must be laid before disasters so that there is a fertile soil for policy change to grow when 'the big one' arrives.

3.2.2. Publicity. Another important mediating factor is publicity; if the policy relevance of the disaster is not communicated in the media, then the government and the public will not link the event to a need for change. This appears to be why the Fermi accident did not have any policy impact in 1966. The anti-nuclear version of the story never made it into the press.

However, even when an activist view is publicized, policy change can still be difficult to achieve because defenders of the status quo will typically be out in full force to deploy their (usually, quite powerful) public relations resources to contain the event. Standard ploys include claiming that everything is under control so there is no need for further action, that there will be minimal long-term damage so there is nothing to worry about, that the blame lies with a lowly scapegoat or a different organization not with the organization under the microscope, or that the event was caused by a freak, 'act of God' about which nothing can be done rather than a systematic problem that is begging for policy reform. Regardless of the particular strategy, the overall goals are to convince lawmakers that there is no need to act and the public that there is no need to be alarmed or that the blame lies elsewhere (e.g. Ice 1991, Williams and Treadaway 1992, O'Connor 2002).

If advocates for change are to overcome these 'spin' moves, they must learn to use the media strategically. Birkland's (1997) research identifies a number of important characteristics. First, the media response must be fast so that it can impact public opinion before the issue is shut down by vested interests. Second, an emotionally compelling narrative should portray the event as an example of a general and important societal problem that is in dire need of policy change. A good story is not only convincing, but also easily told and retold, facilitating diffusion of the message. Third, it is also useful to develop simple, graphic, and 'sticky' images that immediately convey the intended message by appealing to emotion (i.e. the gut) rather than analysis (i.e. the brain). In the Exxon Valdez case, photos and footage of birds and otters drenched in oil were a public relations dream for environmental

advocates. These images can be propagated quickly, widely, and need virtually no explanation; they speak for themselves and provide a cogent, memorable indication of the need for change.

3.2.3. Mobilization. Another key mediating factor identified by Birkland (1997) is the need to mobilize support. In most cases, the status quo dominates because it is more powerful than the community advocating policy change, but disasters provide the latter with an opportunity to grow their support base vastly and quickly. If advocates can build coalitions with other groups to expand the interested community to an entirely new set of organizations, then they may be able to create a tipping point phenomenon that overwhelms the status quo (Schattschneider 1960). Indeed, the power of disasters is that they often can be made to be relevant to many different interest groups that are not usually lobbying for change. In the case of oil spills, many people, not just environmental activists, care about the integrity of the natural ecology. If these other groups can be brought under the same advocacy coalition, then the likelihood of policy change is greatly enhanced. But of course, this requires that the core policy community that is leading the issue be well organized and do their softening-up homework (see above).

3.3. *'Design' implications*

It should be clear from both of these theories that there is a great deal of residual randomness in political change processes; outcomes are uncertain and cannot be determined. Nevertheless, there is also much structure that can be exploited by any policy advocate. Indeed, both of the theories reviewed have important 'design' implications that the human factors community should be aware of to improve its activist movements. Some recommendations for 'tilting the playing field' of political change are listed below.

(i) write more newspaper editorials;
(ii) make more friends with chief executive officers (CEO)s, journalists, politicians, and civil servants;
(iii) build more bridges to other disciplines;
(iv) write more trade books for the masses;
(v) study more cases of successful and unsuccessful human factors engineering change to identify successful strategies and conditions;
(vi) build more advocacy coalitions with like-minded organizations;
(vii) do not wait to get unanimous agreement before taking a public stand;
(viii) prepare to capitalize on the next disaster by continually engaging in a softening up process;
(ix) build a greater capacity for issuing public statements and images quickly;
(x) learn to use the media more effectively by taking advantage of compelling images and seductive narratives;
(xi) make yourself useful to people in power so that they eventually seek your help and input on a regular basis;
(xii) work towards a common paradigm for human factors engineering that is conceptually integrated and that relies on a consistent terminology, rather

than adopting new terms for existing constructs or terms that have not been clearly defined;

(xiii) continually monitor the political landscape for windows of opportunity.

4. Corporate change

In addition to understanding political change, it is also important to study the processes behind corporate change because human factors have the potential to influence, not only government, but companies as well.

4.1. *Punctuated equilibrium: when do corporations undergo radical change?*

There are many different mechanisms to explain why corporations sometimes undergo radical organizational change. One well-known and influential account, referred to as punctuated equilibrium theory (Tushman and Romanelli 1985, Romanelli and Tushman 1994), claims that organizations can experience long periods of resistance to change followed by fast revolutionary change, on the order of two years. The long (and successful) periods of equilibrium 'operate to maintain status quo, often in spite of clear dysfunctional consequences' (Tushman and Romanelli 1985, p. 180). These are the periods in which the obstacles to change listed in section 2.2 create a gridlock to change. During these times, it can seem like efforts aimed at changing corporate behaviour and culture are doomed to fail because the resistance to alternative approaches is so strong.

However, activists should not give up hope because, according to punctuated equilibrium theory, there can be periods in which radical change can occur. Moreover, this change can happen relatively quickly and thereby come as a surprise to those who have been unsuccessfully working the problem during the many years in which a company was in an equilibrium phase. More specifically, the theory postulates three pre-conditions for revolutionary change: (a) a new CEO facilitates radical shifts because new leaders do not have a vested interest in the old way of doing things; (b) a severe crisis in perceived performance—usually financial—encourages a company to question and modify its modes of operation; and (c) major environmental jolts 'that dramatically alter the competitive and operating conditions of an environment' demand change for survival and success (Romanelli and Tushman 1994, p. 1145).

5. Case study

To illustrate the relevance of social science theories to human factors engineering, a case study from the domain of patient safety will be presented (Vicente 2003b).

5.1. *Medical device design and human error*

This case deals with the impact of a particular medical device on human error, and thus, patient safety. A patient-controlled analgesia (PCA) pump was introduced into

the marketplace in 1988. The device allows patients to self-administer small, controlled amounts of pain killer—usually morphine—but only after a number of parameters have been programmed by the nurse via a human-computer interface. A programming error can lead to an overdose and even death. Thus, it is important that the interface obey human factors design principles.

In 1995, 1996, 1997 and 1999, patient deaths owing to programming errors with this PCA pump were reported. Several times, it was noted that the interface was cumbersome and awkward to use and that it should be redesigned to minimize the likelihood of fatal errors. The manufacturer of the device adopted a 'blame and shame' approach to medical error that emphasizes added training rather than device redesign (Kohn *et al*. 1999). Therefore, attempts by many individuals to get the company to change the design of its PCA pump interface were unsuccessful—the signature of a corporation in an equilibrium phase that resists change, even in the face of adverse consequences (Romanelli and Tushman 1994).

5.2. *Challenges to change*

Most of the challenges to change listed in section 2.2 are pertinent to this case. There was a 7 year lag between the introduction of the device (1988) and the first reported death (1995), probably because of market diffusion forces. As a result, it becomes difficult to prove that inadequate interface design is the cause of death because there were many intervening forces at play during that 7 year period.

Uncertainty in information also plays a big role because most of the reported deaths come from an FDA database that is known to severely underestimate the incidence of problems because of under-reporting. Previous research suggests that the number of actual incidents is 13 to 91 times the number of reported incidents, but there is no way of knowing the true number (Vicente *et al*. 2003). As a result, it is possible for the manufacturer to claim that there are only a few isolated cases of death owing to programming errors.

Transboundary problems are also an issue because the PCA pump was sold internationally, but is only regulated nationally. Therefore, it is possible for each government regulator to decide that the problem is nationally too small to warrant action, even though the global problem can be far more significant yet unregulated. In this case, the problem would fall through the cracks of regulatory boundaries, and government pressure would not be put on the company to take action.

There is no doubt that recalling or redesigning the device would not be cheap, so it is understandable that any company would not want to take on such short-costs. This is particularly so when the costs of injuries or deaths are externalized onto patients and their families who are the ones experiencing the loss. When no report is filed (which is frequently the case), then the company does not even know that a death occurred, so it cannot decide to act on information that it does not receive.

There are many cost-benefit trade-offs that can be used to justify inaction, but one is the trade-off between the fact that nurses are familiar with the existing design but not a new design and the benefits of a new design based on human factors principles.

Legal liability is also an impediment to change in this case. If the manufacturer redesigns the PCA pump interface, then that information can be introduced by the

plaintiff in a lawsuit, suggesting that the company is guilty of negligence because there must have been something harmful about the previous design.

The fact that there is little evidence of harm in this case (five to eight reported deaths when the device has been used over 22 million times) can be used to justify inaction, but this does not mean that the PCA pump is safe. Because of the problem with under-reporting mentioned earlier, the estimated number of deaths is much higher (65 to 667) and the estimated probability of death owing to programming error is also higher (2.95×10^{-6} to 3.03×10^{-5}) (Vicente *et al.* 2003).

Finally, change was delayed in this case by the 'shoot the messenger' effect. Two researchers who had been trying to raise awareness about the potentially lethal human factors limitations of this device received a 'cease and desist' letter from the manufacturer who stated: 'I would urge you to cease from making disparaging remarks about [our company] or its products'. The prospect of a lawsuit from a large, multinational corporation slowed down the researchers' attempts to encourage change.

We can see from this list that there are many reasons—some quite forceful—that the manufacturer could use to justify not taking action on its PCA pump.

5.3. *Radical corporate change*

After years of resisting change in the face of dysfunctional consequences, the PCA manufacturer underwent a radical corporate change in a relatively brief period of time. In May 2001, the manufacturer placed a job advertisement for a Human Factors Engineering Program Manager, initiating a remarkable behavioural change: (a) setting up a Human Factors Council at corporate headquarters with representatives from each of its divisions; (b) injecting human factors input into existing medical device design projects; (c) creating a human factors process for designing all future medical devices; and (d) putting on training courses throughout the company to educate employees about the importance of human factors engineering. Why did the manufacturer undergo such a transformation—seemingly overnight—after resisting change for years? And why did the change occur in May 2001, and not at some other time?

The answers to these questions are consistent with the predictions made by punctuated equilibrium theory. First, the manufacturer had a new and more aggressive CEO and management team in January 1999, making it more likely that old ways of doing business would be questioned. Second, the company experienced a profound financial crisis after it signed an agreement with the Department of Justice to pay a fine of $100 M for repeated manufacturing defects in another of its products. The company's stock price declined substantially, its shareholders filed class actions lawsuits against it, its planned acquisition of another drug manufacturer fell through, it feared that it would fall prey to a hostile takeover bid, and it was being monitored closely by the Food and Drug Administration (FDA).

Finally, during the 9.5 month period from 2 November 1999 to 18 July 18 2000, the PCA manufacturer experienced major disruptions that profoundly altered its competitive landscape. The Institute of Medicine report on medical error (Kohn *et al.* 1999) was released on 29 November 1999, and brought the patient safety agenda to the attention of the medical community, raising the profile of human factors. On 28 February 2000 a 19-year old Florida woman died from a

programming error while connected to the PCA pump. This tragic event received national media attention, leading to at least nine newspaper articles that forcefully discussed the relationship between human factors design and error reduction. On 18 July 2000, the FDA published a guidance document to help medical device manufacturers incorporate human factors engineering into their design processes. This document was influential because it provided advice on how to integrate human factors into existing risk management processes, making it more likely that the guidance would be embraced. All the events in this critical cluster provided the PCA manufacturer with strong reasons for adopting a human factors approach. About a year later, the manufacturer initiated a radical behavioural reform.

5.4. *'Design' implications*

The insights provided by punctuated equilibrium theory have important implications for inducing radical corporate change. Given the importance of economic performance to corporate change, human factors engineers should seek to create market forces that reward corporate change by conducting human factors evaluations *before* purchasing medical devices, products and services, and by feeding back the evaluation results to every manufacturer, not just the one that was selected, so that all can improve their designs (Cassano 2003). This recommendation may seem obvious, but it is rarely practiced (e.g., Keselman *et al*. 2003).

Given the importance of environmental disruptions, human factors engineers should partner with other stakeholders to create broad policy coalitions that encourage corporate reform. For example, relationships should be built with news media to raise awareness about the urgent need for a human factors approach to patient safety. In the aforementioned Florida death, the hospital initially did not explain to the family why the patient died and only provided a 'cursory explanation of the incident' to the media (Stark *et al*. 2002, p. 5:1). Were it not for the journalist's persistence, this event would not have reached the public, and the corporate change described here would likely not have occurred when it did (or at all). These findings reinforce Birkland's (1997) point that strategic publicity and mobilization are critical in turning otherwise anonymous tragedies into focusing events that effect profound positive change. Therefore, whenever possible, human factors engineers should partner with the media and seek to publicize, not cover up, tragic adverse events to encourage change. Analogous types of linkages should be built with politicians, government regulators, professional associations, and corporations to induce major environmental jolts that tilt the playing field to improve the quality of human life.

6. Conclusions

The stated purpose of human factors engineering is to use our theories, methods and findings to improve the quality of human life. Thousands of people have dedicated decades of their life to achieving this aim. If we repeatedly fail at effecting societal change, then our research and design efforts will have been for naught and we will fall short as a discipline. Therefore, we have an obligation, not only to ourselves and

to our discipline, but to society—the tax payers who fund much of our research and who are the intended ultimate beneficiaries of our work—to do everything we can to improve our ability to effect societal change, both in government and in the corporate world.

In the present paper, a review has been given of some of the literature from other disciplines that provides insights into the obstacles to change and how to effect change on a large scale. The practical 'design' implications of this research were illustrated with a set of recommendations for tilting the playing field of societal change. By becoming better aware of and making the most of this wealth of scholarship, we can increase the likelihood of improving the fit between people and technology in the service of humankind.

The results of this analysis are relevant to a variety of audiences. Human factors students will be better able to see how the topics they deal with in class and in research can potentially connect with societal issues that are covered in the media and of broad interest to the general public. Human factors researchers and practitioners will be better able to see how societal problems can rarely be solved by purely technical solutions alone; knowledge of organizational, social, and political forces is essential to understanding and fostering change. Finally, professional societies will be better able to see some of the strategies they need to engage in to better advocate for the interests of their members and effect societal change.

Acknowledgements

This research was funded by a E. W. R. Steacie Memorial Fellowship and a research grant from the Natural Sciences and Engineering Research Council of Canada. The author would like to thank Jeff Cooper, Lianne Jeffs, Bentzi Karsh, Jill Kelsall, Brian Kleiner, Neelam Naikar and members of the Cognitive Engineering Laboratory, especially Olivier St-Cyr, for their helpful comments.

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About the author

Kim J. Vicente received his PhD (1991) in mechanical engineering from the University of Illinois. He is professor in the Department of Mechanical and Industrial Engineering, Department of Computer Science, the Institute for Biomaterials and Biomedical Engineering, and the Edward S. Rogers, Sr. Department of Electrical and Computer Engineering at the University of Toronto, and founding director of its Cognitive Engineering Laboratory. Kim is a Senior Fellow and Corporation Member of Massey College, and received the University of Toronto McLean Award, as well as the NSERC E. W. R. Steacie Fellowship. Kim was the 31st Jerome Clarke Hunsaker Distinguished Visiting Professor of Aerospace Information Engineering and Minta Martin Lecturer at the Massachusetts Institute of Technology (2002–2003). He has authored over 170 refereed papers, and holds one patent. In 1999, he was chosen by TIME Magazine as one of 25 Canadians under the age of 40 who is a 'Leader for the 21st Century who will shape Canada's future'.