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COMPLEX SYSTEMS: HEURISTICS FOR THINKING ABOUT _____

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The motivation directing my research is belief in the need for fundamental changes to the way my culture and its people interact with each other, with people from other cultures and with non-human others. 'Inequitable' and 'unsustainable' seem to be fair and reasonable characterizations of current conditions – and both require change. I wonder at their origins, perpetuation and escalation – and about the challenges involved in manifesting something 'better'. Many dilemmas arise: What to change? What to change *to*? How? Who to decide what, to what, and how? – And who to decide, who to decide?

Although my beginnings – personally and academically – are tied to westcoast rainforests, ecology, and concern for conservation, my studies drew me from science toward people, planning, decision-making, ethics and ways to bring all of these together – with rainforests, ecology and conservation. I fell into complex systems theory/thinking without intention. My first introduction was learning about autopoiesis while developing an argument for the moral considerability of ecosystems. I learned more after pulling a book – *Complexity* – off the shelf while grappling with an understanding of sustainability in forest ecosystems. Although mildly embarrassed by the simplistic discussion in some of this earlier writing, I am still trying to catch up to some of the ideas.

Even my early use of system concepts illustrates a simultaneous affinity and criticism for them – as well as efforts toward their re-development. Most explicitly, I advanced the notion of "sympoiesis" – a conceptualization of systems as collectively-producing and boundaryless (Dempster 1995). This coincident affinity/criticism/re-development has continued through my involvement in the UW complex systems discussion group and my current research and writing. Key aspects of complex systems that I find valuable and problematic are briefly noted in Table 1.

Table 1 My perspective on aspects of 'new' systems theory, thinking and approaches*

aspects that I find particularly valuable	• emphasis on relations • holistic, generic perspective with interdisciplinary possibilities • theories speak of chaos, complexity, catastrophe, self-organization, self-production • articulation and acknowledgement of second order observers, some discussion of self-reference, blind-spots and epistemological conundrums
aspects that I find particularly problematic	• continued claim of epistemological and political neutrality rather than ambivalence (as in Ellul's discussion of technology) • seldom accounts for self-reference; even among those who discuss the concept • poor ability to deal with power-knowledge, ethics, human agency… • still relies on (at least vestiges) of predictability, control, hierarchy… • emphasis on boundaries to the point of a subsequent insistence on black/white, in/out, system/environment…
what I have done/am doing to get over the problematic aspects	• emphasizing heuristic nature of 'systems' • exploring and emphasizing self-reference and especially the organizational closure of cognition and of knowledge production and the subsequent blind-spots • emphasis on system-environment-observer triad and subsequent complexifications • conceptualizing systems without boundaries, especially sympoietic systems • exploring and emphasizing self-organizing factors and collective production

* By 'new', I refer to interpretive and critical systems thinking (see McCarthy's paper). Although these differ from functional/hard systems thinking, they seem to have carried-over characteristics from earlier versions. Admittedly, this still covers a very broad range of theory, thinking and approaches, so my comments are only general impressions.

My research focus is 'big picture' thinking – a focus that has led me to, but also arises from, systems theory/thinking. It has been enhanced by excursions into postmodern philosophy, radical democracy and related disciplines and perspectives. I emphasize the development and application of complex systems theory/thinking as heuristics. Rather than provide solutions or testable hypotheses, my intent is to facilitate thinking about the dilemmas involved in manifesting change.

In this brief paper I offer a few heuristics – as departure points not end-points; as means to foster thinking for discussion rather than to provide recommendations for implementation. They are included because they seem to address questions, ideas and comments that arose during the workshop in Vancouver. Since there is not enough detail to illustrate subtleties and complexities, each has to be viewed as a sort-of gestalt. Hopefully the ideas will offer a different perspective, help solidify thoughts held loosely in mind, or offer defence for arguments not yet considered defendable. I rely heavily on illustrations. These, and the ideas, have been drawn from earlier work, which can be pursued for further elaboration and discussion.[1]

REALITY…?

I begin with some basic questions: What is reality? How do we justify our claims to describe certain phenomena as 'real'? How do our perceptions and interactions with 'reality' influence our perceptions and interactions with 'reality'? The following illustrations prioritize my own onto-epistemological view: that our conceptions and experience of 'reality' are 'constructed', but that they are constructed out of *something* not just *anything*. The following points are caricaturized in Figure 1:

- We can only perceive phenomena that we can perceive – tautological but crucial.
- Since our 'reality' is constructed of things we can perceive and devoid of those we cannot, it is a construction or interpretation that arises from our use and reliance on particular sensors, lenses, perspectives and heuristics. (I refer to these, here, as mediators. The arguments and heuristics I offer here are examples – and therefore subject to the dilemmas articulated.)
- Different mediators – separately or in conjunction – lead to different 'constructions' of reality.
- Mediators may be innate as well as learned.
- Tools, instruments and concepts may make more of 'reality' perceivable but there may be (much) more that is missed.
- As examples, most humans claim coffee cups and tables as real, whereas God, neutrinos and inequity are more readily perceived by some than others.

Figure 1 Perceiving/conceiving "reality"

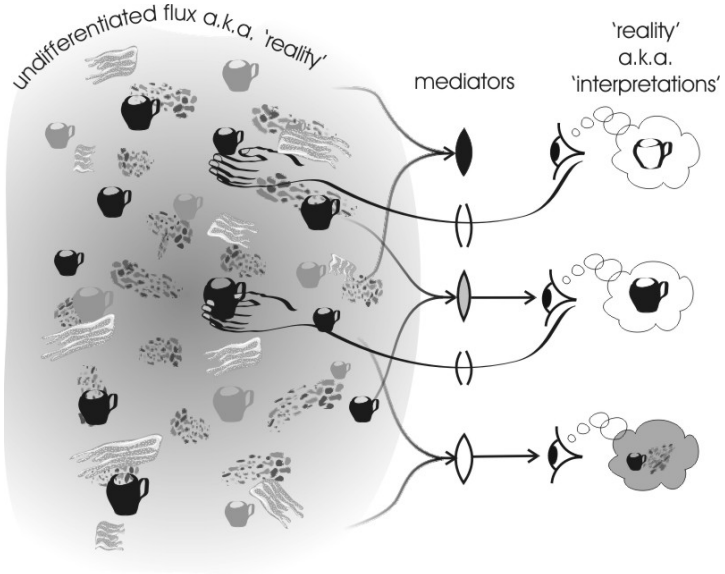


Figure 1b (augmented by Figures 2 and 3) adds further considerations that seem to me to be crucial:

- We appear to be embedded in the very same reality that we are attempting to perceive and understand and are subsequently challenged by the conundrums of

[1] More details than most would desire can be found on my website: www.fes.uwaterloo.ca/u/mbldemps/, including "Snapthoughts" which offer short comments on many of the ideas discussed here.

self-reference – in particular – the concern that "we do not see what we do not see" (Maturana and Varela 1987) (Figure 2).

- The perceptual capacities and conceptual heuristics that mediate are created through mutual interaction among mind, mediators constructed realities and environments. This mutually influential interaction occurs in different ways:
  - biologically – over evolutionary time – through development of eyes, fingertip nerve endings, etc.,
  - epistemologically – over human history – through theory, concepts and technologies,
  - politically – over current history – through socio-economic roles and positions and distributions of power,
  - personally – over individual lifetimes – through a combination of these factors in individual persons.
- This mutual interaction – which Maturana and Varela (1980, 1987) have termed *structural coupling* – reinforces the following:
  - Each of our individual perceptual/conceptual structures are attuned to some types of phenomena but not others.
  - Other entities – human and otherwise – may be attuned to other phenomena.
  - There is a recursive or hermeneutic aspect to all this: our capacities and heuristics influence – and are influenced by – our perceptions and interpretations, which in turn influence – and are influenced by – 'reality' and by our perception and interpretation of it (Figure 3).

In thinking about the implications of these comments for sustainability, consider the following quotation:

We face the tragic prospect of the next generation being caught in a conceptual double bind where the ability to understand the problem will be dependent upon the same patterns of thought partly responsible for the scope of the crisis (Bowers 1993: 32).

Figure 1b – Immersion, recursion and 'reality'

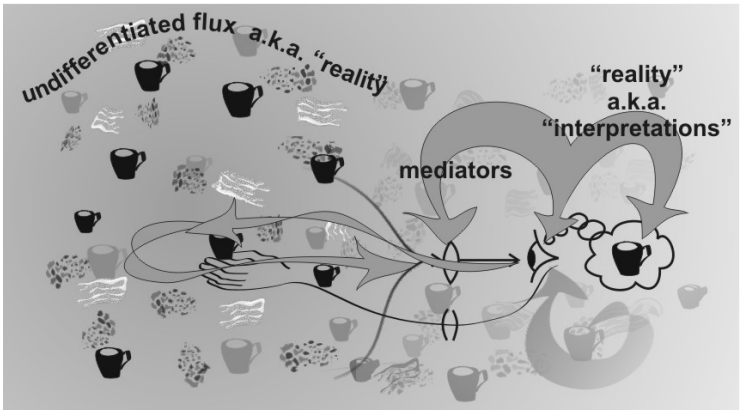


Figure 2 Coping with blind-spots

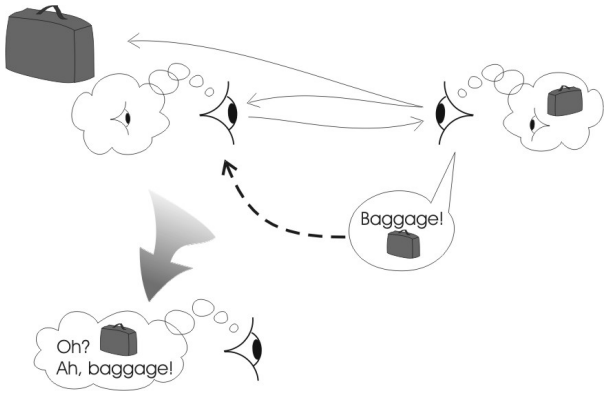
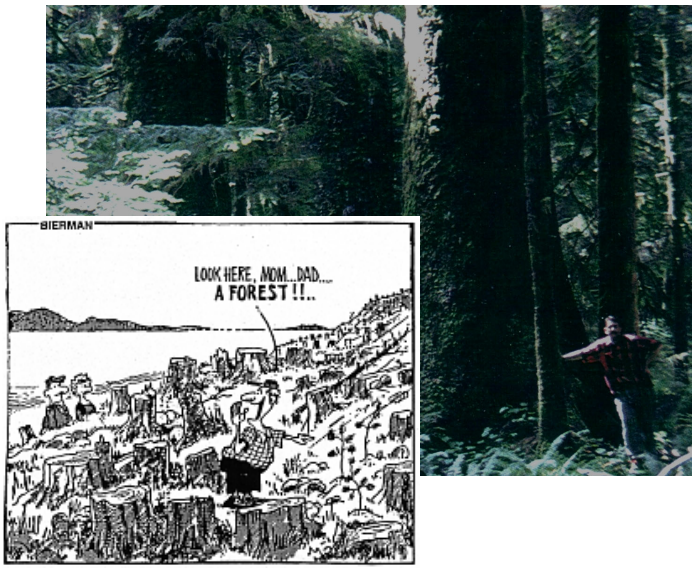


Figure 3 Perception influencing reality influencing perception…



In trying to grapple with an understanding of these issues – particularly recursion, self-production and the underlying influences – I have relied on the concepts of self-organization and autopoiesis, which have furthered my conceptualization of sympoiesis (see, for example, Dempster 2000).

DRIVING FACTORS AND SELF-ORGANIZATION

In one aspect of my research, I draw attention to the role and importance of global-local interactions as contributors to the process of self-organization. As an example, think about the ubiquitous dendritic pattern of river systems and how they are formed (Figure 4). Gravity provides a global-directional influence on water: *go down*. Interaction with the local-constraining influence of landscape (enhanced by erosion, transported bedload, etc.) leads to the emergence of river systems.[2] Dynamic tension among these counteracting global-local influences, and the variety among the local-constraining influences, lead to the emergence of different types of rivers (Figure 4b).

Figure 4 Interacting global-local influences leading to the emergence of a river systems

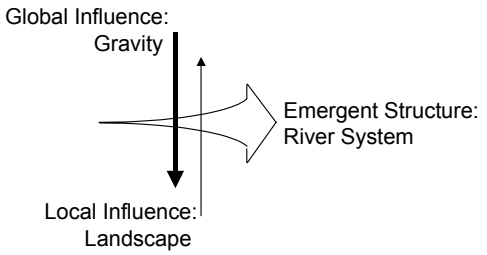
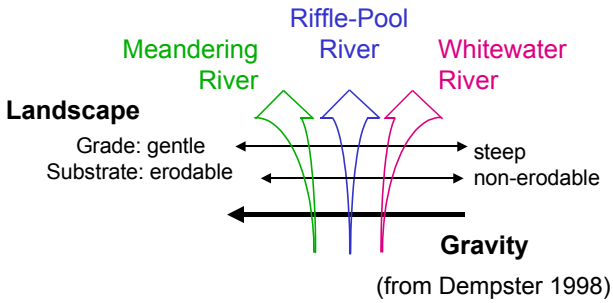


Figure 4b Different local influences leading to different river types



(from Dempster 1998)

In thinking about human behaviour and about how changes might contribute to more equitable and sustainable conditions, a comparable heuristic can be drawn to facilitate thinking about factors that have an influence.

First, however, a bit of an aside: Some people question the validity of applying models and theory developed for understanding 'natural systems' to 'social systems'. To counter this concern, I make a few points. 1) As explanatory heuristics, application of these ideas to gain understanding of natural systems should *also* be questioned. 2) Cross-disciplinary pollination has been fruitful in the past – even if also problematic. 3) Some people find it is easier to envision complexities with comparative examples – particularly simplistic ones. 4) Any metaphor will have disadvantages as well as advantages. I suggest caution in their application rather than prohibition of it.

In the Vancouver workshop, a point that rose often was recognition that information is not the only factor influencing people to make decisions. Values, attitudes, opportunities and other factors are also significant contributors. Turning to a psychological understanding of behaviours, different perspectives point to various cognitive, intrapsychic and environmental factors as influential. Smith (1993) argues that these factors should be considered in conjunction rather than as mutually exclusive disciplinary perspectives. Figure 5 illustrates these factors as a mix of self-reinforcing influences that each contribute to, or detract from, manifestation of particular behaviours. Note that none of the factors are shown to play the global-directional role of gravity (although the different perspectives may each suggest different interpretations).

[2] Note that the system referred to here is the *pattern* of a river, with its familiar dendritic branchings, not the hydrologic cycle.

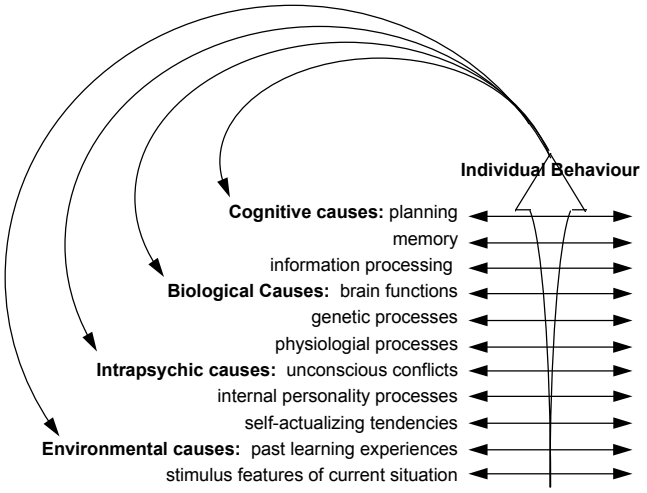
Since each factor is presented as a binary, the illustration fails to address the nuances of each individual factor. Also, because of the number of factors involved, it does not readily allow categorizing the behaviours that emerge as was illustrated in the river example. However, the illustration does facilitate attention to a rich set of factors relevant to thinking about manifesting change. Most especially it draws attention to the potentially conflicting array of factors that play a role in decision-making and the behaviours that emerge – in single individuals or across populations.

In addition, the illustrations offer some potential for thinking about multi-scalar issues since the factors listed in any one of these diagrams represent different scales.

Another illustration, Figure 6 – which also takes into account positive feedback – shows the formation of contrasting positions between academics and practitioners. As with the other illustrations, it does not intend to be comprehensive or to represent the ways things *are*, but to act as a heuristic to facilitate thinking.

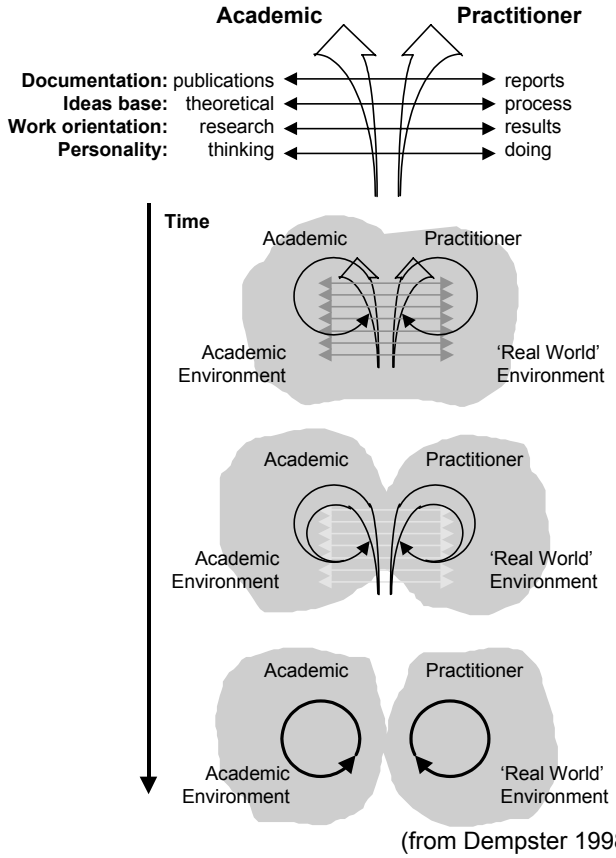
Different propensities and requirements for academics and practitioners in a few different areas are represented[3] – as set within an 'environment'. Over time, due to the self-reinforcing nature of factors and environments, each position becomes more like itself and contributes to an environment more suited to its own enactment. Over time, the two become isolated and separated. So – to a certain extent – do their environments. This illustration aids in understanding some of the challenges that arise in attempting to do cross-sectoral or cross-disciplinary work. Without addressing the range of factors that carry an influence, recommendations for bridging the gap remain partial.

Figure 5 Interacting influences leading to the emergence of human behaviours



(from Dempster 1998)

Figure 6 Self-reinforcing self-organizing process



(from Dempster 1998)

[3] I acknowledge this to be a very restricted representation – and somewhat stereotypical. However, I believe it makes the point without being too unfair...

AUTOPOIESIS AND SYMPOIESIS

As the final heuristic to include in this paper, I briefly note a distinction between autopoietic and sympoietic systems – a distinction relevant for thinking about the process illustrated in Figure 6 and for thinking about suitable responses. The two individuals resulting from the process illustrated above – who are each bound by the reinforcement of their own preferences and capacities and coupled to their particular environments – fit the characterization of autopoietic systems (Table 2). In contrast, sympoietic systems – originally developed to characterize ecosystems – carry different characteristics (also Table 2). The defining characteristic of each type leads to the different mutually reinforcing tendencies that describe the two system types. Note that the advantages and disadvantages are situational assessments.

While the two sets of characteristics were developed for descriptive and explanatory purposes, they can also be considered prescriptively. For example, in wondering about how to bridge sectoral or disciplinary gaps, the sympoietic characteristics can be viewed as design criteria for developing less boundaried systems. Further discussion about these system-heuristics can be found in other work (e.g. Dempster 1998, 2000).

Table 2 Comparison of autopoietic and sympoietic system characteristics

AUTOPOIETIC SYSTEM HEURISTIC	SYMPOIETIC SYSTEM HEURISTIC
Defining Characteristics	
self-produced boundaries	lacking boundaries
organizationally closed	organizationally ajar
external structural coupling	internal and external structural coupling
Characteristic Tendencies	
autonomous units	complex, amorphous entities
centralized control	distributed control
'packaged,' same information	distributed, different information
reproduction by copy	amorphous reproduction
evolution between systems	evolution within system
growth/development oriented	evolutionary orientation
homeostatic balance	balance by dynamic tension
steady state	potentially dramatic, surprising change
finite temporal trajectories	potentially infinite temporal trajectories
predictable	unpredictable
Advantages/disadvantages	
efficient	adaptable, flexible
constrained, codified information	open to new and different information
require certainty	ok with surprise

(from Dempster 1998)

APPLICATION: DIALOGUE IN URBAN ENVIRONMENTS

At times, linkages between theory and practice seem distant. Musings, questions and conceptual diagrams about reality, structural coupling, global-local influences and collectively-producing systems seem to hold little relation to 'on-the-ground' actions and interactions. Yet I find linkages to be present, real and compelling. My involvement in interdisciplinary and community-related projects over the past few years have presented opportunities for applying concept and theory and for simultaneously revising and expanding them. Most concretely, this involvement includes the *Urban Environmental Management Project* and the *Civics Research Group*[4] where my participation and contribution arises from understanding gained by applying the heuristics described above.

[4] www.fes.uwaterloo.ca/research/civics/uem/ and www.civics.ca.

For example, thinking about society as a sympoietic system, with distributed information and control, suggests different ways to think about 'planning' – the process that mediates between past, present and future. Rather than being the restricted purview of planners and formal processes, planning can be seen to involve multiple interactions among multiple people with multiple understandings. People throughout society – through habits and small daily decisions *as well as* through larger and more formalized processes and institutions – influence the futures that emerge. In addition to the increasing emphasis on public participation, then, a broader emphasis on the more elusive notions of civics and civil society are also (perhaps more) important (see Dempster 2001, Dempster and Nelson 2001).

Thinking about society as a system that emerges from counteracting global-local influences provides one way to conceptualize the concerns. For example, it raises the question: What influence(s) play the global role of gravity? I think about my culture's orientation toward 'progress' and interpret consumerism as a directional drive. Much like gravity, it posits a direction: *go buy*. Interactions with the local 'landscapes' of personal preferences, sales venues and commodity availability, lead to the emergence of particular patterns and characteristics – the prevalence of SUVs and fast food; of toxic waste and sweatshops. Social pressures – such as those listed in Table 3 – act as positive feedback.

Table 3 Social Influences on individual behaviour (from Cialdini 1993)

Reciprocation	We feel "we should try to repay, in kind, what another person has provided us" (p 19).
Consistency	"Once we make a choice or take a stand, we will encounter personal and interpersonal pressures to behave consistently with that commitment (p 51).
Social proof	"We determine what is correct by finding out what other people think is correct... We view a behaviour as correct in a given situation to the degree that we see others performing it" (p 95).
Liking	"We most prefer to say yes to the requests of people we know and like" (p 136).
Authority	We tend to have a "deep seated sense of duty to authority" (p 175).
Scarcity	"Opportunities seem more valuable to us when they are less available" (p 195).

In response, it might seem simplest and most effective to jump into alignment with environmental advocates who call for 'sustainability' and an end to consumerism. Yet two cautions come to mind. First is simply that changing the direction of gravity will not change the manifestation of patterns: Too often planning has unintended consequences – occasions where undesirable conditions arise *because* of not in *spite* of the plans that are made. Second, other reading and discussion[5] raises questions of equity, power and influence. While I agree with an ethic that argues against 'go buy', I argue from a position buffered against detrimental consequences. Epistemological and political blind-spots caricatured in Figure 2 suggest the need to interact and communicate with others in order to grasp what I cannot see or understand. Further, the concern highlighted by a postmodern or Foucauldian perspective carries a depth not readily recognizable in Figure 2. I find the idea of structural coupling to be instructive.

Think about different aspects of a knowledge system – paradigms, methods, modes of communication. Structures can be thought of as particular fixed expressions of these aspects that are coupled to each other in mutually reinforcing ways (e.g. mathematical thoerems, experimentation and quantified results; also Figure 6). This makes it possible to conceptualize some of the challenges involved in cross-disciplinary and cross-sectoral work as well as the subtle and significant constitution of power-knowledge. For example, a process or institution with particular knowledge structures may welcome diverse participation, yet unless they have structures able to couple with a diversity of other and *different* knowledge structures, their 'openness' will be moot. Perhaps most obvious are the

[5] In particular, I acknowledge numerous discussions with my colleague Eric Tucs.

challenges presented by different 'languages'. Additionally, narratives are difficult to record in databases and degrees of anger, fear and elation are de-legitimized if the only way to report significance is statistically. More subtlety, think about the structures of knowledge that are fixed into and by institutions of straight, Euro-centric, men, with similar norms, expectations, ways of thinking and styles of dress, and with a shared fraternity arising from common experiences – all reinforced by social influences (Table 3). Even if broad participation is encouraged, the difficulty for any 'other' to structurally couple within such a system makes survival as unlikely as that of a carefully transplanted tree that receives inappropriate amounts of water and sunlight.

Again the value of public discourse is highlighted. Beyond participatory process, there is need for sustained opportunities for interaction among people with divergent backgrounds and perspectives; to learn of different and oppositional values and attitudes. Such discourse and interaction may provide opportunities for uncovering personal blind-spots (with recognition that any such uncovering involves the creation of others). It may also provide opportunities for developing new structures: different ways of communicating, increased comfort with people who look different, awareness of different life histories, unveiling of previously unrecognizable circumstances and positions...

Attempting to create such opportunities, a central focus of the Civics Research Group has been to bring people together by hosting "civic dialogues" on topics of current interest. The dialogues are *not* intended to arrive at consensus or 'solve problems' but rather to provide an opportunity for the expression of divergent views. The hope is that since consensus is not required people are freer to express their thoughts and positions, providing a means of learning and exploration about many issues among people with different backgrounds, interests and values. Participants are left to apply what they learn in their own way in their own circumstances as agents of change in a distributed sense.

CLOSING COMMENT

One of the challenges in manifesting more equitable and sustainable conditions is finding different ways to think about current situations, their origin and the factors involved in their perpetuation and escalation. The heuristics described here are intended to facilitate different ways of thinking; the examples to indicate their potential. I do not ask that you agree with the ideas presented, but do hope that the heuristics might facilitate thinking about your own perspectives as they have my own.

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