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Systems Intelligence in the Process of Systems Thinking

Master's Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Technology in the Degree Programme in Engineering Physics

Espoo, May 26, 2009

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ABSTRACT OF MASTER'S THESIS

Author	Jukka Luoma
Degree Programme	Engineering Physics
Major subject	Systems and Operations Research
Minor subject	Industrial Management
Title	Systems intelligence in the process of systems thinking
Title in Finnish	Systeemiäly systeemiajattelun prosessissa
Chair	Mat-2 Applied Mathematics
Supervisor	Professor Raimo P. Hämäläinen
Instructor	Professor Raimo P. Hämäläinen, Professor Esa Saarinen

Abstract

In any decision process, some kind of "big picture" is assumed. It encompasses a series of interdependent holistic judgments such as what is the overall purpose of the process, what issues are taken into account, what resources are decided upon, and what sources of information and expertise are used. The process of trying to see this big picture is an important element in the process of systems thinking. The field of systems thinking studies and provides tools for problem solving processes in which understanding the big picture and the interactions between different issues are essential.

The goal of this study is to analyze the current situation of the field of systems thinking and identify new research opportunities. Based on an analysis of the systems thinking literature, I identify links between the systems thinking literature and other fields. These include experimental studies of judgment and decision making and empirical studies of team interaction. Drawing on the different traditions, I describe systems thinking as a process and discuss novel ways in which it can be supported.

There exists a number of "systems approaches" that provide guidelines and theoretical ideas that help in the process of systems thinking. The application of systems approaches typically involves activities such as modeling, simulation, and the use of checklists. The ways in which the process of systems thinking actually takes place in organizations and other contexts have received less attention in the literature.

I review experimental studies of judgment and decision making, connecting some of the key results of the field with systems thinking. Reported studies indicate that people have a natural tendency to assess situations holistically. Intuition plays a key role in the process. This sometimes leads to biases in judgments.

I import a new concept called systems intelligence as an integrative lens on the different studies that are relevant from the point of view of supporting systems thinking. The process of systems thinking can be conceptualized as part of a higher-level system that includes the personal, social and material circumstances that enable and constrain the process as well as the "systems thinker's" perception of the situation and the use of systems approaches, if applied. I conclude that acting intelligently as part of such systems is likely to require skills that are not restricted to systems thinking abilities.

I develop ideas for future research in the field of systems thinking. Research opportunities include studying the impact of the context in the process of systems thinking. As an example, I suggest studying the role of team dynamics and emotions in the process and from the point of view of systems thinking.

Number of pages	60	Keywords	systems thinking, systems intelligence, decision making

Faculty fills

Approved		Library code	

Teknillinen korkeakoulu
Informaatio- ja luonnontieteiden tiedekunta

DIPLOMITYÖN TIIVISTELMÄ

Tekijä	Jukka Luoma
Koulutusohjelma	Teknillisen fysiikan koulutusohjelma
Pääaine	Systeemi- ja operaatiotutkimus
Sivuaine	Teollisuustalous
Työn nimi	Systeemiäly systeemiajattelun prosessissa
Title in English	Systems intelligence in the process of systems thinking
Professuurin koodi ja nimi	Mat-2 Sovellettu matematiikka
Työn valvoja	Professori Raimo P. Hämäläinen
Työn ohjaaja	Professori Raimo P. Hämäläinen, professori Esa Saarinen

Tiivistelmä

Päätöksenteon taustalla vaikuttaa aina jonkinlainen kokonaiskuva päätöksentekotilanteesta. Kokonaiskuva sisältää oletuksia siitä mitkä ovat päätöksenteon tavoitteet, mitkä ovat päätöksentekotilanteen ydinkysymykset, mistä resursseista päätetään sekä mitä informaatiota ja asiantuntemusta hyödynnetään. Prosessi jolla tätä kokonaisuutta pyritään hahmottamaan on systeemiajattelun tutkimuskohde. Systeemiajattelu tutkii ja tarjoaa myös työkaluja ongelmanratkaisuprosesseihin, missä kokonaiskuvan hahmottaminen on keskeisessä roolissa.

Tämän diplomityön tavoitteena on analysoida systeemiajattelun tutkimuksen nykytilaa sekä ehdottaa uusia tutkimusideoita. Työssä käyn läpi systeemiajattelun kirjallisuutta sekä nostan esiin ja tarkastelen systeemiajattelun ja muiden tutkimusperinteiden välisiä yhteyksiä ja yhtäläisyyksiä. Työssä kuvaan systeemiajattelun prosessia sekä tunnistan uusia tapoja tukea kokonaisuuden hahmottamista.

Systeemiajattelukirjallisuus tarjoaa useita menettelyohjeita ja työkaluja kokonaisuuden hahmottamisen prosessin tueksi. Kirjallisuudessa systeemiajattelun tueksi ehdotetaan usein matemaattisten mallien ja tietokonesimulaatioiden käyttöä. Kirjallisuudessa keskitytään pääasiassa näihin työkaluihin itse kokonaisuuden hahmottamisprosessin jäädessä taka-alalle.

Diplomityössäni tarkastelen päätöksenteon psykologian kirjallisuutta sekä tulkitsen joitain tämän tutkimusalan tuloksista systeemiajattelun tutkimuksen kannalta. Tutkimukset osoittavat että ihmisillä on luontainen taipumus hahmottaa kokonaisuuksia. Kokonaisvaltainen ajattelu on usein myös ihmisille itselleen näkymätön prosessi. Tämä vaikeuttaa omien päätösten implisiittisten taustaoletusten kriittistä tarkastelua, mikä saattaa johtaa huonoihin päätöksiin.

Tässä diplomityössä liitän systeemiälyn käsitteen systeemiajattelun käsitteistöön. Kokonaisuuden hahmottamiseen vaikuttavat yksilölliset ja sosiaaliset sekä muut ympäristötekijät. Prosessin lopputulokseen vaikuttavat myös implisiittiset taustaoletukset sekä sovellettu menettelytapa. Siten voidaan todeta, että kokonaisuuden hahmottaminen on itsessään vuorovaikutteinen kokonaisuus, systeemi. Tarkoituksenmukainen toiminta tällaisessa prosessissa vaatii tietoja ja taitoja, jotka eivät ole rajoittuneita systeemiajattelun soveltamisen taitoihin.

Diplomityö nostaa esiin tutkimusideoita systeemiajattelun alalla. Yksi tutkimusidea olisi tarkastella ympäristötekijöiden vaikutusta systeemiajattelun prosessiin. Esimerkkinä tarkastelen ryhmädynamiikan ja tunteiden vaikutusta kokonaisuuden hahmottamiseen.

Sivumäärä	60	Avainsanat	systeemiajattelu, systeemiäly, päätöksenteko

Täytetään tiedekunnassa

Hyväksytty		Kirjasto	

Preface

This work has been carried out at the Systems Analysis Laboratory at the Helsinki University of Technology. I am imdebted to Professor Raimo P. Hämäläinen, the supervisor and instructor of this thesis, for the excellent guidance and expertise that continues to push me towards making the most of my abilities. I wish to thank Professor Esa Saarinen who is also as the instructor of this work. His insightful comments as well as his encouraging and enthusiastic support have been invaluable to this project.

I want to thank my colleagues at the Systems Analysis Laboratory for a pleasant working environment. This thesis has benefited from many discussions with the members of the Systems Intelligence Research Group and the participants of the seminars on Creative Problem Solving (LOR). I also want to thank my friends and colleagues who have proof read the text.

There are no words to match my gratitude to my family for their love and support throughout my life. A man is known by the company he keeps. I feel proud and fortunate thinking about the company of friends I am part of. Finally, I wish to thank my girlfriend Selma Gaily for her love, care and companionship. I am lucky to have found her.

Espoo, May 26, 2009

Jukka Luoma

Contents

Chapter 1

Introduction

1.1 Motivation and the statement of purpose

Ackoff and Emery (1972, 4) argue that "Nature does not come to us in disciplinary form. Phenomena are not physical, chemical, biological, and so on. The disciplines are the ways we study phenomena; they emerge from points of view, not from what is viewed. Hence the disciplinary nature of science is a filing system of knowledge. Its organization is not to be confused with the organization of nature itself."

The same could be said of the problems we solve and the decisions we make. Problems do not exist as pre-defined entities, ready to be taken separately from their environment and solved. Failure is often the product of solving problems in isolation, without considering the interconnections between the problem and other issues. On the other hand, grasping the relevant whole and the important connections within and without is the crux of effective management of problems. Concepts such as the matrix organization, early supplier involvement, and just-in-time production represent acknowledgements of this fact. The expression "systems thinking" represents the generic process in which one tries to take the relevant interdepencies into account. To "think in terms of systems", according to Emery and Trist (1965, 21), "seems the most appropriate conceptual response so far available when phenomena under study – at any level and any domain – . . . when understanding the nature of the interdepencies constitutes the research task."

In this thesis I investigate systems thinking, as it relates to applied human endeavors such as problem solving, decision making, and planning. More specifically, I discuss the importance and nature of systems thinking as a process. By adopting a systems intelligence perspective, the thesis discusses novel ways in which the process of systems thinking can be supported.

1.2 What is systems thinking?

The term "systems thinking" has come to signify an effort to take into account the interconnected and dynamic nature of the problems people face, for example, in organizations (e.g., Ulrich 1993). The mutual interplay of events can produce consequences that are unforeseeable if the events are viewed in isolation. The pressing challenge of climate change serves as an illustrative example. The problem of climate change is tricky because the actions that reduce the risks of climate change can have unanticipated adverse side-effects. For example, climate change can be mitigated by reducing green house gas emissions. "Many governments perceive biofuels as a part solution to ... the need for GHG [green house gas] mitigation." (Ölz, Sims, and Kirchner 2007, 10) The problem with what are today known as "first-generation biofuels" is that, ultimately, "they compete with food production for land, water, and other resources." (ibid, 5) The problem of feeding people and providing vehicles with fuel are interdependent. Thus, food and fuel production can be seen as part of the same "system" which integrates the problem of hunger and the problem of transport as parts of a common system. Solving the problem of transport independent of the problem of hunger can cause the latter problem to grow worse. Systems thinking means taking this fact into account. It means looking at the elements as parts of an interrelated set, that is, as part of a wider system.

The interpretation of the meaning of an event, action or phenomenon depends on the context within which it is viewed. The use of biofuels for filling cars can be seen as an act to mitigate climate change. Yet biofuel production subsidies have lead to higher food prices, "with painful consequences to the poor." (The Economist 2008). The interpretation of the role of biofuels depends on the perspective. One could even say, as The Netherlands' Crown Prince Willem-Alexander did, that the use of biofuels is then just a "great way to support our western way of life" (Ritter 2007).

There is no single definition of "systems thinking" but there are important common elements in the different characterizations.

- "The systems approach to problems focuses on systems taken as a whole, not on their parts taken separately." (Ackoff 1971, 661)
- "According to a widely held understanding of the systems idea, systems thinking means an effort to "look at the whole" of an issue, e.g., to include the entire relevant problem environment in one's definition of a design problem." (Ulrich 1993, 583)
- "For many, the solution lies in *systems thinking* – the ability to see the world as a complex system, in which we understand that 'you can't do just one thing' and that 'everything is connected to everything else.'" (Sterman 2001, 9-10)
- "Systems thinking is holistic rather than reductionist." (Jackson 2006, 649)

- "Holism forces us to ask, with Drucker and Ackoff (1999), not only 'are we doing things right?' but also 'are we doing the right things?'" (Jackson 2006, 651)
- "A holistic approach, in mapping out the interrelationships of a situation, attempts to account for the medium to longer term goals and consequences and does not focus only on the short term." (Georgiou 2007, 11)

The terms "systems approach" and "systems thinking" are used interchangeably by many researchers. I will use the term "systems approach" to refer to a set of guidelines and theoretical ideas that help in understanding or intervening in some real-world situation (Checkland 1992). By the term "systems thinking", I refer to the mental activity itself. This activity may or may not involve the conscious application of some "systems approach". For clarity, I will use the expression "the process of systems thinking" to underscore that for me a systems approach is "words on paper" (using an expression of Checkland [2000]) but systems thinking is a form of embodied and situated action.

1.3 The importance and implicitness of systems thinking

Any decision or assessment is based on a series of holistic judgments (Churchman 1968; Ulrich 1988; Ulrich 1994b). These judgments form a kind of a "big picture" that works in the background, affecting our actions and perceptions (Midgley 2003b). Interestingly, in everyday language we rarely make explicit references to this big picture nor are we fully conscious of what constitutes it. In systems thinking literature, the process of demarcating the relevant big picture is known as making "boundary judgments" (Ulrich 1994a).

To illustrate this, consider a business executive making the following statement in the board room: "Our market share has declined alarmingly and we need to reverse the trend." This statement rests on a number of assumptions, or "boundary judgments". The process of making these assumptions can be seen as an essential part of the process of systems thinking.

First, the company's market share is calculated by dividing its sales by the size of the total available market. What is included in the "total available market" is a judgment that involves determining which products compete for the same market, and/or who are the potential customers that belong to the market segment in question. The *total* market is determined by the actual behavior of the company's competitors and customers as well as by the *perceptions* of the company regarding what business it is in.

Second, the term declining trend is relative because short term decline might be due to short term variations, and the longer term trend might still be growing. The way in which a pattern is perceived depends on the time scale adopted. For a related discussion, see Midgley and Ochoa-Arias (2001, 640-641).

Third, the extent to which the situation is alarming, and the question whether action is needed, are determined by the relationship between the situation and the "observer". The declining market share might be bad news for the company, but good news from the point of view of its competitors. Thus, whether an event is desirable, undesirable or inconsequential depends on the values and interest of the decision maker (e.g., Churchman 1970; Checkland and Winter 2006). Even in the case where a declining market share is considered bad, it is not self-evident that action is needed. Efforts to reverse the trend carry an opportunity cost. The company could use the same resources to occupy other markets or invest in the development of new products. For another discussion of opportunity costs, see Churchman (1979, 44-47).

Thus, the statement "Our market share has declined alarmingly and we need to reverse the trend," is based on assumptions such as *What business the company is in*?, and *What other opportunities does the company have*? In systems terms, these questions are "boundary questions" (e.g., Ulrich 1994a) that delineate the relevant "big picture" that guides action and perception. Similar questions can be found under other labels also, such as customer-oriented thinking (Levitt 1960) or value-focused thinking (Keeney 1992; 1996). The answers to these questions are typically implicit, implied by the way the individual or the organization makes decisions. It is possible to say that the *processes* of systems thinking are relatively *independent* of any systems thinking terminology; just like psychological phenomena are independent of psychological research[1]. Systems thinking brings the process of systems thinking into focus. The process involves making assumptions about the purposes and scope of the decision or assessment. Although the process is largely implicit and informal, the resulting assumptions often have important consequences.

1.4 Perspectives on supporting systems thinking

The case for "systems thinking" is often made by referring to an example that demonstrates how the interconnections between some variables can produce unexpected, undesirable consequences (e.g., Midgley 2000, 40-41; Sterman 2002; Senge 2006, 70). This leads to a conclusion that there is a need to look at the whole, not only the parts. In other words, there is a need to apply systems thinking. It is often assumed that using an appropriate systems approach will lead to effective systems thinking (e.g., Jackson 1999). As a result, the methodology, instead of the process itself, tends to be emphasized (Mingers and Brocklesby 1997; Ormerod 2008).

In this study, I will discuss the nature of the process of systems thinking. The study emphasizes the question of how the process can be supported and enhanced. It seems to me that the typical approach is to apply some set of explicit guidelines for systems thinking. This usually involves modeling, simulation, the

[1] Obviously, labeling a phenomenon as psychological depends on psychological research, but – to a degree – the processes that underlie the labeled phenomenon are insensitive to the labeling.

use of checklists and the like. Based on this study, it can be said that there are *other means* as well. It is natural to think that these other means are not systems approaches as such, although they affect the process of systems thinking. There are contextual elements that affect the process of systems thinking. For instance, the scope of an individual's attention is widened when he or she is in a positive emotional state (Fredrickson and Branigan 2005). Thus, affecting the emotional state of a person can support his or her process of systems thinking. Naturally, these *other means* are complementary to using different systems approaches.

This study will also discuss the links between systems thinking and systems intelligence which is a new concept introduced by Saarinen and Hämäläinen (2004). Hämäläinen and Saarinen (2006; 2007a; 2008) argue that systems intelligence takes the field of systems thinking, as it currently stands, forward. In this thesis I describe systems intelligence as a new perspective on the process of systems thinking. It can be said that the systems intelligence perspective focuses on the process as a form of embodied and situated action. In this study, I will discuss how such descriptions of the process draw attention to finding new ways of supporting or enhancing the process of systems thinking. This perspective emphasizes the *other means* that can support the process. Thus, the systems intelligence perspective can be said to complement other systems approaches.

This study is organized as follows: Chapter 2 describes the historical roots of the systems movement and different perspectives on the concept of a system. This forms the background for the discussion that follows.

Chapter 3 conceptualizes the process of systems thinking as situated action. Experimental research into decision making under dynamic complexity and behavioral decision making is reviewed. The review provides some behavioral underpinning to the process systems thinking.

Chapter 4 introduces the concept of systems intelligence. The relationship between systems intelligence and systems thinking is discussed. This implies that enablers of effective systems thinking are not restricted to matters regarding the tools and the process itself. Other means and contextual elements are relevant as well.

Chapter 5 discusses what supports effective systems thinking. As an example, the role of team dynamics in the process of systems thinking is discussed. It is argued that team dynamics affect the emotional states of the individuals involved and, thereby, potentially affect the systems thinking abilities of the team.

Chapter 6 summarizes the findings. Future research opportunities are suggested.

Chapter 2

The systems movement

2.1 Historical roots

The foundational ideas of systems thinking can be traced back to Aristotle and Plato (Ackoff 1981; Jackson 2003). For instance, Aristotle, in *Poetics*, argues that the parts of the plot should form a unified whole. Quoting Butcher's (2009) translation, "the plot, being an imitation of an action, must imitate one action and that a whole, the structural union of the parts being such that, if any one of them is displaced or removed, the whole will be disjointed and disturbed. For a thing whose presence or absence makes no visible difference, is not an organic part of the whole." The parts support the whole and, thus the whole cannot be understood by just examining the parts separately. Other philosophical ideas, according to Jackson (2003), include those that stem from the work of Kant. Kant believed that it is "helpful for humans to think in terms of wholes emerging from and sustained by the self-organization of their parts." (Jackson 2003, 5)

The mid-20th century is viewed by many as a time of advancement of holism in science (see, e.g., Checkland 1984a; Checkland 1999; Jackson 2000; Jackson 2003; Midgley 2003a; Mingers 2006). Organismic biologists, for example, argued that an organism could not be fully understood by studying its parts (Checkland 1999). Ludwig von Bertalanffy (1956/2003), a biologist, introduced "general system theory", a theory of systems applicable across disciplinary boundaries. "There are", according to von Bertalanffy (2003, 37), "structural similarities between biological systems... and human societies". General system theory could provide a "theory of organization" (ibid., 28). To study the organization of a thing, or phenomenon, is to study it as a whole. Kenneth Boulding (1956), an economist, built upon the ideas of general system theory and argued that complex phenomena will not always be predictable by studying them as if they were simple. According to Boulding, science had developed to study phenomena of low complexity. In the following quotation Boulding refers to quantitative management science and operations research methods:

> "...we must never quite forget that ... in dealing with human

> personalities and organizations we are dealing with systems in the empirical world far beyond our ability to formulate. We should not be wholly surprised, therefore, if our simpler systems, for all their importance and validity, occasionally let us down.“ (Boulding 1956, 203)

Norbert Wiener (1948, 14) introduced cybernetics as an attempt to “cover the entire field of control and communication in machines and living organisms.” (ibid., 14) For example, Wiener (1961) discusses the problem that it is difficult to find a physiological basis for many psychopathologies. The same physical structure of the brain operates differently, given different stimulus. “There is”, argues Wiener (1961, 147), “... nothing surprising in considering the functional mental disorders as fundamentally diseases of the memory, of the circulating information kept by the brain in the active state, and of the long-time permeability of synapses.” Mental disorder is not produced by the human body alone. It is co-produced by the human body and its environment.

An early academic who has contributed to the outgrowth of the systems movement is Alexander Bogdanov (1910-1913, trans. 1996). His “tektology”, or what Klir (2001, 51) calls “general organizational science”, is a Russian precursor to von Bertalanffy's general system theory. Herbert A. Simon (1962) discusses the hierarchical organization of systems. Hierarchical systems are often what Simon calls “nearly decomposable”. A consequence of this view is that – although everything is connected to everything else directly or indirectly – “most things are only weakly connected with most other things; for a tolerable description of reality only a tiny fraction of all possible interactions needs to be taken into account” (Simon 1962, 478)

In summary, theories that build around the concept of a system accumulated in the mid-20th century. This, according to Checkland (1999), was a response to the inability of reductionist sciences to cope with complexity. Holism itself was nothing new, but the institutional manifestation of it as the “systems movement” was. To quote Checkland (1984a, 45), “In all ages there have been systems thinkers, of course, thinking in terms of the emergent properties of wholes, but the *conscious* development of systems ideas and the language to express them stems only from the late 1940s. The *systems movement* is only 35-years-old.” It is to be noted that the systems movement is not the only scholarly community that has consciously build upon the notion of holism. The concepts of holism and emergence has been discussed and applied elsewhere relatively independent of what Checkland calls the systems movement, for instance in physics (Healey 2008), psychology and philosophy (Corning 2002). In any event, the systems movement can be said to have three branches (Jackson 2000), see Figure 2.1.

The first branch, “theoretical development of systems thinking” includes cybernetics and general system theory discussed above. It also includes control theory which is a mathematical approach to the study of control and feedback systems. Theoretical development of systems thinking involves the study of systems “in their own right” (Jackson 2000, 92). The other two branches involve the application of the principles developed in the first branch. Applications can,

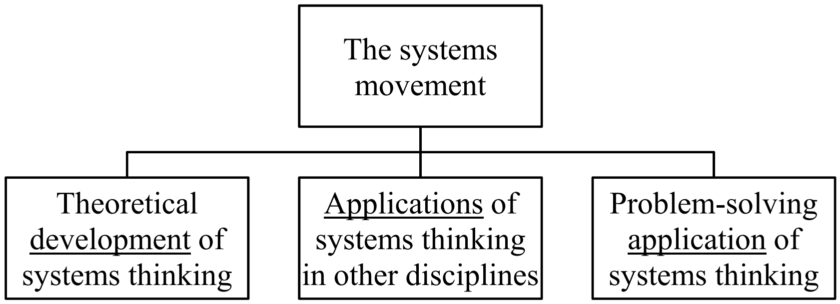

Figure 2.1: The systems movement, modified from Checkland (1999) and Jackson (2000)

of course, generate ideas that can inform further theoretical development. The middle branch is the application of the principles of systems thinking into an academic discipline. One example is Jervis' (1997) application of the systems idea to social sciences. The third, problem-solving branch refers to the application of systems concepts in areas such as problem-solving, decision making, and planning. "Problem-solving application of systems thinking" means a conscious effort to approach problems as *interconnected wholes*, that is, *systems*. Jackson (2000, 93) calls it "applied systems thinking". Jackson (ibid.) argues that it is the area in which systems thinking "has had its greatest success and has its most distinctive contribution to make".

2.2 Perspectives on the concept of a system

The concept of a system can be understood in different ways in different contexts. Next, I will review four perspectives on the concept of a system. This will illustrate the diversity of meanings that the concept of a system enjoys.

2.2.1 Boulding's hierarchy of complexity

Boulding's (1956) paper *General Systems Theory - The Skeleton of Science* introduces a hierarchical map of theoretical discourses, or what he calls a "system of systems" (ibid., 198). Boulding's hierarchy consists of nine levels of real-world complexity. Lower level systems are simple. Higher level systems are complex. The disciplines are organized according to the complexity of the unit of analysis. Such organization of systems and the disciplines that study those systems reveals gaps in theoretical construction. If a system is complex and it is studied using methods designed to study simple systems, one should not be surprised if the simple methods occasionally fail. The hierarchy is presented in a tabular form in Table 2.1.

Table 2.1: Boulding's hierarchy of complexity according to Mingers (1997, 306)

Level #	Description	Characteristic	Example	Discipline
1	structures and frameworks	static, spatial pattern	bridge, mountaion, crystal, atom	descriptive elements of all the disciplines
2	clockworks	predetermined motion	clocks, machines, solar system	physics, astronomy, engineering
3	control mechanisms	closed-loop control	thermostat, homeosta-sis	cybernetics
4	open systems	structurally self-maintaining	flames, cells	theory of metabolism
5	genetic-societal systems	society of cells, functional parts	plants	botany
6	animals	nervous system, self-awareness	birds and beasts	zoology
7	humans	self-consciousness, knowledge, language	human beings	biology, psychology
8	socio-cultural systems	roles, communications, values	families, boy scouts, clubs	history, sociology, anthropology
9	transcendental systems	unescapable unknowables	God?	philosophy, religion

Boulding uses economics as an example. Economic behavior is human behavior (Level 7) amidst social structures (Level 8). Yet, its "theoretical and mathematical base is drawn largely from the level of simple equilibrium theory and dynamic mechan isms. It has hardly begun to use concepts such as information which are appropriate at [Level 3] ... and makes no use of higher level systems." (Boulding 1956, 207) Since that time, economics as a field has been bridging this gap. Developments and trends include the application of psychology and neurosciences to the study of economic behavior (Kahneman 2003; Lichtenstein and Slovic 2006; Glimcher et al. 2008).

Each level in Boulding's hierarchy incorporates all of those below it. A society consists of human beings who consist of cells, and so on. However, the properties of a system, say, a nation, cannot be reduced to the properties of the parts, the members of the nation. The whole is greater than the sum of its parts. In systems terms, the system has "emergent properties". Emergence, in fact, is a central concept to systems thinking. There has been a considerable amount of discussion around the concept.

Boulding's paper expresses the belief that real-world systems have properties that cannot be reduced to the properties of the parts. The result is that the world presents itself as being hierarchically organized. As Wilby (1994) argues, Boulding sees that this hierarchical organization of the real-world is not simply a cognitive impression although he does not grant any ontological status to his own description of the hierarchy.

Boulding's framework highlights the fact that we have poor understanding of highly complex phenomena. We do not fully understand how the human being operates, and we cannot even begin to think about artificially reproducing them. However, because "in a sense, each level incorporates all those below it, much valuable information and insights can be obtained by applying low-level systems to high-level subject matters" (Boulding 1956, 207). Moreover, although we cannot understand the human being as an objective entity we can act and cooperate with human beings as subjective creatures. In Bouldings (1956, 207) words, we have an "inside track" to knowing *how* to act without knowing much *about* the system that performs the action, because we *are* that system.

2.2.2 Ackoff's system of systems concepts

Ackoff (1979) states in the introduction of his paper *Towards a System of Systems Concepts* that

> "Despite the importance of systems concepts and the attention that they have received and are receiving, we do not yet have a unified or integrated set (i.e., a system) of such concepts. Different terms are used to refer to the same thing and the same term is used to refer to different things." (Ackoff 1979, 661)

Ackoff's (1979) paper gives an organized description of systems concepts in order to reduce the confusion and help students of systems thinking to digest the insights of the field more efficiently. He starts with listing some general properties of systems and, then, moves to different types of systems. According to Ackoff (1971, 662-663), a "*system* is a set of interrelated elements... Each of a system's elements are connected to every other element, directly or indirectly... system's environment consists of all variables which can affect its state."

Ackoff identifies a state-maintaining, goal-seeking, multi-goal-seeking, purposive and a purposeful system. The controller of a heating system is a *state-maintaining* system because it attempts to maintain the room temperature at a desired level. It can only react in one way by switching the heating on or off. The desired temperature is determined from outside the system. A *goal-seeking* system can carry out a sequence of behaviors in order to produce a particular outcome. An automatic pilot is an example of a goal-seeking system. It chooses from different sequences of behavior in order to reach a desired destination or trajectory. A *multi-goal-seeking* system can have several goals; the one to be pursued will be determined by the initial state. A *purposive* system is a multi-goal-seeking system, but the different goals have a common property. For example, the operating system of a computer runs different programs. Running a program is a goal which is chosen by its operator, the user.

Finally, *purposeful* systems can choose their goals and, thus, display will. Human beings are examples of such systems. Ackoff (1971) uses this definition to construct a definition of organizations. An organization is a purposeful system that contains at least two purposeful systems which have a common purpose. This description incorporates both *what* the organization is made up of as well as *why* it exists, what is its raison d'être. He uses the definition to explain why organizations cannot be described as organisms. The parts of an organism – e.g. the lungs, heart and limbs of a human being – are not purposeful. A hand can pick up different objects but the hand does not choose the objects it picks up.

One important concept of Ackoff's "system of systems concepts" is that of variety. A system is variety *increasing* if the relationships of the parts allow the whole to produce more complex behavior than the parts in isolation.

> "For example, consider two state-maintaining systems, A and B. Say A reacts to a decrease in room temperature by closing any open windows. If a short time after A has reacted the room temperature is still below a specified level, B reacts to this by turning on the furnace. Then the system consisting of A and B is goal-seeking." (Ackoff 1971, 667)

Individually, A and B can react in one way only. Jointly, they can produce a more complex sequence of behaviors. Conversely, a system is variety *decreasing* if the behavior of the total system is less complex than that of the parts.

> "A ... familiar example of a variety-reducing system can be found in the groups of purposeful people (e.g., committees) which are incapable of reaching an agreement and hence of taking any collective action." (Ackoff 1971, 668)

Ackoff argues that all systems are either variety-increasing or variety-decreasing. There is a link between Boulding's hierarchy and Ackoff's system of systems concepts. Clearly, a human being (Level 7) is capable of more complex behavior than its constituent parts, organs (Level 4). Also, human beings can pursue jointly (Level 8) goals that they could not pursue individually.

2.2.3 Checkland's hard vs. soft systems

In his paper *O.R. and the Systems Movement: Mappings and Conflicts*, Checkland (1983) distinguishes between "hard systems thinking" and "soft systems thinking". This distinction is widely used and it has both its supporters as well as its non-supporters (Fuenmayor 1991; Jackson 2006; Mingers 2006; Midgley 2000; Midgley 2003a; Wierzbicki 2007). Checkland argues that the concepts of systems thinking are *only* a particular way of describing the world, not a proposition of what the world *is* like, whereas Boulding (1956), for example, proposes that the hierarchical organization of systems is an aspect of the real world. A basis for Checkland's (1983) argument is a distinction between three types of systems (Checkland 1981):

1. "Situations or phenomena characterized by interconnections which are part of the *regularities of the universe*. Examples would be frogs, foxgloves, ecological systems, systems of chemical reactions."
2. "Situations characterized by interconnections which derive from the *logic of situations*. Examples would be arrangements to manufacture or assemble products, or situations dominated by a decision about to be taken to achieve a known objective."
3. "Situations in which interconnections are cultural, situations dominated by *the meaning attributed to their perceptions by autonomous observers*. Most real-world problem situations are of this type, both on the small scale (e.g. how should we behave towards ageing parents?) and on the large (e.g. should the nuclear deterrent be abandoned?)."

This classification of different types of systems serves the purpose of illustrating that there is something different about human systems. Using Checkland's (1984b, 16) example:

> "if you ask people to answer the question 'What is a prison?', many different answers will emerge. It is to be described in terms of a punishment system, a rehabilitation system, a system for revenge, a system to protect society, a system which constitutes a 'university of crime'? Many such answers might emerge, and it would be unhelpful to try to decide which one was 'correct'."

In Checkland's (1984b) example, different descriptions of the same human activity emerge because each description emphasizes particular aspects of that human activity, according to the worldview, or *Weltanschauung*, adopted. The consequence of Checkland's view is that "*systemicity is transferred from the world to the process of inquiry into the world*" (Checkland 1983, 672).

In "hard" systems thinking, the reality outside the observer is believed to be consisting of interacting systems. The goal of a "hard" systems thinker is to identify the systems and their interconnections. Problems may arise, for example, due to unexpected consequences of the interplay among the elements of the system. Even so, the systems thinker is much like a scientist or an engineer who is trying to identify the correct system or manipulate the system in a desired way.

In "soft" systems thinking, the world is taken to be problematic: we cannot know what it is really like. Nevertheless, systems concepts can be used as a means to structure a kind of sense-making process. Surfacing different perspectives on a problem situation can produce helpful learning. People can compare their beliefs about the system in order to learn about the problem situation and find ways for taking mutually agreeable action. "Soft" systems thinking *can be as rigorous* as "hard" systems thinking. The difference is that "soft" approaches focus on subjective beliefs and values instead of objective reality (Checkland 2000).

2.2.4 Jackson's and Keys' system of system methodologies

Checkland (1985) sees that there are special cases where "hard" systems thinking can be applied whereas "soft" systems thinking is applicable notably more often. Jackson and Keys (1984) argue in their paper *Towards a System of Systems Methodologies* that the relevance of a "hard" or a "soft" approach depends on the nature of the problem situation *as well as* on the decision makers who are concerned with the problem situation. The paper makes an analytical distinction between the system that embeds the problem and the decision maker.

Jackson and Keys (1984) distinguish between simple and complex systems. Simple systems have few elements and the relationships between the elements are known. Complex systems are characterized by a high degree of interconnectivity and dynamically complex behavior. Intuitively speaking, problems that relate to simple systems are relatively easy to solve whereas problems that relate to complex systems are difficult to solve. Jackson and Keys (1984) state explicitly that the complexity of the system is observer-dependent. System complexity depends on the problem to be solved.

> "The labour market, for example, can be treated as a simple supply-demand system and is often so treated in the models of the national economy... In this case the labour market is being treated as highly aggregate manner because the problem being considered refer to the macro-economic issues... Alternatively, the labour market may be taken to comprise many individuals, each acting as parts of a highly complex system. This approach is useful if the problem being addressed concerns the individual." (Jackson and Keys 1984, 475)

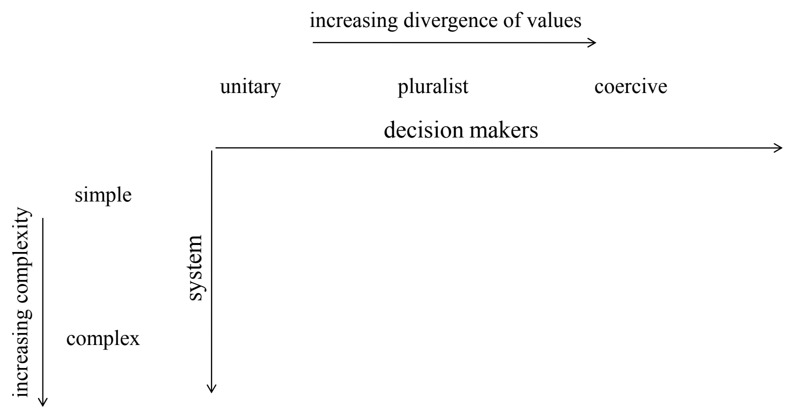

Figure 2.2: The system of systems methodologies, modified from Jackson (2006)

The problem to be solved, in turn, depends on the views of the decision makers. In the "system of systems methodologies", the set of decision makers are said to be *unitary* if the decision makers agree on the goals. If the decision makers' objectives are different, the set of decision makers is called *pluralist* by Jackson and Keys. The latter is the case where the different meanings attributed to the problem situation are the issue. Moreover, the reason why the set of decision makers are perceived to be unitary may be because differing opinions have been silenced. Those with power might use their position to force a consensus which has arguably been the case with many totalitarian governments. Such set of decision makers is called *coercive*.

Jackson's and Keys' analysis can be condensed into a matrix with six cells, each cell corresponding to a combination of the degree of system complexity and the nature of the decision makers. This is presented in Figure 2.2.

The matrix in Figure 2.2 serves as a tool for classifying different problem solving methodologies and systems approaches. For example, system dynamics focuses on the dynamics that the set of relationships between multiple elements produce (Sterman 2001). Thus, it is useful in situations where the set of decision makers is unitary but understanding the dynamic behavior of the system constitutes a challenge. Checkland's soft systems methodology (Checkland and Scholes 1990), on the other hand, is suitable for situations where understanding and learning about different worldviews of the decision makers is the key. It involves producing simple models of human activity systems. It could thus be considered to be placed in the pluralist-simple cell of the matrix.

Of course, an approach might not fit comfortably into a single cell: For instance, a system dynamics model can be taken as a representation of subjective beliefs, not only as a model of the objective world (Lane and Oliva 1998; Paucar-Caceres and Rodriguez-Ulloa 2006). Moreover, an approach can be used in "non-standard ways" (Mingers 2003) so that the approach *de facto* occupies several cells in the matrix (see, Ormerod 2007; Jackson 2007). Classifying methods involves subjective judgments that depend on the context (Mingers 2003).

2.3 Summary and discussion

The underlying ideas of systems thinking are not new. However, the systematic effort to develop a systems language under labels such as general system theory, cybernetics and systems thinking has not emerged until the mid-20th century (Checkland 1984a).

Since that time, the meaning of the concept of a "system" has been the topic of many academic debates. One of the ideas that have emerged from those debates is that the description of a system can tell as much about the observer's worldview, or *Weltanschauung*, as it does about the reality. Checkland's (e.g., 1984a) position is that the description of a system is not a representation of reality. The use of a systems language is only a means to structure a learning process. The paper by Jackson and Keys (1984) highlights the fact that in practical problems, sometimes the key challenge is to understand the interconnections between different issues and the long-term consequences of one's actions; in other cases, the primary challenge may be that of finding out how to accommodate different interests and worldviews so that joint action can be taken. Moreover, the interests that are to be served may change the nature of the problem that needs to be solved. Thus, the complexity of a system depends on the decision maker's interests.

Chapter 3

The process of systems thinking

3.1 Systems thinking as situated action

The concept of the system has different meanings to different people in different situations. Nevertheless, different schools of systems thinking share the goal of avoiding what Churchman (1979) calls "environmental fallacy", that is, "the tendency ... to define and solve problems on their own basis rather than to include the problem environment." (Ulrich 1988, 419). An apt expression is from Ulrich (1993, 583), for whom "systems thinking means an effort to 'look at the whole' of an issue, e.g., to include the entire relevant problem environment in one's definition of a design problem." Thus viewed, systems thinking is not seen as a static framework, but as an active process. The concepts and ideas of systems thinking are applied in the process of systems thinking. In Figure 3.1, the agent, a person or a group, is interested in understanding and intervening in the "perceived real world" because some aspect of it is perceived as problematic. The agent recognizes an opportunity, problem or a crisis (Mintzberg, Raisinghani, and Théorêt 1976). In response, the agent makes sense of the situation, or acts in order to improve the situation. The agent uses systems thinking as a tool in that process.

The description of the process of systems thinking can be enriched further, as shown in Figure 3.2. First, systems thinking takes place in an environment that enables and constrains the process. It is possible to say that this environment has a personal, a social and material dimension (see, e.g., Mingers and Brocklesby 1997). Second, systems thinking can be seen as a form of "situated action" which is a concept that has been discussed at length elsewhere (Brown, Collins, and Duguid 1989; Suchman 2006). The perspective of situated action means that we take action as primary. The particular systems approaches that guide the process are secondary. Thus, the term situated action is used here in the sense of Suchman (2006, 70):

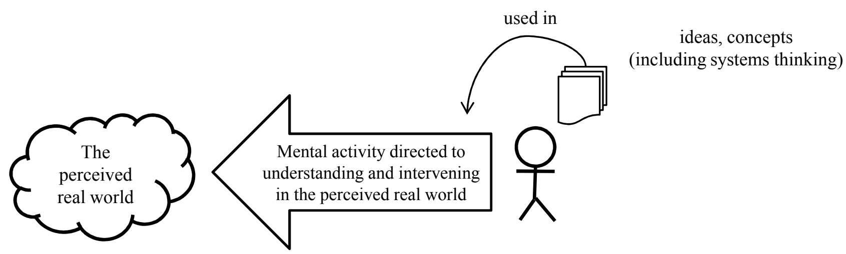

Figure 3.1: Systems thinking as a process, adopted from Checkland and Scholes (1990)

> "That term underscores the view that every course of action depends in essential ways on its material and social circumstances. Rather than attempt to abstract away from its circumstances and represent it as a rational plan, the approach is to study how people use their circumstances to achieve intelligent action. ... More generally, rather than subsume the details of action under the study of plans, plans are subsumed by the larger problem of situated action."

If systems thinking means looking at the whole of an issue, or "attending to the big picture" (using an expression of Gasper and Clore, 2002), we can certainly observe a process of systems thinking that takes place without the aid of any particular systems approach. Grasping the relevant whole and interconnections, or seeing the whole from relevant perspectives, may or may not require the use of a systems approach. The conscious use of some systems approach is neither a necessary nor a sufficient condition to effective systems thinking, although guidelines for systems thinking can be useful (see, Checkland 1984a; Checkland 2000, S37).

One should note that the notion of systems thinking as situated action is related to Checkland's (2000) concept of "Mode 2" use of soft systems methodology. By "Mode 2" he means the process where soft systems methodology is used as an internalized model, rather than as a set of external guidelines. I think it is important to emphasize that the principles of systems thinking can be manifested in situated action without an explicit effort to apply systems thinking. This may be just a matter of taste but, to me, "Mode 2" gives the impression that some systems approaches need to be learned and internalized *before* the principles can be put into action. I am also interested in the processes of systems thinking that manifest themselves without the conscious use of any systems approach.

The perspective on systems thinking as situated action emphasizes that systems thinking does not only mean using some explicit set of guidelines for systems thinking. Systems approaches, like soft systems methodology (Checkland and Scholes 1990) or system dynamics (Sterman 2001), can be useful tools, but

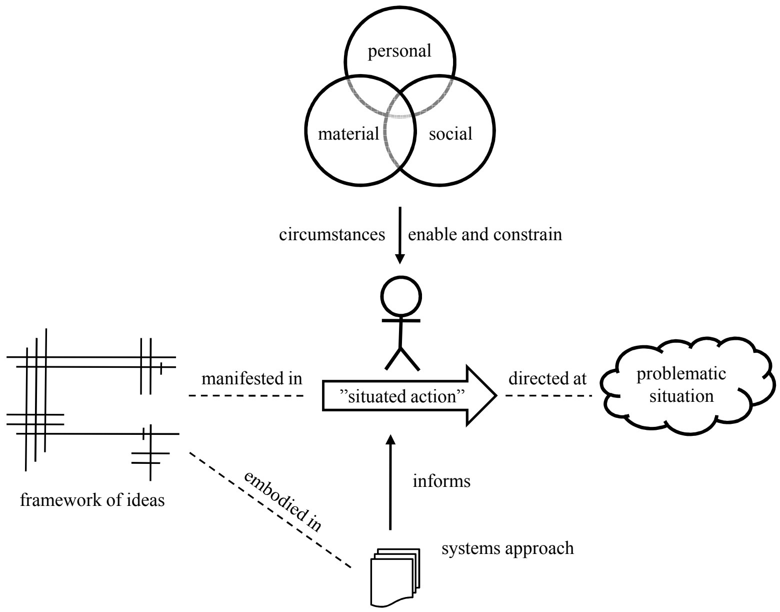

Figure 3.2: The process of systems thinking as situated action, based on Checkland and Scholes (1990) and Checkland and Holwell (1998).

using them is not always a necessary step in the process of systems thinking. Interestingly, different systems approaches are often compared to one another but almost never to ad hoc or to non-academic approaches. In practice, using a non-academic method can have the same consequences as using a method developed in the academia (see, Ormerod 2008). Also the role of the agent often receives little attention, as compared to the role of the approach (see, Mingers and Brocklesby 1997; Ormerod 2008). In contrast to this, the perspective on the process of systems thinking as situated action places the process and the actor in focus. Systems intelligence (Saarinen and Hämäläinen 2004) is a conceptual framework that embodies the idea of situated action within a systems perspective. This makes it a natural "amendment" to systems thinking (see, Hämäläinen and Saarinen 2007, 300). Systems intelligence as a perspective on the process of systems thinking is spelled out in more detail later in the section 4.3.

3.2 On our ability to systems think

3.2.1 Difficulties in understanding dynamics

Even simple systems with just *few* parts and *well-known* interactions can produce unintuitive dynamics (Lorenz 1963; Forrester 1971; Sterman 2000a). Elements such as delays, feedback and stocks create dynamics that make it difficult to grasp the dynamics of a system. This also makes it hard to take action that would lead to desirable system behavior (Sterman 1989; Cronin, Gonzalez, and Sterman 2009; Sterman and Sweeney 2002; Sterman and Sweeney 2007). Moxnes (2004, 139) labels these difficulties as "misperceptions of dynamics".

The well-known "Beer Distribution Game" is an interactive role-playing simulation of a demand-supply chain (Sterman 1989). The supply chain consists of four players. Each player represents a sector in the chain: a retailer, a wholesaler, a distributor, or a factory. The retailer supplies the (customer) end-demand with beer from its inventory. The retailer can order more beer from the wholesaler. These orders represent the demand of the wholesaler's inventory. The wholesaler, in turn, can place orders which represent the demand of the distributor's inventory. Finally, the factory produces the commodity and delivers the beer to the distributor through the factory's own inventory. Each sector has a stock, a demand for the product, and the possibility to order more beer (the factory *produces* the beer). The beer stock has a holding cost. Backlog is also costly. The goal of the game is to minimize the costs of the supply-chain as a whole. In an ideal situation, each sector would have as small an inventory as possible while consistently avoiding stockout. However, problems arise because there is a time lag between placing an order and receiving the order. Moreover, deliveries take time to arrive at the destination. As a result, a simple step change in the customer demand results in large fluctuations in the stocks and create backlogs across the supply chain. (Sterman 1989; see also Senge 2006; Wu and Katok 2006)

The beer game system has only a few, clearly identifiable parts. Nevertheless it is dynamically complex. Optimal choices from the point of view of one sector are suboptimal from the point of view of the supply chain as a whole. Orders that are placed today affect the optimal orders in the future. Orders and deliveries which are on their way to and from the supplier accumulate. Order and delivery delays create the system dynamics. Experiments show that people fail to produce even near-optimal results (e.g., Sterman 1989; Wu and Katok 2006). The problems can be partly attributed to the fact that each sector makes decisions based on local information. In control theoretic terms, the system is neither observable nor controllable by any one player (see, e.g., Kirk 2004). However, the key issue, according to Sterman (1989), is that people fail to take properly into account the effects of feedback, delays and accumulation in the system. The important observation is that people attribute the problems to exogenous events. In post-play debriefings, people typically attribute their poor performance to volatile end-demand – in reality, the end-demand has been a simple step function (see, Sterman 1989, 328-335). In Senge's words, people "do not understand how they are creating the instability in the first place." (Senge 2006, 40) Failures due to endogenous factors, that is, decision making and system structure, are attributed to exogenous events. Sterman (1989) calls this "open-loop" thinking, see Figure 3.3.

Difficulties in understanding dynamics have been shown to arise in different types of situations. Cronin, Gonzalez, and Sterman (2009) ran experiments

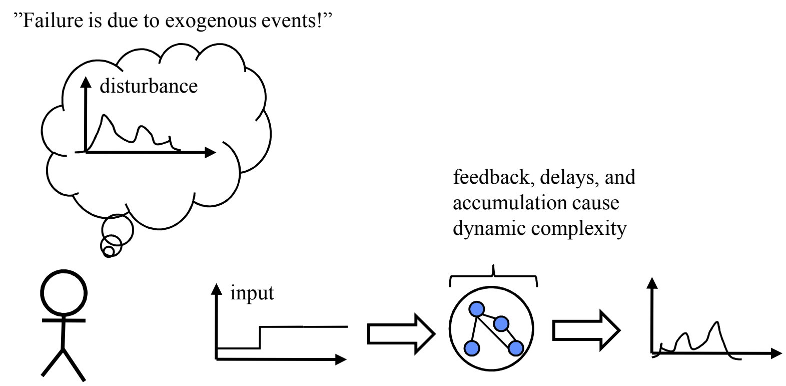

Figure 3.3: Open-loop thinking

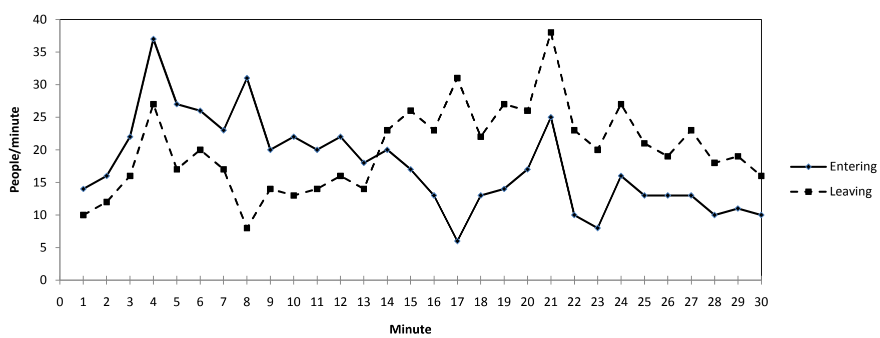

Figure 3.4: People entering and leaving the department store, modified from Cronin, Gonzalez, and Sterman (2009, 118)

where participants were given a graph that shows the number of customers going in and out of a department store, see Figure 3.4. The participants were asked to estimate when there are the most people in the store. In one of the experiments, only about 44 % gave the correct answer (Cronin, Gonzalez, and Sterman 2009, 119). One can see from Figure 3.4 that up to the 13th minute, more people enter than leave. After that more people leave. Thus, after the 13th minute the number of customers starts to decrease and the highest number of customers is at the 13th minute. Simplifying the graph, displaying the information in a different way (using a table, a bar graph or text), or changing the context (water flowing in and out of a bath tub) did little to improve people's performance (Cronin, Gonzalez, and Sterman 2009).

Misperceptions of accumulation have been demonstrated in the context of climate change also (Sterman and Sweeney 2002; Sterman and Sweeney 2007;

Sterman 2008). In these experiments CO2 emissions represents the inflow and removal of CO2 from the atmosphere represents the outflow. The amount of CO2 in the atmosphere grows if inflow exceeds outflow. The amount of CO2 falls if outflow exceeds inflow. People fail to take this basic fact into account. Respondents believe that the amount of CO2 in the atmosphere can be stabilized by stabilizing the atmospheric emissions, even if they exceed the rate of removal! This belief leads to decisions that are biased in the direction of a "wait and see" approach, as opposed to prompt CO2 abatement (Sterman and Sweeney 2007). Moxnes and Saysel (2004) modified the experiment of Sterman and Sweeney (2002). Moxnes and Saysel found that changing the context to a more concrete one (filling a leaking air balloon) improves the results. Providing respondents with information feedback also improves the performance. Thus, context and the availability of information feedback can be used to manipulate the correctness of respondents' answers.

Moxnes (2000) discusses the "tragedy of the commons" (Hardin 1968). When self-regarding agents utilize a common resource and there is no coordination of the agents' behavior, overutilization will occur. When the commons problem is eliminated, overutilization can still occur if the agents have a strong preference for short-term benefits. Moxnes conducted resource management experiments where the participants utilized a private resource. They were explicitly asked to manage the resource profitably but sustainably. The better they achieved this goal, the higher the compensation. Yet, overutilization occurred. The reason, according to Moxnes, was the participants' inability to intuitively understand the system's behavior. Despite the fact that some of the respondents were subject matter experts, misunderstanding of the system dynamics resulted. Although the difficulties in understanding dynamics can be overcome by means of modeling and simulation, the fact that the problem exists in a particular situation is not cognitively accessible. As a result, there is a risk that the "misperception of dynamics" problem is not acknowledged soon enough.

Studies of decision making under dynamic complexity indicate that people use inappropriate heuristics to solve problems related to dynamic systems (Moxnes 2000; Sterman and Sweeney 2007; Cronin, Gonzalez, and Sterman 2009). The fact that people use simple heuristics is not a problem in itself. Indeed, they are often very effective (see, e.g., Gigerenzer 2007). The problem is that simple heuristics can produce problems if they are applied in the wrong situation. One can avoid such problems by means of carefully thinking about the problem and, perhaps, by modeling. The problem is that this possibility does not present itself to us. Often, we receive no subjective indication that our intuitive judgment is incorrect (Kahneman 2003). Sometimes we fail to see the system's internal structure as the cause of failures, because we mistake internal complexity for external turbulence (Sterman 1989, Senge 2006). Unfortunately, the fact that an important systemic effect might have, and, indeed, should have been considered, often presents itself in hindsight.

3.2.2 Behavioral economics and decision making

Behavioral economics and decision making aims to describe and understand how people make decisions in real life situations (Kahneman and Tversky 2000; Kahneman 2003). It is surprising to notice that this field is very seldom cited in the systems thinking literature. I used the ISI Web of Science to study this[1]. Out of a sample (N = 3,659) of papers that cite a classic paper on behavioral decision making (Tversky and Kahneman 1974), no more than 10 are from the following journals dedicated to systems thinking: *Systemic Practice and Action Research* ($n \leq 2$) (formerly *Systems Research*, n = 4), *Systems Research and Behavioral Science* ($n \leq 2$), and *System Dynamics Review* (n = 4). Articles published in the *European Journal of Operational Research* cite the paper 22 times, *Management Science* 33 times, and the *Academy of Management Review* 19 times.

Notwithstanding this fact, studies of behavioral decision making shed light on the process of systems thinking. Next, I will discuss a few such examples. My primary source is Kahneman's extensive metastudy (Kahneman 2003) which reviews three decades of research on what he calls the "psychology of bounded rationality." The purpose of this is to indicate the relevance of these fields to one another, a point which I think has not been addressed sufficiently.

Kahneman (2003) distinguishes between intuition (System 1) and reasoning (System 2). He adopts the terms "System 1" and "System 2" from Stanovich and West (2001). Figure 3.5 summarizes some key features of System 1 and System 2. System 1 is fast, and operates several tasks in parallel. System 2 is slow. Tasks tend to disrupt each other. System 1 generates impressions. System 2 is responsible for monitoring mental processes and behavior. It monitors intuitions generated by System 1. The monitoring capacity is limited. As a result, the control is "quite lax and allows many intuitive judgments to be expressed" (ibid., 699). Intuitive thinking can lead to poor results and accurate conclusions. (Kahneman 2003) Ideally, System 2 would serve as a gatekeeper to intuition which lead to undesirable results, while not preventing the operation of System 1 where it is effective. A more thorough review of the so-called dual-processing theories is found in Evans (2008).

A central aspect of intuitive thoughts is that "under appropriate circumstances, they come to mind spontaneously and effortlessly" (Kahneman 2003, 699). The term "accessibility" refers to "the ease (or effort), with which particular mental contents come to mind". Whether particular mental content comes to mind depends on the cognitive mechanisms that produce it. Some thoughts are more easily evoked than others. Some thoughts need the intervention of System 2, others emerge spontaneously. In Figure 3.6, lines have been drawn by freehand. In the context of Figure 3.6, an interpretation of the lines is readily accessible for the reader.

[1] The sample was generated by using the Cited References Search. From the search results [accessed 9.2.2009], I selected the record that referred to the article in question and had the highest number of citing articles, see http://apps.isiknowledge.com.

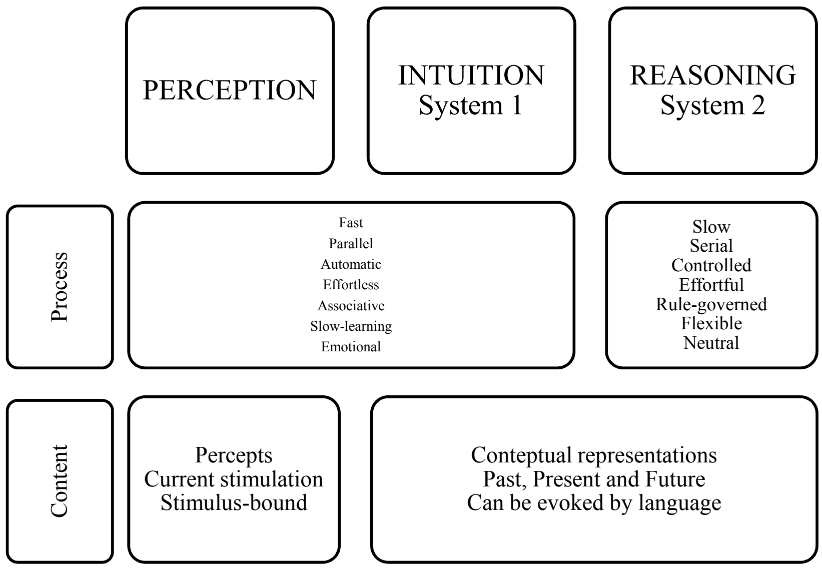

Figure 3.5: Process and content in two cognitive systems (Kahneman 2003)

Figure 3.6: Context and accessibility (A), redrawn from Kahneman (2003)

Typically, the drawing in Figure 3.6 is interpreted as a sequence of letters. What is more, any possible ambiguity related to the interpretation is suppressed. The person who sees a sequence of letters receives "no subjective indication that it could be seen differently" (Kahneman 2003, 701). However, when the "middle letter" is presented in a different context, a new interpretation becomes accessible, see Figure 3.7.

The accessibility of a thought depends on the related cognitive mechanisms as well as the context. This has interesting implications for systems thinking.

Figure 3.7: Context and accessibility (B), redrawn from Kahneman (2003)

People seem to have a natural tendency to “see” patterns as wholes, and phenomena as parts of a larger whole. Different interpretations of the same pattern in Figure 3.6 and Figure 3.7, arise because they make sense as part of the wider system. Seeing the big picture, then, seems to be the norm, rather than the exception. Moreover, the big picture is not merely a conceptual representation. Rather, it seems to be readily accessible as a largely non-verbal gestalt of some kind. This argument concurs with the ideas of Christopher Alexander and Louis Sander. Alexander, who is to many an architect[2], argues that “holistic mode of perception is achievable, natural, and that once it is attained it is stable and reliable.” (Alexander 2003, 14; see also, Alexander 2002-2005). Sander, to whom Nahum (2000, 30) attributes bringing “systems perspective to both psychoanalysis and the study of development”, discusses the related concept of *gestalt perception*:

> “Gestalt perception is able to take into account a greater number of individual details and more relationships between these than in any rational calculation. Here is an innate capacity for experiencing the complexity of the organism as a whole that disappears as we think about it. One can propose such a capacity as basic to the way our brains function, to our developmental origins, and to the process of recognition” (Sander 1991; quoted in Nahum 2000, 34)

The same facts can lead to different conclusions. Indeed, people do reach different conclusions depending on the context and perspective adopted. A central tenet of systems thinking is that systems look different from different perspectives. However, to paraphrase Churchman (1968), seeing the world through the eyes of the other seems dauntingly difficult. Other worldviews are easily suppressed. It is not only a matter of good vs. bad intentions. A situation simply appears unambiguous and the individual receives no indication that this might not be the case.

[2]http://www.natureoforder.com/aboutca.htm [accessed 6.3.2009]

Another important concept is that of framing (Tversky and Kahneman 1981). Different ways of presenting the logical content of alternatives results in different choices. Decisions depend not only on the decision maker's preferences, but also on the frame. The concept of a 'decision frame' embodies both the (perceived) logical structure of the decision as well as the information, beliefs and values that are emphasized (Tversky and Kahneman 1981). Systematic "preference reversals" can be observed in decision making under uncertainty: decision frame is associated with whether the typical decision maker chooses a risky or a low-risk option (ibid.). Preference reversals also occur in decision making with multiple attributes. Whether people prefer a high cost highway safety program or a low cost program that saves less lives, depends on framing. Thus, valuation of human lives depends not only on the degree of altruism. Different ways of asking (logically) the same question leads to different answers, and to different tradeoffs (Tversky, Sattath, and Slovic 1988). Research by Bond, Carlson, and Keeney (2008) indicates that people have difficulties identifying objectives relevant to a decision situation at hand. According to the study, people discover (by themselves) only about a half of the objectives that they consider to be important with regard to an important personal decision.

As far as I am aware, links between research on framing and systems thinking have not been extensively addressed (but see, e.g., Cronin, Gonzalez, and Sterman 2009). Framing effects can be seen as an aspect of the process of systems thinking. In the light of different frames, the same situation makes different actions meaningful. In systems terms, people adjust to what they believe is the system (paraphrasing Hämäläinen and Saarinen 2006). In the process of systems thinking, that is, in the process of trying to "figure out the bigger picture, freedom looms large" (Saarinen 2008) because the situations look different from different perspectives. The process of systems thinking is akin to the process of constructing a decision frame that guides the decision process.

Research on framing demonstrates the sensitivity of our thinking to the process. For instance, providing written reasons for a decision affects the decision itself (Miller and Fagley 1991; Sieck and Yates 1997). Group processes also affect the decision (Kühberger 1998; Milch et al. 2009). In the process of trying to see the big picture, the initial frame and the procedure we follow condition the big picture we finally reach. At worst, a quest for holism can lead to a false sense of security that turns out to be contingent on some initial frame that camouflages an important issue or perspective.

Finally, there is the concept of "reference dependence" in choice. The prospect theory of Kahneman and Tversky (1979) postulates that people value decision outcomes relative to the reference level. As a result, choice depends not only on its outcomes but on the reference level to which it is compared. Moreover, losses weigh more than gains, relative to the reference level. People are loss-averse. For example, consider the following problem:

> "Two persons get their monthly report from a broker:
>
> A is told that her wealth went from 4M to 3M.

> B is told that her wealth went from 1M to 1.1M." (Kahneman 2003, 706)

"Who is happier today?" Kahneman (2003, 706) asks. Although A is better off in financial terms, B is probably happier. The problem demonstrates that people evaluate consequences relative to a reference level. Although it is possible to argue that in many cases, we *should* look at the consequences of different options independent of some reference point, people often do not follow such a model of rational action. Moreover, "Because reference point is usually the status quo, the properties of alternative options are evaluated as advantages and disadvantages relative to the current situation, and the disadvantages of the alternatives loom larger than the advantages." (Kahneman 2003, 705)

As a special case of prospect theory, consider the so-called "endowment effect" (Thaler 1980): "The maximum amount that people pay to acquire a good is commonly much less than the minimal amount they demand to part from it once they own it." (Kahneman 2003, 705) The endowment effect explains how money back guarantees work. The money back guarantee signals the consumer that he or she can only lose the transaction costs involved in buying the good and returning it, making it more likely that the consumer will take the good home for a trial period. Due to endowment effect, once the consumer buys the item, it is immediately worth more to the consumer. As a result, the consumer does not want to return it. The seemingly generous offer of a riskless trial in fact increases the probability of nailing a sale (see, Thaler 1980, 275).

The concept of reference dependence is also relevant from the point of view of systems thinking. To me, it supports the idea that people naturally consider phenomena as part of a whole. A key idea of systems thinking is that for an action to be meaningful, its consequences need to make sense as part of a wider system (see, Checkland 2000, S28). People are able to make such judgments intuitively, on the spot. Literature on systems thinking does not emphasize this point very much. Yet it seems highly significant from the point of view of systems thinking that people are able take the wider system into consideration without explicitly thinking about it. The fact that people's judgments depend on some reference point indicates that people have an *ability to grasp interconnections instantaneously*, in this case between an outcome variable and the reference point. Thus, intuition has a central role in thinking systemically, although systems thinking literature mainly focuses on ways in which intuitive reasoning leads to ignoring systemic effects (e.g., Sterman 2000a).

3.2.3 Discussion

My interpretation of the aforementioned behavioral studies of decision making in relation to systems thinking is this: People have a natural tendency to perceive patterns as part of a whole. At the same time, people are inclined to be naïve realists with relation to the whole they "see" (see, e.g., the discussion on Figure 3.6 and Figure 3.7). People are *both* naturally inclined to "systems think" *and* critically constricted and biased in their ability to "systems think".

- People have poor intuitive understanding of system dynamics when the system involves feedback, delays and accumulation, especially when information feedback is scarce. People use simple heuristics that are often very effective. Sometimes they are applied to the wrong problem which leads to undesirable system behavior. (Sterman and Sweeney 2007; Cronin, Gonzalez, and Sterman 2009)

- The difficulties in understanding dynamics can be overcome by means of careful deliberation and through the use of tools such as modeling. The problem is that open-loop thinking results in identifying problems as being caused by exogenous events, rather than by the decision maker's misunderstanding of the system dynamics. As a result, the needed learning process might not get started, or is aimed at issues with less leverage. (Sterman 1989; Sterman 2000a; Moxnes 2000)

- People make decisions based on cues that they are able to detect from the environment. Common sense tells us that people make decisions in order to manipulate the system in a desirable way. The reverse is also true. The system manifests itself in people's decisions. Events and objects are interpreted as part of the wider system. Different interpretations make different actions meaningful. It is not only the means that change when the context changes. Ends are susceptible to the process, context and frame as well. (see, Kahneman 2003)

- People's cognitive mechanisms do little to warn them that their impression of a situation might be flawed or biased. The subjective view is prone to manipulation. Humans are not objective observers of the world. One could rather say that people are subjective actors. It seems that people receive no subjective indication that they might be ignoring an important issue or a relevant perspective (see, Kahneman 2003). In fact, people are poor in acknowledging the biases of their own thinking although they are able to identify errors that other people make (Pronin 2007).

Some authors conclude that people's intuitive systems thinking skills are poor (notably, Forrester 1971; Sterman 2000a; Sterman 2002). These authors often suggest that the cure is to teach people systems thinking and modeling, so that they would become more aware of their own processes of systems thinking. Yet, intuition, in addition to reasoning, seems to have a pivotal role in systems thinking. A key aspect of intuition is the basis of making rapid judgment about situations. Indeed, a metastudy by Dane and Pratt (2007) concludes that a key function of intuition is to produce holistic, on-the-spot impressions about situations. It seems to me that the "biases" that research into behavioral studies of decision making has revealed are often *due to* people's intuitive systems thinking skills. People seem to have a natural tendency to see patterns as part of a whole. It is just that a seemingly significant interconnection might become 'irrelevant' on second thought. The problem is that second thoughts are, by definition, inaccessible to the intuition that takes place on the spot.

The fact that people's intuitive holistic judgments may turn out to be wrong does not presuppose that people should think more about systems in explicit terms, I maintain. People have a limited pool of resources for applying reason (in the sense of System 2 [Kahneman 2003]). Thus, thinking about systems in explicit terms involves an opportunity cost because the same cognitive resource could be used for something else (see, Bargh and Chartrand 1999). Even so, the explicit use of systems thinking can have two advantages. First, systems approaches can provide guidelines that support people's intuitive systems thinking abilities. Guidelines for systems thinking can provide the needed structure so that thinking is more likely to produce desirable results. Moreover, model-building and simulation can provide a means to examine and challenge intuitions. Second, accumulation and internalization of the systems concepts can build one's ability to intuitively apply systems thinking in a more effective way. Next, I will review some systems approaches with special focus on how they guide and support the process of systems thinking.

3.3 Dealing with bounded rationality, complexity and diversity

Typical arguments for a systems approach include that they help the user overcome some limitations of bounded rationality, deal with real-world complexity, or take into account the diversity of values and beliefs that different people have. Implicitly they all assume that using a systems approach improves the process of systems thinking in some way. Different approaches embody different notions of systems thinking. The perspectives reflect the diversity of thinking of the systems thinking scholars.

3.3.1 Learning through system modeling and simulation

Sterman (2000a; 2001; 2002) argues that our difficulties in producing desirable effects in a system are due to not being able to understand dynamic complexity. Learning from experience helps but is often costly or not possible. As a result, information feedback is needed prior to making the actual decisions. Modeling and simulation offers hope. It can be said that modeling and simulation provide augmentation to our bounded rationality. By means of model building we make our mental models explicit which offers a platform for re-framing. Simulation offers a means of overcoming some of the problems that relate to the difficulties of inferring system dynamics of system structure. An extensive discussion of the *system dynamics* methodology is found in Sterman (2000b).

3.3.2 Ackoff's interactive planning

Ackoff (1974; 1981; 1999) describes reactive and preactive [sic] approaches to planning. Reactive planning is a bottom-up approach. Changes in the environment are dealt with by means of local adjustments. The problem with this approach is that what seems locally desirable might produce undesirable consequences in the wider system. Preactive planning is a top-down approach. It consists of preparing for the foreseeable future. It tries to identify plausible scenarios for which plans can be made. However, the problem still remains that the future for which the plans have been made might never materialize. The result is that the plans are useless and that the current situation has not been prepared for. Interactive planning tries to create a desirable *present moment*. It moves from making sense of the current situation, to designing the desirable result to be achieved, to choosing the means with which to close the gap between the current situation and the situation where one would like to be (see, e.g., Ackoff 1981, 52-65). The process is governed by principles of participation, continuity, and holism (see, e.g., Ackoff 1981, 65-74).

Ackoff's "interactive planning" embodies the idea that due to complexity, a reactive mindset is inadequate. Myopic reacting to environmental turbulence can lead to undesirable consequences. However, the preactive *predict-and-prepare* paradigm is also problematic because – due to bounded rationality and complexity – it is likely that we fail to see the future we should prepare for. Interactive planning deals with bounded rationality and complexity by actively reaching towards a desirable present moment. Continuous engagement in such activity overcomes some difficulties that relate to the reactive and preactive approach. As to diversity, interactive planning reverses the order of designing means and ends. Thinking about ends first makes new means accessible (in Kahneman's [2003] terminology). Thus, it makes win-win suggestions more likely.

3.3.3 Soft systems methodology

Checkland's (Checkland and Scholes 1990; Checkland 1999; 2000) soft systems methodology (SSM) embraces a subjectivist approach to systems thinking. It assumes that people's beliefs and values are paramount in bringing about 'improvement'. It discards naïve notions of objectivity and instead aims to offer a rigorous approach to manage subjectivity. Soft systems methodology embeds a host of concepts that can be used to organize thinking or debate about a problem situation or a decision process. One concept is that of a "problem owner" (Checkland and Winter 2006). Problem owner refers to those people that might be concerned with a problem solution. Considering possible problem owners highlights deficiencies of, or alternatives to a proposition that might not be accessible from a single perspective. For instance, a person might consider herself as a client of her own actions. She might also envision "herself in a five years time" as a problem owner: someone who does not care too much about the benefits to the client (the person herself now – after all, it is in the past) but does care about the consequences for herself (in a five years time). Thinking in this way makes new perspectives and action options more accessible.

3.3.4 Critical systems heuristics

Ulrich (1987; 1993; 1994a; 1994b; 2000; 2001) following Churchman (Churchman 1968; 1979; Ulrich 1988; 1994b), warns against blind belief in improvement. Ulrich (1994a, 256) asks: "How can the planner ever know that experts' skills, experience, or tools are not a source of deception rather than a source of guarantee that improvement will result?" Ulrich's critical system heuristics provides a 12-point checklist for making one's assessment of a situation transparent. These questions include: *Who is the decision maker?*, *Who is the client?*, etc. When these questions are answered in an ought-mode – for instance: *Who should be the client?* – they reveal the normative contents of system designs. Epistemology-wise, individuals' rationality is bounded. Furthermore, improvement involves an ethical dimension. When the sources of facts and pool of values that justify a proposal are made explicit, it is possible to identify shortcomings more effectively. (For a brief introduction, see, Ulrich 2005.)

Ulrich adopts a dialogical perspective on rationality (Ulrich 1996). An action proposal should incorporate all the information that could strengthen or undermine its position with regard to other proposals, including inaction. However, no man is equipped with the knowledge or skills to sweep in all the relevant information. To remedy this, boundaries of analysis can be drawn and re-drawn by means of boundary critique in a dialogical process. For Ulrich, the concept of "witnesses" represents those affected but not involved in the planning process (Ulrich 1994a, 252). This group of people includes those who cannot speak for themselves, such as the natural environment or the future generations. Ulrich argues that ordinary citizens can criticize policies, not on the basis of questioning the facts justifying the proposal, but on the basis of the policies' normative content. Through examining and re-examining our own assumptions, through making our assumptions explicit and open to critique we can hope to reach more rounded analyses and defendable propositions.

3.3.5 Discussion

Different approaches have different emphases. Ackoff's ideas are embodied in the guidelines of "interactive planning". The process of systems thinking is triggered and cultivated by following the guidelines of the procedure. Sterman calls for modeling and simulation. Stock-and-flow diagrams can be used to surface and learn about one's own mental models. Simulation can challenge intuition. Ulrich's critical systems heuristics and Checkland's soft systems methodology provide rich conceptual frameworks for describing the perceived real world in systems terms so as to enable meaningful debate among the involved stakeholders.

The above approaches seem to have a unifying aspect. They approach the problem of improving the process of systems thinking by focusing on the process itself. The approaches provide guidelines, new concepts and analytical tools with which the process of systems thinking is intended to produce better results. This is all fine, but to my knowledge, the following question that points beyond these advances, is seldom asked: What are the supporting elements of effective systems thinking, *given people's current systems thinking skills, concepts and tools*?

It is often taken for granted that the *conscious* application of systems thinking is a *precondition* for effective systems thinking. Systems approaches can provide overall structure for thinking and discussions. Using a systems approach in the process of system thinking in a group can be helpful because it provides a common terminology and set of overall guidelines that the group shares. This way of supporting the systems thinking affects the process *directly*. Systems approaches are consciously applied as part of the process. However, it is possible to find other means that affect the process of systems thinking *indirectly*. For instance, emotions are likely to play a significant role in the process of systems thinking (see, Seo and Barrett 2007). I will return to this issue in Chapter 4 and Chapter 5.

Chapter 4

Systems intelligence

4.1 Definition and conceptual basis

Systems intelligence (SI), introduced by Saarinen and Hämäläinen in 2004, refers to

> "intelligent behavior in the context of complex systems involving interaction and feedback. A subject acting with Systems Intelligence engages successfully and productively with the holistic feedback mechanisms of her environment. She perceives herself as part of a whole, the influence of the whole upon herself as well as her own influence upon the whole. By observing her own interdependence, she is able to act intelligently." (Saarinen and Hämäläinen 2004, 9)

Conceptually, systems intelligence builds on the work on systems thinking. In particular, Saarinen and Hämäläinen (2004) acknowledge the works of Peter Senge (Senge 2006; Senge, Kleiner, and Roberts 1994; Senge, Kleiner, and Roberts 1999) and C. West Churchman (Churchman 1968; Churchman 1979). Systems concepts like emergence, communication, control and feedback as well as system boundaries address the interlayered and interconnected nature of human action as it is experienced (see, Hämäläinen and Saarinen 2007). The ability of humans to act intelligently within and with regard to what they naturally perceive as wholes, Saarinen and Hämäläinen (2004) argue, is a competence not covered by the theories of multiple intelligences (Gardner 1983).

The stated purpose of the concept of systems intelligence is to provide a bridge between what Saarinen and Hämäläinen (2004) label as "engineering thinking" and "human sensitivity". Improvement is a mediating concept between the two. Engineering thinking represents the rational approach, systems thinking being a key ingredient therein. Human sensitivity represents the first-person, experiential, emotional, preconscious and relational aspects of human action. Science has generated a conceptual cleavage between these two modes of action. "Human sensitivity" is often considered either irrelevant or counterproductive from the perspective of rational pursuit of improvement. However, recent studies indicate that the creation of desirable change often involves intuitive (Gigerenzer et al. 1999; Gigerenzer 2007), emotional (Seo and Barrett 2007), non-verbal and inter-subjective aspects (Beebe and Lachmann 2003). In practice, "engineering thinking" and "human sensitivity" form a unity as the subject orchestrates action. The concept of systems intelligence points to the moment where a human subject tries to act productively from the point of view of the whole, by whatever resources the person has available at the time.

4.2 Two cases of systems intelligence

In discussing systems intelligent leadership, Hämäläinen and Saarinen (2007b) review a number of success stories where productive action is not easily reducible to any single factor. One is the story of how the concept of microloans emerged. Muhammad Yunus was in

> "a near-by village to which he had gone in order to explore ... poverty from what he called the 'worm's eye view'. Yunus approached cautiously a woman in her poor household. . . She was preparing a bamboo stool for her survival. But she could not buy the material at the equivalent of 22 US cents. . . Thus she was trapped in a vicious cycle that forced her to sell back the stool to the trader of the bamboo at an unfairly low price. . . There were 42 women in a similar situation in the village. Yunus gave loans to each of them, amounting to the equivalent of 27 US dollars. He created a new system through an intervention of 27 USD. The total number of borrowers now is 6.91 million, 97 % of them women." (Hämäläinen and Saarinen 20078b, 29)

A traditional financing system entraps poor, illiterate micro-scale entrepreneurs. They are unable to make full use of their productivity potential. In some ways, the innovation was to discover a gap between the current productivity and its potential. The solution, microloans, makes perfect sense once the bottleneck is discovered. The question is: How does one discover the bottleneck? Based on the reconstruction of the microloan story by Hämäläinen and Saarinen (2007b), one key is a belief in the human potential.

> "Yunus emphasizes the potential of each human being. 'I firmly believe that human beings have an innate skill. . . So rather than waste our time teaching them new skills, we decided to make maximum use of their existing skills.'" (Hämäläinen and Saarinen 2008b, 29)

It seems natural to assume that the microloans initiative was conditional on Yunus' belief in human potential. This kind of belief is strongly personal, emotionally charged and based on scarce and probably biased evidence. Thus, we do serious damage to the unity of the story if we leave *either* the rational *or* personal dimension out.

Luoma, Hämäläinen, and Saarinen (2008) discuss a recent story of General Motors published in the *BusinessWeek* magazine (Welch 2008). According to the story, General Motors (GM) has had trouble adapting itself to recent transformations of the car industry. The era of extravagant, gas-guzzling cars has transformed in to a culture that appreciates economical and environmental factors. Toyota launched its first hybrid, Prius, in 1997[1]. Compared to traditional cars, hybrids give better mileage and, thus, promise to restrain the environment less (de Haan, Mueller, and Peters 2006). In the light of what seem to be the prevailing market conditions in the first years of the 21th century, Toyota acted more intelligently than GM. GM, realizing this, is trying to catch up. It is possible to rationalize Toyota's smart strategy, in hindsight, based on knowledge about the wider systems that embed Toyota and GM. It is possible to reconstruct both Toyota's success and GM's failure as processes of systems thinking. However, the rational reconstruction easily camouflages some elements in the process that affected the outcome. Reducing the explanation to, say, the companies' strategy formation pattern (Mintzberg 1978), does not guarantee that changing the pattern would lead to improvement. There is a need to look at the process more holistically.

4.3 Systems intelligence in the process of systems thinking

The concept of systems intelligence represents the perspective of the individual as part of a wider system that embeds her. She is both enabled and constrained by the systems she perceives herself to be part of. She has a first-person view of the system. She is having an impact, but the impact is uncertain and it is cognitively non-transparent. The boundary between the subject and her environment is not clear. Nevertheless, the focus is upon the mutual interplay of the agent and the system. The agent's behavior is a product of the system and the system is partly a product of the agents' behavior. Somewhere in-between there is agency, the capacity to choose and to take action.

The systems intelligence perspective combines the first-person systems view with the idea of intelligence. To quote Neisser et al. (1996, 77), the concept of intelligence represents an effort to understand how

> "Individuals differ from one another in their ability to understand complex ideas, to adapt effectively to the environment, to learn from experience, to engage in various forms of reasoning, to overcome obstacles by taking thought. Although these individual differences can be substantial, they are never entirely consistent: A given person's intellectual performance will vary on different occasions, in different domains, as judged by different criteria."

[1] http://www.toyota.com/html/hybridsynergyview/archive/pdfs/priusview3spring2003.pdf [accessed 19.5.2009]

The concept of systems intelligence reflects the ability of an individual to act as part of complex wholes which involve a social dimension. In such "systems" it is likely that a multitude of skills and capabilities, or a *system* of skills and capabilities, is needed. Intelligent action in and as part of complex wholes probably requires combining propositional knowledge, which can be taught, with implicit (see, e.g., Polanyi 1967) and relational knowledge (see, e.g., Lyons-Ruth et al. 1998) as well as other awareness and mindfulness (Langer 1989; Siegel 2007). As part of a complex social system, one needs to interrelate with others *heedfully* (Weick and Roberts 1993).

We can say that the process of systems thinking takes places as part of a larger whole and the "systems thinker" is part of this whole. Thus, in the process of systems thinking, one has to deal with the process itself, plus something more. The concept of systems intelligence draws attention to the fact that in order to make the process of systems thinking work, one needs skills and abilities that go beyond "systems thinking" skills.

The relation between systems intelligence and systems thinking can be analyzed by reconstructing Checkland's (2000, S39-S41) story of the "situation-driven" use of soft systems methodology (SSM). Checkland calls this "Mode 2 use of SSM".

> "This example of near-Mode 2 use of SSM occurred at a one-day conference on 'Mergers in the NHS [UK]'. This was a topic of interest because the Health Service has seen many mergers in recent years... In the morning the conference heard a number of talks... After lunch the participants split into small groups for discussion, this to be followed by a final plenary session to summarize the day. The organizers were anxious to avoid the usual problem in such circumstances: small-group discussions generate flip-charts containing long unstructured lists of points made... and so everyone ends up unable to see any patterns... To do better than this the people chairing the small groups were asked to structure the discussion by following an explicit agenda... Alas for the well-laid plans... uncontrollable discussion broke out and anecdotes were exchanged! The problem now to be solved during the afternoon tea-break was to prepare for the final plenary presentation and discussion in the absence of the hoped-for coherent responses from the groups." (Checkland 2000, S39-S41)

The solution, which Checkland attributes to SSM, was to produce a simple word-and-arrow model of NHS. This model provided the needed structure for the final discussions. Perhaps a strong understanding of systems concepts underlaid Checkland's ability to rapidly organize a coherent description of NHS in a collectively understandable way. Checkland argues that this was an example of using SSM as an "internalized model".

> "...users of SSM will internalize its guidelines and use them in an increasingly sophisticated way." (Checkland 2000, S40)

From the systems intelligence perspective, Checkland faced a situation where he needed to act in the presence of time pressures. Soft systems methodology was helpful because its internalization had armed Checkland with the necessary competence to deal with the situation at hand. The ideas of systems thinking were manifested in situated action. However, a number of other forces were also at play. According to Checkland's report, the decision to produce a word-and-arrow diagram was not preceded by any explicit analysis of the situation. Checkland (or anyone else) did not produce a systems model of the situation *for himself* (or for themselves) before taking action. Most likely, Checkland's decision was based on extensive experiential knowledge of similar situations and, perhaps, on his ability to read the situation as a social system. However, Checkland's actions seem to be only partly attributable to SSM – notwithstanding the importance of that element.

Any further analysis of the forces at play in the situation is difficult by leaning on just Checkland's story. It is important to notice that improvement is the product of an interplay of social, emotional, preconscious and other tacit forces. Attributing the success to the "internalization" of SSM camouflages these. The perspective of systems intelligence conceptualizes the process of systems thinking in a way that takes a broader view of the circumstances that constrain and enable systems thinking and, more fundamentally, improvement.

Many writings on systems thinking are concerned with the way in which the process of systems thinking itself is organized and the tools and models that are used in the process. The systems intelligence perspective emphasizes the process of systems thinking as part of a wider system. Systems intelligence reflects the ability to acquire and apply knowledge and skills in order to cultivate the process of systems thinking. This might involve, for instance, the need to take into account the interrelations between one's actions and the actions of others (Weick and Roberts 1993), and how these actions collectively contribute to the process of systems thinking. The idea is to use whatever resources, skills and abilities are disposable and whatever means are available so as to make success more likely. Witness a related quote by Hämäläinen and Saarinen (2008, 821)

> "the human systems skills, systems sensitivities and pragmatic systems capabilities go far beyond what Systems Thinking seems to have acknowledged. Human systems comprehension and action capabilities are an abundantly rich endowment."

In this quote, attention is drawn to the fact that in order to make something work, often the wider system should be considered as the source of success and failure. When the process of systems thinking is at focus, leverage can be found in processes that are not systems thinking as such.

Human beings have a natural tendency to perceive wholes (Nahum 2000; Sander 2002; Hämäläinen and Saarinen 2008; see also Chapter 3). Thus, the mastery of systems approaches can help, but it is not a precondition for effective systems thinking. Hämäläinen and Saarinen (2008) take the position that the starting point should be humans' natural "systems comprehension and action

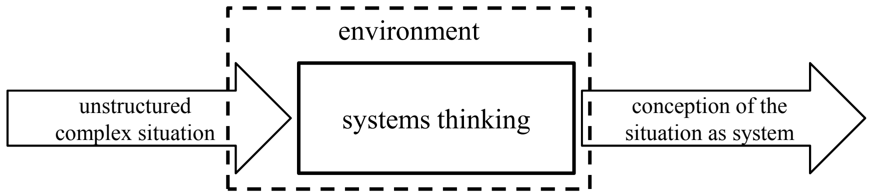

Figure 4.1: The process of systems thinking as a system

capabilities". The key, then, is to find ways to enhance and make more use of the competence that is already there. It is possible to say that the use of systems approaches is one way to cultivate the process of systems thinking. The systems intelligence perspective draws attention to the fact that this is but one means amongst a larger system of means united by the goal of cultivating the process of systems thinking.

To me, taking the systems intelligence perspective on the process of systems thinking means taking a systems perspective on the process. In this systems view, the actors are assumed to have a pivotal role. For instance, we can describe systems thinking as a form of sensemaking (see, Weick, Sutcliffe, and Obstfeld 2005), where real-world complexity is being transformed into an understanding of the situation as a system. Thus, the process of systems thinking can be described as a system that embeds the activities that transform complexity into an understanding of some system. The environment of the system consists of the elements that help or hinder the process of systems thinking. Furthermore, the understanding of the system forms the basis for future actions. See Figure 4.1.

The environment of the process of systems thinking consists of elements such as the history, knowledge and skills of the actors that participate in the process. Moreover, it includes elements such as emotional states, unspoken thoughts, non-verbal communication. These elements are not systems thinking as such but they can, nevertheless, have a significant effect on the outcome of the process.

It is possible to say that the process of systems thinking is part of a bigger "system". We can say that it is a social system because the process of systems thinking is always carried out by one or more human actors who interact with other individuals. Thus, the process of systems thinking depends also on the capabilities of the individuals to *act* as parts of a social system. These capabilities include the ability of the individuals to interrelate heedfully (Weick and Roberts 1993), that is, in a way that takes into account that the interdepencies between the actions of those who participate in the process. In order to interrelate heedfully, one is likely to need capabilities that are not restricted to systems thinking abilities. These include very basic social abilities such as "reading other people's ... intentions; resonating with another's emotion; experiencing what someone else is experiencing; and capturing an observed action so that one can imitate it" (Stern 2004, 78).

As an example, envision a group of managers who are using, say, system dynamics (Sterman 2001) in addressing a problem in their organization. When they create a model of the problem situation they are engaged in a process of systems thinking. At the same time, the managers form a social system and are acting as parts of it. The managers are taking into account that what they say has an effect on what others will say. They are reading each other's intentions and resonating with each other's emotions. It is likely that the group is not very conscious about these things. Nevertheless, these social processes clearly have an impact on the model building process. From this viewpoint, it is clear that the process of systems thinking depends on a set of factors and skills. These factors and skills are not limited to those that are directly related to systems thinking.

4.4 What does systems intelligence encompass?

The basic idea of systems intelligence is that human beings are *endowed with an ability* to approach their environment holistically. People are able to take into account the interconnections of their environment *as part of their actions*. This ability to grasp the relevant interconnections is partly non-verbal and automatic, not just a product of conceptual representation of systems. (Hämäläinen and Saarinen 2006; Hämäläinen and Saarinen 2008) This view was supported in Chapter 3. In contrast, the system dynamics strand of systems thinking seems to state that human beings *do not* have a natural ability to understand and grasp the system that embeds them (Forrester 1971; Sterman 2002). However, in spite of an apparent tension, I suggest that these positions can be viewed as two sides of the same coin.

Hämäläinen and Saarinen (2008a) review some research that they interpret as examples of a wide and robust system of "systems comprehension and action capabilities". These capabilities include intention-detection abilities (Stern 2004) and other forms of social intelligence (Goleman 2007). Suppose that this system of systems comprehension and action capabilities, called systems intelligence, does give the individual the ability to act intelligently as part and with respect to systems. It is obvious that what is desirable, indeed, *intelligent* from the point of view of one system, is undesirable from the point of view of another system.

By definition, the limits of systems intelligence are defined by the boundaries of the system with respect to which the 'intelligence' is measured. For example, what seems like a smart thing to do now may turn out to be a bad move in the long-term. As a result, procedurally systems intelligent action can lead to undesirable, even catastrophic consequences. On the other hand, outstanding results may be due to action that is considered non-rational because it does not conform to a model of rational action (see, Dunwoody 2009). It is to be noted that previous writings on systems intelligence apply both criteria of rationality. It is possible to conceptualize systems intelligence as a collection of skills, or, rather a system of skills (see, e.g., Hämäläinen and Saarinen 2008a). It is also possible to take success as a starting point and work one's way backwards to discover what led to the desirable outcome, that is, was 'intelligent' about that process (see, e.g., Hämäläinen and Saarinen 2006).

In any event, the systemically *undesirable* consequences are often the focus of systems thinking (see, Sterman 2002, Senge 2006). However, as Hämäläinen and Saarinen (2006; 2008a) emphasize and everyday experience verifies, failure is not always the end result. The fact that the systems intelligence emphasizes competencies that facilitate success enables the conceptualization of improvement as a result of doing things to some extent right, as opposed to conceptualizing success as the avoidance of errors (Hämäläinen and Saarinen 2006).

Chapter 5

Improving the process of systems thinking

5.1 Introduction

In the previous chapter, I have described the concept of systems intelligence as a perspective that conceptualizes the process of systems thinking and the systems thinker as part of a larger whole. That larger whole affects the extent to which the systems thinking skills and other resources are productively utilized. This perspective opens the prospect of investigating processes that are not systems thinking *as such* from the *point of view of systems thinking*. With the *supporting structures* of systems thinking I mean those elements that help the individual or group increase their systems thinking abilities and make better use of them. Interestingly, and perhaps surprisingly, there is no one agreed-upon definition of systems thinking abilities. The following appear often in the literature:

- ability to understand how phenomena are created by the system structure *as a whole*
- ability to see an issue from multiple perspectives
- ability to reframe an issue
- ability to see a *bigger* picture

5.2 The case of team dynamics

As an example, consider how team dynamics might be relevant from the point of view of systems thinking abilities. Losada and his colleagues argue that there is a relationship between the conversational dynamics of teams and team performance (Losada and Heaphy 2004). One of the findings is that positivity in team interaction is associated with team performance. Based on Fredrickson's

(2001) broaden-and-build theory, I see that positive emotions can support effective systems thinking. By drawing on the broaden-and-build theory, Losada's findings can be explained so that team dynamics affect the team's systems thinking abilities. A related discussion of Losada's findings is found in Fredrickson (2009).

Losada (1999) and his colleagues observed 60 management teams develop their annual strategic plans. The speech acts of each team member were coded using the following rules:

> "A speech act was coded as inquiry if it involved a question aimed at exploring and examining a position and as advocacy if it involved arguing in favour of the speaker's viewpoint. A speech act was coded as self if it referred to the person speaking or to the group present at the lab or to the company the person speaking belonged, and it was coded as other if the reference was to a person or group outside the lab and not part of the company to which the person speaking belonged. A speech act was coded as positive if the person speaking showed support, encouragement or appreciation, and it was coded as negative if the person speaking showed disapproval, sarcasm or cynicism" (Losada 1999, 181)

This process generated a database of speech acts, each with a code (e.g. positive, inquiry, or self) and a timestamp. A number of measures for the characteristics of the meeting can be computed. The ratio of positivity to negativity can be computed by counting the number of positive speech acts and dividing it by the number of negative speech acts. Losada aggregated the observations in one-minute intervals. The so called "degree of connectivity" can be "measured by the number of cross-correlations [between the participants' time series] significant at the 0.001 level or better" (Losada 1999, 180). Connectivity is a measure of how much the team members influence one another. For instance, the higher the connectivity in the team, the more likely it is that a positive (or negative) speech act will be followed by a positive (or negative) speech act (Luoma, Hämäläinen, and Saarinen 2008a).

Losada classified the teams as high, medium and low performance teams using three indicators:

> "profitability (measured by the P&Ls), customer satisfaction, and assessments of the team by their superiors, peers, and subordinates. . . A team was assigned to the high performance category if it achieved high ratings in all three measures. A team was assigned to the low performance category if it had low ratings in all three measures. Medium performance teams did not achieve ratings that were consistently high or consistently low." (Losada 1999, 180)

It turned out that high degrees of connectivity and high ratios of positivity to negativity are associated with high performance. Furthermore, high performance is associated with ratios of inquiry to advocacy and self to other that

Table 5.1: Aggregate measures of Losada's observations (Losada and Heaphy 2004)

	$\frac{Positivity}{Negativity}$	$\frac{Inquiry}{Advocacy}$	$\frac{Other}{Self}$	$Connectivity$
High performance teams (N=15)	5.614	1.143	0.935	32
Medium peformance teams (N=26)	1.855	0.667	0.633	22
Low performance teams (N=19)	0.363	0.052	0.034	18

are close to one. Low performance is associated with more negativity than positivity, more advocacy than inquiry, more self-orientation that other-orientation. Table 5.1 summarizes the results.

Table 5.1 shows that, for instance, positivity and connectivity are associated with high performance. Losada and Heahpy (2004) do not discuss further if there is a causal connection one way or another, that is, if positivity is due to success or success due to positivity (Fredrickson, 2009).

5.3 How positivity in team interaction supports systems thinking and improves performance

Losada (1999, 182) observed that high performance teams "had time series that showed high amplitudes over the whole duration of the meeting in all three dimensions." At times, there were more negative speech acts but, on average, there were five times more positive speech acts. What prevented the teams from becoming trapped with temporary negativity? What sustained positivity? According to Losada's observations (see Table 5.1), the degree of connectivity was high in high performance teams. A high degree of connectivity predicts that a high number of positive speech acts at Time 1 is followed by a high number of positive speech acts at Time 2. One explanatory mechanism could be that positivity expressed by one team member predicts positive emotions in another team member. For instance, if one team member shows encouragement, it is likely that this generates positive emotions in others. Furthermore, positive emotions are probably a predictor of positive speech acts. The result is a reciprocal relationship between positive speech acts expressed in the team meeting and positive emotions experienced by the team members, see Figure 5.1.

According to Fredrickson's broaden-and-build theory, positive emotions "broaden people's momentary thought-action repertoires and build their enduring personal resources, ranging from physical and intellectual resources to social and psychological resources." (Fredrickson 2001, 219; Fredrickson 2004).

An experiment by Fredrickson and Branigan (2005) shows that in positive emotional states, people's *scope of attention* increases. In a visual processing task, people are more likely to focus on the patterns of the whole, rather than on the characteristics of the parts. The reverse is true for negative emotions.

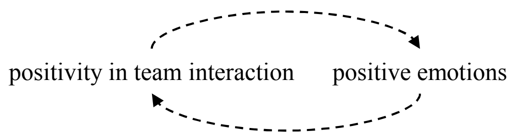

Figure 5.1: A hypothetical relationship between positive interaction and positive emotions

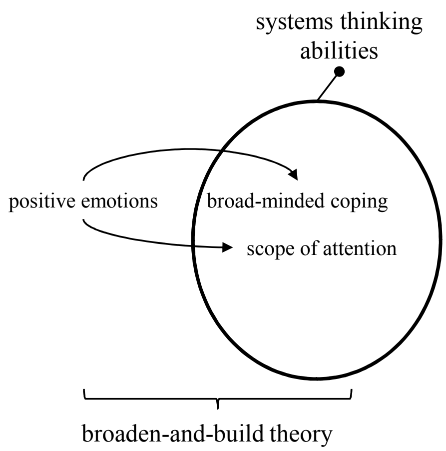

Figure 5.2: Positive emotions broadens and builds one's systems thinking abilities.

Thus, people in positive emotional states "Literally take a 'big-picture' view." (Cohn and Fredrickson 2006, 39)

Another study, by Fredrickson and Joiner (2002), suggests that positive emotions predicts broad-minded coping when facing an important problem. This means, for instance, thinking about different ways of dealing with the problem (Fredrickson and Joiner 2002, 173). Positive emotions increase the "use of adaptive reframing and perspective-taking" (Cohn and Fredrickson 2006, 39). Moreover, broad-minded coping predicts positive emotions (Fredrickson and Joiner 2002).

In summary, people in positive emotional states take a bigger picture view (scope of attention) and are more likely to reframe and take different perspectives on a problem (broad-minded coping). These are all relevant systems thinking abilities. Thus, one can claim that positive emotions increase one's systems thinking abilities, see Figure 5.2.

It is a common belief that systems thinking abilities contribute to team performance. There is, indeed, evidence that suggests that this might be the case. Nutt's (1998) study demonstrates that "exploring the rationale for action"

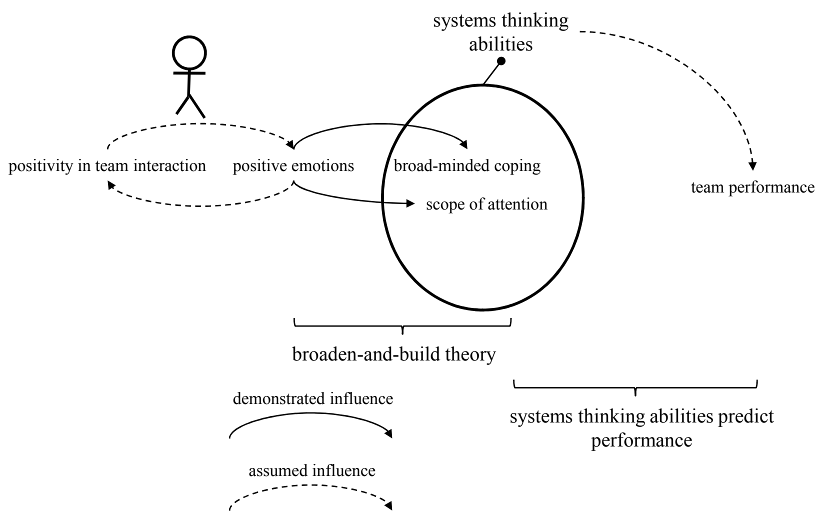

Figure 5.3: A suggestion for the systemic effect of positivity in enhancing systems thinking and team performance

(Nutt 1998, 207) rather than adopting a "ready-made solution" (Nutt 1998, 206) increases the likelihood that the decision is "adopted, in the shortest average time, with the best results." (Nutt 1998, 208), see Figure 5.3.

The assumed influences in Figure 5.3 are represented by dotted arrows. Some of them might be supported in previous studies that I am not aware of. However, with this model one can state the following overall conclusion. Positive team interaction generates positive emotions which enhance the team's systems thinking abilities. Consequently, this means that it is possible to enhance systems thinking without teaching more systems thinking skills. It is possible to make more use of people's natural abilities and current systems thinking resources.

5.4 On the supporting structures of systems thinking

Positivity in team interaction can be seen as one supporting element of systems thinking. Together this and other elements that help in the process of systems thinking form *the supporting structures of systems thinking*. I think the term "supporting structures" emphasizes the process of systems thinking and, in particular, the contextual elements of the process that may have an effect on its outcome. In order to make the process of systems thinking work, one has to have an appropriate process of systems thinking as well as the appropriate supporting structures for the process.

It is also possible to say that the use of some systems approach is a supporting element in systems thinking. Supporting systems thinking in this way can be seen as analogous to supporting decision making with decision support systems. For an example of a decision support system, see Mustajoki, Hämäläinen, and Sinkko (2007). System dynamics, for example, can support systems thinking because "people are unable to accurately infer the behavior of even the simplest systems" (Sterman 2002, 524-525). System dynamics simulations "lead to more reliable inferences about dynamics and uncover errors in our mental simulations. Most importantly, computer simulations help build our intuition and improve our mental simulation capability." (Sterman 2002, 525). I think it is important to draw attention to the structures that help the process of systems thinking. Quoting Sterman (2000a, 35),

> "When we attribute behavior to people rather than system structure, the focus of management becomes the search for extraordinary people to do the job rather than designing the job so that ordinary people can do it."

In this quote, Sterman does not discuss the process of systems thinking but the systems, such as demand-supply chains, that are improved by *applying* systems thinking. I think the idea is right, but it applies to the process of systems thinking as well. It is not always possible, necessary or even desirable to teach people to become masters of some systems approaches. The process can still be improved by focusing on the structures within which the process takes place. In part, these structures are created on the spot. For instance, drawing on Losada's and Fredrickson's findings, it can be said that the conversational dynamics of the team can support the process of systems thinking. Rather paradoxically, by being mindful about the small conversational exchanges, such as whether one shows encouragement or not, one can help the team focus on the big picture.

Chapter 6

Conclusions

6.1 Summary

During its relatively brief history, the field of systems thinking has grown into a rich and diverse field (Jackson 2009). Senge's (2006) *Fifth Discipline*, an international best seller, is the most popular text on systems thinking (Jackson 2000). The book, originally published in 1990, has brought systems thinking into the attention of the managerial audience beyond the boundaries of the academic community. Systems thinking is also having an impact within the academia. A recent *Science* article addresses the topical issue of climate change (Sterman 2008). According to Sterman (2008), a key reason for much of the confusion around climate change mitigation policies are the poor systems thinking skills of people. At the same time there is discussion about why systems thinking is not applied more (Ackoff 2006; Hämäläinen and Saarinen 2008). Some scholars disclaim the usefulness of systems thinking altogether (Stacey, Griffin, and Shaw 2000).

The basic principles of systems thinking seem intuitively useful. It is easy to point to cases where, in hindsight, undesirable consequences were due to leaving critical assumptions about levels of abstraction, system boundaries and feedback processes unexamined. The question is not whether we should try to see the big picture – to some extent, we do it anyway. The twist is that not all big pictures – what is the relevant system, and what is it like – are equal. The key is to investigate the mental activity that constructs the system, the process of systems thinking.

Where systems thinking is deemed important, it is often taken for granted that the best way to improve the process of systems thinking is to pay extra attention to it. One suggestion is to use modeling and simulation (Sterman 2002). Through learning to use problem solving methodologies one can, in time, internalize concepts that support the process of systems thinking (Checkland 2000). However, managers might not always want to go through a process of learning a new method or approach as that might appear to bring benefits only in the long term. Managers are often concerned with what helps them in their current situation (Eden et al. 2009). This observation points to another way of improving the process of systems thinking.

The systems intelligence perspective on the process of systems thinking places the emphasis on the "system" that embeds the "systems thinker". This system often includes social interaction. The system is affected by the long-term concerns and the histories of the individuals as well as their personal characteristics and emotional states. These are all structures that support or hinder the process of systems thinking. In this study, I have used the term "supporting structures" of systems thinking to emphasize the fact that given the current systems thinking abilities and tools, it is possible to find ways to improve the process further. As an example, the theme of team dynamics was discussed. For instance, team performance is associated with the ratio of positivity to negativity (Losada and Heaphy 2004). In organizations, both positivity and negativity are generated in the context of everyday interaction, exchange of ideas, negotiation, and random encounters. On the individual level, positive emotions appear to enable grasping a *bigger* picture, discovering wider patterns and seeing more action options (Fredrickson and Branigan 2005).

Linking Losada's and Fredrickson's studies, it is possible to argue that the conversational dynamics of teams contribute to the team members' systems thinking abilities. The implication is that we can enable more effective systems thinking without teaching any systems thinking. Thus, the behavior of individual A toward another individual, B, can be seen as part of the structures that support the individual B's process of systems thinking. It seems obvious that a vast number of other supporting structures could be identified.

6.2 Future research opportunities

To summarize the results of my analysis of the current state of systems thinking, I see important opportunities for future studies of the process of systems thinking with the following emphases.

- *Focus on the process.* It is important to understand what kind of processes of systems thinking actually take place in organizations and other contexts. For example, how do managers actually go about seeking the bigger picture or looking at the whole of an issue? It is likely that these processes do not entirely correspond to the *prescribed* processes of systems thinking (e.g., Checkland 1985; Jackson 2006). Which type of processes work in different circumstances?

- *Focus on the bigger picture.* Systems thinking is but one form of human action. What kind of action is needed depends on the given situation and the purposes of the actors involved. To understand the relative merits of systems thinking, it is important to investigate how do different modes of action, including systems thinking, co-contribute to the wider concerns of the organization, group or the individual in question, in the short-term as well as in the long-term.

- *Focus on the environment.* From the point of view of systems thinking research, it is interesting to investigate what elements and behaviors support or hinder the process of systems thinking. For example, what is the role of emotions in the process? What is the impact of context on the process? In a similar fashion, the themes of emotions and context are gaining momentum in the study of organizational behavior (Johns 2006; Seo and Barrett 2007).

- *Focus on the subjective.* The systems intelligence perspective emphasizes that the process of systems thinking is human action. For this action to be productive, a wide array of skills and capabilities is required. How can the individual as a subjective actor enhance the process of systems thinking, given the current situation and systems thinking abilities? Some of the ways in which the individual can support the process are likely to require abilities such as grasping and adjusting oneself to what happens "at the local, micro level of the present moment" (using an expression of Stern [2004, xviii]). Such events take place as part of and parallel to the process of systems thinking.

It is useful to focus on the ways in which the processes of systems thinking actually take place, what affects the process, and which types of processes work in different circumstances. I see that new results thus obtained would have practical relevance and broaden the scope of future research within the field of systems thinking.

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