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Designing Cognitive Systems in the Systems Sciences for Human Betterment

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Designing Cognitive Systems in the Systems Sciences for Human Betterment

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Abstract
This group report is a synopsis of our four-day conversation. Our conversation consisted of an exchange of information, discussion, and articulation of select constructs and knowledge domains pertinent to our focal topic. Philosophical foundations, the nonsystemic nature of contemporary cognitive psychology, cognitive schemata, emergence, role of the researcher, transdisciplinarity, knowledge as a construct, centrality of the human being in knowing, and our heightened awareness represented nodes in the sequence and topical flow of our conversation.

1. Introduction

The general goal of our conversation was to examine the topic of design in reference to human cognitive systems that will likely bring some benefit to humankind. In the process of covering our topic, we were especially mindful of outcomes of our conversation that might inform others of our thinking and what we had gained from our participation in conversation. Specifically, we included some focus on the synopsis of our conversation (presented as the summary and conclusion section of this report), the construction of this group report, a group publication for a systems oriented journal, and possibly even a book prospectus.

2. Starting the Conversation

We brought ourselves into the domain of the topic area via a discussion of two streams of philosophical and historical heritage --- the legacies of Plato and Aristotle --- and their influence on the rise and contemporary development of cognitive psychology and cognitive sciences.

From Plato, there are two levels to consider: 1) cognition, symbols, and 2) phenomena; the level of cognition is the true reality; a key source having led us to cognitive psychology; and the emphasis on primarily the epistemological. From Aristotle, there is one level to consider, where cognition and phenomena are same; the one level is the true reality; he has led us into physics; and the emphasis is primarily on the ontological.

Given this heritage, what does it mean to consider the domain more from a systemic point of view? We discussed whether the Platonic and Aristotelian traditions can be complementary and malleable into one cognitive psychology. There may however be conditions when one tradition and others when their combination is the more relevant. But we agreed that to take it to a deeper level of conversation will require some consideration of the implications of each tradition and their combination in regard to more specific and current: 1) philosophy (frameworks, assumptions), 2) methodology, 3) theory, 4) knowledge, 5) control, and 6) uncertainty.

3. Generating Key Constructs

We generated a set of key constructs to describe a more systemic view toward research in our domain of discussion. There are research cycles, which develop the fit between the goals and cognitive schemata of the researcher via experimentation. There is the larger context that allows other schemata and tests of the researcher's schemata via inputs from environmental demands and applications to enable transformations to occur. Goals, values, and cognitive schemata of researcher-->experiments-->data->results-->interpretation-->(goals etc. above) create feedback cycles. Applications and Environmental Demands are separate inputs; they enable transformations to broader and alternative cognitive schemata, which may be considered a feedforward cycle.

4. Absence of a Systemic View

We briefly reviewed reasons touched on in a previous conversation that cognitive sciences and psychology are not systemic, namely (1) no emphasis on the observer; (2) many key constructs assumed as given (ex: stimulus, response, drive, consciousness, mind) without discussion and consensus regarding definition; (3) only one cognitive scheme allowed, only one form of methodology (ex: experimentation) applied; (4) no need of generalization, general theory, unifying principles; (5) specialization, science of particulars, and specifics rooted to circumstances and situations; (6) disciplinary focus and at best cross and inter disciplinary but rarely transdisciplinary; (7) analytic and little attention to synthesis, integration, and comprehensiveness; (8) reductionistic (note also: biological and computer metaphors); (9) disciplined without considering systemic characteristics; (10) lack of perspectivism; (11) fragmented. diffuse, disparate collection of scientific pursuits, domains, fields of study and research (lack of integration, organization for integrative and holistic pursuits of theory and knowledge.

5. Cognitive Scheme, Knowledge Organization, and Human Inquiry

A key area of articulation for the design of cognitive systems is cognitive scheme. By this we came to mean particular cases of organization of knowledge. Some examples are cognitive maps, mental images, frames, scripts, connectionist models, stories, perceptual schemata, and semantic memory.

There are general forms of knowledge organization based on constructs such as slots and hierarchical links. Two outstanding forms are declarative and procedural. The former refers more specifically to semantic memory largely considered independent from the context. The latter refers more specifically to that which is context dependent; for example, if (condition) then (action). Some key questions however remain. How to detect cognitive schemata from experimental data? Why some data are refused and/or excluded? One theoretical view leads to the following line of reasoning and ordering about the process: a Procedural to Semantic to Episodic knowledge process evidently gives rise to cognitive schemata. Further, the experimental situation involves cognitive scheme of the human participant that is studied and an attempt to conceptualize it is the object of the research, but the researcher has his/her own cognitive scheme. There is a two relation between them. The researcher must acknowledge also that cognitive schemata are observer dependent. In short, cognitive schemata are emergent phenomena, abstractions, and interpretations from the interaction between humans.

In consideration of a more systemic methodology for designing cognitive systems for human betterment, four aspects in relation seem paramount: (1) the primary researcher observing object (human subject manifest and displaying phenomenon); (2) the reflective actions (reflexivity) of the primary researcher, including serving as an object of research and experiencer of the phenomenon researched; (3) the human subject acting as secondary researcher informing the primary researcher; and (4) the trainer of researchers supervising researchers and observing researchers and objects of research. To include more data to consider and incorporate into the cognitive scheme, the researcher observes the object (human subject), becomes the subject of observation (participant), participant becomes co-researcher to juxtaposition both researcher and participant, and the trainer also gives the broader overview. Resultant cognitive schemata benefit from inputs of these perspectives because a more encompassing range of data becomes available and included to enable the more comprehensive, holistic, and integrated (i.e. systemic) outcome for researchers. During training period of the researcher, the trainer shows the researcher other sources of data and other methods appropriate to data collection, such that the researcher can get different perspectives to research one phenomenon. And thereby the research becomes less dependent on one researcher, one method, one data source, and the like.

6. Emergence

Next we turned our attention to a focus on emergence and noted that emergence, as a key systemic construct seems observer dependent. It often gives rise to surprise when we observe a (macroscopic) phenomenon, unexpected according to our previous knowledge. Emergence cannot be predicted on the basis of our abilities, theories, data, etc. Some examples of emergent phenomena we discussed are neural network behavior, artificial life, collective phenomena (ex: laser effect and superconductivity in physics, flocking in animals, perceptual phenomena (ex: ambiguous figures and perpetual staircase), collective problem solving, creativity, collective reasoning to a goal, and memory.

Emergence and methodology have a key connection. We noted that through the applications of methodology more microscopic and macroscopic phenomena become visible to us and on our plane of human reality, Both the more micro and macro level phenomena would be largely invisible to us, were it not for our methodologies. Advances in technology (methodology) help to make the invisible more visible. Multi-method approaches enable study of multiple levels in the methodology of an inquiry.

Of the relation between emergence and theory, the same macro to micro levels apply, and the human point of reference remains in a narrow range of the visible. Theoretical explanations may be addressed to each given level perhaps without necessity of reductionism; i.e. a dependency on lower levels to explain more macroscopic phenomena. Also, emergence may be more observer uncertainty about being able to explain a phenomenon at its level of behavior, depending on more micro level to explain, which again suggests another presence of reductionism. A focus of interest is the ground states and the transformation from one phase to another of a phenomenon. Phase transition may also be relevant to the case of two ground states.

7. Transdisciplinarity

As the construct of emergence has a central place in the design of a cognitive system, so also does the idea of transdisciplinarity. More matters of interest posses a complex problem focus. Research draws increasingly on a transdisciplinary leader to focus and organize human inquiry. It is common that interdisciplinary persons to comprise the group to address a problem. The way of thinking about methodology, knowledge, theory, etc. involves a range of knowledge domains and those experienced and trained in those domains. Systems concepts, principles, theory, and methods form commonality to translate the disciplines. Systems orientation becomes a language to communicate among the disciplines. Transdisciplinarity suggests intelligence amplifiers, emergent properties, collective perceptions and intelligences, experts in disciplines plus stakeholders, and a confluence of methods and tools thought appropriate to problem focus. The transdisciplinary scientist applies the systemic view.

Before moving our conversation to the subject of knowledge, we noted some aspects of transdisciplinary inquiry, which we expect would help guide designers toward more productive research for the design of cognitive systems: (1) disciplinary inquiry is informed by theory, methodology, knowledge domain, praxis, pedagogy, etc. of the discipline; (2) many disciplines which are directly relevant are needed to converge on the complex problem focus; (3) the movement of inquiry is to more transdisciplinarity and to de-emphasis single disciplines; (4) meta level emergence of the knowledge domains (theory, methodology, knowledge, etc.) as mapped at disciplinary level but the emergence is meta; (5) the process in general is toward meta level emergence; (6) whether a particular discipline is a system or a set is determined in that inquiry; (7) there are potential benefits for those engaged in the inquiry to broaden their cognitive schemata and acquire more systemic thinking of the problem focus; (8) systems thinkers may bring more transdisciplinary knowledge to bear and be better prepared to work with complex problem as leader and facilitator, in that person can translate into systems or via systems language across the disciplines applied in the inquiry, but he/she has to be skilled also in interpersonal communication and group facilitation; (9) each discipline is like a set, their interconnections form a structured set, and from their multiple overlapping and interconnections RemergeS a system (meta level) over the course of the inquiry; (10) the problem focus is placed at center and relevant disciplines form inputs to that focus; (11) whether one discipline has a more central position in the inquiry compared to all disciplines is up to the researchers in their conceptualization of the problem focus; (12) some conceptualizations of the problem focus and cognitive schemata applied may be more productive for inquiry than others; and (13) the process of inquiry may be seen to move through the following phases: monodisciplinarity, crossdisciplinarity, interdisciplinarity, multidisciplinarity, and eventually to transdisciplinarity. Monodisciplinarity means each discipline is characterized by its own specific concern only; there is no communication between different disciplines, and the different disciplines constitute a set. Interdisciplinarity means that several disciplines deal with a common problem; they must communicate, but again the contribution of each discipline depends on its concern; the disciplines constitute a structured set. Transdisciplinarity subverts the distinctions among different disciplines; a new discipline emerges from their interaction at meta level, and the meta discipline constitutes a system.

8. Knowledge

Taking up the topic of knowledge brought a major shift in focus of our conversation. We utilized several trigger questions to spark and move the conversation, specifically, (1) what is knowledge? (2) what is knowledge emergent from transdisciplinarity? (3) what is systemic about knowledge? (4) what is knowledge in a systemic cognitive psychology? (5) how does knowledge work? (6) is there an embodiment of knowledge? (7) is knowledge experience? (8) is knowledge information?

(9) is knowledge process? and (10) is knowledge representation? This series of questions also captures the tenor and development of this phase of our conversation. Further, the questions tend to consider a movement in thinking from knowledge as a thing to knowledge as a process.

It was helpful to contrast knowledge with information. The central importance of information stems from contributions of the von Neuman computer and Shannon-Weaver theory. Thingness and uncertainty of information are addressed by indication of an average to the variety. Declarative knowledge is on one side and procedural knowledge on the other, but strategy suggests that procedural relates to and stems from declarative. Declarative + Procedural is a step toward knowledge as process and a step toward a more systemic view of knowledge. We noted at this point Popper's 3 (ontological) worlds: (1) physical reality, (2) reality of experience, and (3) reality of statements.

We touched on the following conceptual and definitional aspects of knowledge as a key construct in any cognitive system designed for human betterment: Knowledge as representation, idea, discovery, production, creation, metaphor, and process. The idea as a configuration of elements + interconnections from earlier systems presentations was an intriguing notion, as was three additional schemes attributed to Minati, Paritsis, and Piaget. For example, the Piagetian scheme can be construed to emphasize a systemic dynamic of assimilation and accommodation processes of organism-environment adaptive relationship generating knowledge and development of the cognitive system. The Paritsis model emphasized variety + logic leads to ordered statements; information is variety without order; knowledge is order to information with logical relations. In closing, we noted that one can share information and knowledge but not experience (it is personal).

From a systemic view, knowledge is generated in the boundary space of organism (person) and environ (context) relations via the interactions between human system and its environment. In short, knowledge is a boundary property and emergent phenomenon. At this point we noted once again the Piagetian contribution: sensorimotor to concrete operations to symbolic stages of human cognitive development. In contrast, other approaches were helpful to our conversation. The classical conception of knowledge yields representations of processing from sensory peripheral systems to central cognitive processing systems. A philosophical perspective is conveyed by the Chinese room example of Searle. Also, there are the separate models of Paritsis and Royce to consider. Finally, we touched on the contribution of Gelepides about knowledge from experience of humans is different from that of computers and robots.

9. Toward a Systemic View

Moving the field toward a more systemic design of cognitive systems for human betterment presents a major challenge of the future. We have to ask: what do we want to know? And what is the place, role, presence of knowledge in a systemic cognitive science and psychology? Certainly, the science has to be centered in the human being, self referential, and inherently limited as a result of who we are and what we presently know. But we are part of the world we (want to) observe. Uncertainty is omnipresent.

What imbues the existence of knowledge? Does it exist with as well as without the human being? There seems to be both personal versus collective forms of knowledge. Conscious compared to nonconscious knowledge seems a necessary consideration. Knowledge is incomplete; we have extreme difficulty to distinguish between knowledge and consciousness of knowledge (to know that you know). Knowledge exists whether or not there is interaction with another person. There are distinguishable differences among core constructs of consciousness, awareness, attention, and the like, and the different uses and definitions across disciplines, knowledge domains, and applied fields create confusion.

Awareness entails knowledge and meta knowledge. It is characterized by active engagement with the environment. There is an activity and use of knowledge. Though knowledge often seems static (time zero) and meta knowledge is after the fact (time one), for one cannot observe oneself (meta) at same time one is engaged in an activation and use of knowledge. Insight is an example of a nonconscious phenomenon (working knowledge that is not visible).

This phase of our conversation concluded with some reflections back on what had been transversed. What one knows and what one knows that one does not know reduce and deal with uncertainty and anxiety. One may think one knows, when one does not---a lack of meta knowledge.

10. Two Models of Cognition in Contrast

Our conversation then took a jump to a specific example of two models. We reviewed the Paritsis model and contrasted it with the Pessa model, thereby obtaining a greater sense in the group of the level of detail we might attempt in a future conversation that would take us to the next step of specificity for the design of a cognitive system for human betterment.

Some key constructs and points are epitomized here. Paritsis model contrasted abstract and concrete language; the model had a central place for affective cognition and sensorimotor experience. Communication between two persons consists of levels of abstraction, each iteration is a more refined esoteric symbolic and abstract derivation perhaps of lower level. The Pessa model emphasized the structure of knowledge and contrasted problem consciousness linked to the situation, unconsciousness linked to the solution, and consciousness linked to action.

With these two models and others noted previously, we concurred that comparisons across humanity, i.e. the commonality makes our thematic topic feasible. Regardless of the cultural context, there are basic cognitive operations to solve problems. focus the attention, control the awareness state, and so on. Even though there are books. computers, and the like that provide Stored knowledge that is separate and public manifestations of what is known (and not the same as stones, artifacts, etc.), which may be distinguished from Observable knowledge, i.e. observations of objects, of the observer, static, retrospective, indirect, method dependent, and observer dependent. Before stored knowledge in artificial forms we had natural forms of story telling, oral history, dance and ceremonies, and making of artifacts; writing symbols and language on artifacts enables stored knowledge. The study the basic operations is key to develop a more systemic view of cognitive science and psychology with an eye for the commonalities across humans and human groups.

We concluded this phase of the conversation by stressing, it is the confluence of Stored and Observable knowledge that is relevant to the future and design of the future. What you want to know becomes the key question.

11. Coming to Closure

Before composing our summary, we considered some future topics in relation to the group thematic domain (i.e. artificial intelligence, human organizations, human development, and metaphors) and the specific tasks ahead of us (e.g. group report, summary for the IFSR Newsletter, book prospectus, journal article, and Fuschl Conversation in the year 2000).

12. Summary

Having had prior meetings in which we developed our rationale for the interest in considering more systemic approaches to cognitive psychology and cognitive science to design systems for human betterment, we began our first day in discussion of ideas covering the philosophical foundations of theories and traditions of knowledge, specifically Plato and Aristotle. We reviewed and extended our articulation of reasons and argumentation as to why contemporary cognitive psychology and science tend not to be systemic.

During the second day, we discussed the idea of cognitive schemata in its various forms, such as cognitive maps, mental models, semantic networks, and stories. Cognitive schemata, possibly illustrative of emergent phenomena, highlighted a shift in our conversation toward methodology and the problem of the role of observer/researcher to describe a more systemic approach to science.

On the third day, we covered the topic of transdisciplinarity. We listed definitional characteristics, compared and contrasted this more systemic view to less systemic forms, such as monodisciplinarity and interdisciplinarity, and described transdisciplinarity in systems science more as a process of emergence and meta level aspects.

For the last phase of our conversation, we took up the idea and problem of knowledge as a construct critical to any considered examination of a more systemic science for human betterment. We covered a variety of forms and contrasts, specifically what is it and how does it work, declarative and procedural knowledge, representation and process, conscious and nonconscious knowledge, basic versus stored versus observed knowledge, the accumulation and assimilation of knowledge the role of simulation, and the centrality of the human being in asking what do you want to know.

We culminated our conversation with greater awareness of the central importance of multiplicity of viewpoints, knowledge representation, emergence, transdisciplinarity, and research methodology for complexity, in order to take our conversation to the next phase toward a more systemic cognitive science, which can enable the design of systems for human betterment, given the emerging global problems.

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General Principles underlying the Design of Cognitive Models

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The general plan of the investigation was:

- Introduction
  - The need for cognitive models in a number of different domains (psychology, psychiatry, human-computer interactions, organizations, etc.)
  - The need for general principles underlying the design of cognitive models
- Problems of definition
  - Different definitions of knowledge
  - Problems with different approaches
  - Need for considering the different approaches as complementary rather than opposite
- General Principles
  - The models should be presented in a wider context
  - The model could be improved by considering higher and lower levels of system organization, by taking are of the interfaces between levels, so as to constrain the model.
  - Attempt is to be made to relate microscopic and macroscopic aspects of model in clear way. (hybrid models)
  - Clarify the relationships between traditional informational content (amount) and knowledge content of the model
  - Consider the relationships between cognitive functions taken consideration and non-cognitive aspects, such effects, emotions, etc.
  - Use of interdisciplinary and trans-disciplinary approach which can be related to social and psychological approaches
  - Use as much as possible systems concepts and language
  - Find isomorphisms between information-processing systems and other living, and artificial, organizational systems
  - Consider the purpose of the model in order to decide the contents and the tools of modeling (e.g. Jackson's classification)

- Try to find descriptions as economic as possible
- mainly those involved in circular causality processes
- quote the technical methods to eliminate variables in loops
- Examples of cognitive models which could become frameworks for cognitive modeling
  - Model by Paritsis
  - Model by Anderson (ACT)
  - Artificial life Model
- Relation to general principles
- Use as few variables as possible (only the most important ones) to explain and represent the complexity of the cognitive processes.
- Pay attention to circular causal loops that have to be preserved in the model because they usually play an important role.