THREE WORLD VIEWS AND SYSTEMS PHILOSOPHIES

Brian R. Gaines & Mildred L. G. Shaw

Department of Computer Science, York University,
4700 Keele Street, Downsview, Ontario, Canada M3J 1P3

ABSTRACT

General systems theory (GST) should be neutral with regard to major philosophical issues in order to be able to encompass all philosophies. This paper develops GST based on the primitive notion of a distinction as a basis for knowledge science and technology. It analyses the development of systems of distinction and how different philosophies arise through different basic distinctions generating world hypotheses. It is suggested that any situation can be analysed in terms of the distinctions being made, whether they are ascribed to necessity or choice, and the inferences possible between them.

1. BACKGROUND

Notes on the background to the work.

1.1 This paper is concerned with the foundations of general systems theory (GST).

1.1.1 It continues a sequence that commenced in 1979 at Gordon Pask's IVth European Conference on Decision Making in Complex Systems, was presented at SGSR 1981 as a programme for the development of a systems methodology (Gaines & Shaw 1981), at SGSR 1984 as generative principles for a range of system theories (Gaines & Shaw 1984a), and has been exemplified in a range of applications at a number of conferences (Gaines & Shaw 1983, 1984b,c,d, Shaw & Gaines 1981, 1983a, 1984a,b).

1.1.2 We have found a GST based on the notion of a distinction (Brown 1969) very powerful in developing theories for a range of topics, analysing methodologies in a number of disciplines, and solving practical industrial and commercial problems.

1.1.3 Our analysis and presentation of such a GST is by no means complete and will continue to develop, but this Symposium presents an appropriate opportunity to discuss its current state.

1.2 We are concerned to present a complete basis for GST such that a small number of primitive constructs may be used to generate all others.

1.2.1 There are many complete bases for GST.

1.2.2 We do not claim that the basis presented is unique or to be preferred over all others.

1.3 We are concerned to develop a basis for GST which is universal in being able to subsume any other.

1.3.1 However, subsumption does not necessarily imply precedence, greater strength, acceptability or utility.

1.3.2 Two bases may subsume one another without being equivalent, e.g. the basis that all is in the "mind of God" may account for the calculus of distinctions, and vica versa, but the bases are not equivalent.

1.3.3 The notion of equivalence is itself relative to a system and is not meaningful outside its system.

1.3.4 Considerations of strength, precedence, acceptability and utility are also relative to systems.

1.3.5 Whether there is an absolute basis subsuming all others is thus clearly also relative to a system.

1.3.6 It would be reasonable to require that an absolute basis should make provision for its own existence.

1.4 We are concerned to develop a basis for GST in which the primitives are simple to understand and intuitively meaningful.

1.4.1 A GST that was widely communicable and acceptable would provide one universal language (of many universal languages) uniting all disciplines.

1.5 We are concerned to develop a basis for GST which is useful for prediction,

decision and action in a world where these are possible.

1.5.1 This does not imply the priority of pragmatism, only that pragmatic considerations are fully supported.

1.5.2 A GST targeted on action would provide foundations for the evolution in knowledge systems taking place as fifth, and later, generation computing systems are developed (Gaines 1984b) to provide new media extending human capabilities (Shaw & Gaines 1983b).

1.5.3 Knowledge science and technology are the foundations of the next stage of development of our civilization, and the philosophical principles underlying knowledge acquisition, representation and processing, have to be operationalized through expression in systemic terms.

2. GST AS PROTO-WORLD HYPOTHESES

Notes on reasonable expectations for a GST.

2.1 Pepper (1942) defines **world hypotheses** as unrestricted products of knowledge which cannot reject anything as irrelevant. He notes that:
"Every consideration is relevant to a world hypothesis and no facts lie outside it."

2.2 We propose that any GST should satisfy this constraint upon a world hypothesis.

2.3 Pepper analyses world hypotheses in terms of their **root metaphors.**

2.3.1 He proposes that someone desiring to understand the world will take an area of commonsense fact and use this as a basic analogy with which to understand other areas.

2.3.2 The structural characteristics of this root metaphor become the categories for his basic concepts of explanation and description.

2.3.3 Pask (1975) notes that:
"cybernetics is the science or art of manipulating defensible metaphors; showing how they may be constructed and what can be inferred as a result of their existence."

2.3.4 Lakoff and Johnson (1980) have analysed linguistic forms in terms of root metaphors and suggests that they pervade all language.

2.3 Pepper proposes that:
I. A world hypothesis is determined by its root metaphor;
II. Each world hypothesis is autonomous;
III. Eclecticism is confusing;
IV. Concepts which have lost contact with their root metaphors are empty abstractions.

2.4 Pepper derives four root metaphors underlying world hypotheses: formism, mechanism, contextualism and organicism.

2.4.1 Bahm's (1982) systemic analysis of closely related categories demonstrates the fundamental roles of such root metaphors in determining the nature of a systems theory.

2.5 We propose that any GST should be a **proto-world hypothesis** in providing a framework for each of these root metaphors.

2.5.1 Pepper's analysis is itself a GST at a formative stage, providing the means for examining and comparing world hypotheses, and developing the underlying principles systemically.

2.6 Kant noted in his **Prolegomena to Any Future Metaphysics** that the critical issue is not whether a world hypothesis is correct or incorrect, but whether one is **possible**:
"we have left but one critical question upon whose answer depends our future conduct, viz., **is metaphysics at all possible?**...In the **Critique of Pure Reason** I have treated this question synthetically, by making inquiries into pure reason itself and endeavouring in this source to determine the elements as well as the laws of its pure use according to principles." (Kant 1977)

2.6.1 This question of possibility still applies to any world hypothesis and to GST as a proto-world hypothesis.

2.6.2 Ayer (1936) would assert impossibility according to any reasonable criterion of **verification.**

2.6.3 Popper (1972) would allow the possibility as meaningful if it were possible to set up a criterion for its **falsification.**

2.6.4 Neither verification nor falsification criteria are applicable to world hypotheses or GST since by their very nature such hypotheses must account for considerations of verification and falsification.

2.6.5 It would be a weak consistency requirement for a world hypothesis that it not falsify itself, and a strong consistency requirement that it verify itself, but neither provides the intended style of answer to Kant's question.

2.6.6 If the question is still asked then the available answers range from Kant's (1897) **transcendental arguments**, through Kuhn's (1970) **paradigms** as fashions accepted by a community, to Feyerabend's (1975) anarchic **anything goes.**

2.7 The categorial systems developed by Aristotle, Kant and Hegel may be seen as proto-world hypotheses. Peirce (Esposito 1980) expressed the motivation behind his development of these in eloquent terms that may be applied directly to GST today:
"The new conception will not be content to be restricted to the particular phenomena it was devised to explain: it will insist upon applying itself to analogous phenomena, and to others analogous to these again, without stint. For that purpose it must be widened and probably simplified and rendered more agreeable to reason. It will not be content with explaining the history of thought, but will aim to explain history in general. It will not be content with accounting for man, but will wish to grasp all the forms in the universe, which is greater than man. It will not be content with an accidental universe, but will wish to assimilate every universe that the mathematician may suggest. It will not be content with allowing to the unreflective view a sort of subordinate legitimacy, but will insist on elevating it to a truth in full harmony with its own. These tendencies are irrepressible: in the long run they will cause that which they need to come into being."

3. GST BASED ON DISTINCTIONS

Notes on distinction-based foundations for a GST.

3.1 A **distinction** is a primitive concept, formally unanalysable.

3.1.1 Natural language carries many connotations which are important in conveying the meaning of a statement. However, for formal analysis each connotation needs to be separated as an additional component of meaning.

3.2 We shall use the term **distinction** approximately in the sense of "One of the parts into which a whole is divided: a division, section; a class, category." (Oxford English Dictionary)

3.2.1 We note, however, that no "whole" is presupposed, and neither is the notion of division.

3.2.2 Classes, sets and categories are examples of systems that may be generated through distinctions.

3.2.3 They are the natural products of simple distinctions and come to mind as we think about distinctions, making it important to keep in mind that the notion of a distinction is prior to them and cannot be derived in terms of them.

3.3 A second sense of distinction is "The action of dividing or fact of being divided" (OED).

3.3.1 We note, however, that the notions of "action", "actor", "being divided", are again not presupposed.

3.3.2 All of these additional connotations are extensions of the primitive notion of a distinction, not necessary to it, and standing in relation to it as distinctions about distinctions.

3.4 The primitive notion of a distinction has no content.

3.4.1 There should be no content to that which is taken as ultimately primitive.

3.5 It is the introduction of the notion of distinctions among distinctions that generates other notions.

3.5.1 The recursive application of distinctions to themselves is what generates content.

3.5.2 The primitive notion of a distinction has no connotation of application, but no prohibition either.

3.5.3 The conceptual leap that distinctions may be applied, instantiated, come into existence, is outside the framework of the theory.

3.5.4 The first leap may be used to account for later leaps but its account of itself transcends the theory.

3.6 Distinctions among distinctions are sufficient to generate all other notions.

4. THE DIALECTICS OF DISTINCTIONS

Notes on the cyclic processes underlying the development of systems of distinctions.

4.1 The dynamics of distinctions are unanalysable in the sense of determining a unique system whereby all distinctions arise, but the processes of distinction formation for particular systems of distinctions may be analysed in terms of the distinctions involved.

4.2 Hegel's (1929) **Logic** is an analysis of the sources of distinctions as arising out of processes of reflection within the mind.

4.2.1 Hegel's philosophical works may be seen as exemplifying these processes in action. At the end of his **Encyclopaedia** he notes that his system of logic is "the only true method" but also that "I could not pretend that the method...is not capable of greater completeness, of much elaboration in detail" (Hegel 1959).

4.2.2 Burbidge (1981) takes this as the essence of Hegel's method:
"the advance of the natural sciences will show that there are other ways in which nature must be philosophically comprehended; developing history will produce new events, both radically more destructive and radically more creative

than anything known previously; further reflection will make distinctions and add clarifications that will render more rigorous the science of logic."

4.3 Kelly's (1955) **Personal Construct Psychology** is an analysis of the sources of distinctions as arising out of the processes by which the mind models the world.

4.3.1 Like Hegel, Kelly saw the role, and transiency, of his own distinction-making processes in his system. His only core construct was that of **constructive alternativism** (Mancuso & Adams-Webber 1982), that we have a choice in our construct systems and that problems may often be solved by exercising this choice (Shaw 1980).

4.4 Pope (1984) has given a four-stage model of the dynamics of the distinction making processes that accounts for the radical reconstructions described by Hegel and Kelly.

4.4.1 Pope shows that these dynamics occur in many distinct cultures and suggests that they represent a universal process of system formation.

4.5 Pope's model may be expressed in terms of distinctions.

0: Chaos	No distinctions
1: Separation	Distinctions
2: Union	Distinctions among distinctions
T: Transcendence	Distinguishing levels 0 to 2 as a process

4.5.1 At level zero there are no distinctions: the world has its primeval, chaotic form.

4.5.2 At level one distinctions are made in the world but no distinctions are made among distinctions so that the world is seen as atomic and the concept of a whole cannot be expressed.

4.5.3 At level two distinctions are made among distinctions themselves and many new concepts are possible, including those of wholeness, agency and reality.

4.5.4 At level T the entire process is transcended by the recognition that it may be distinguished as a process.

4.6 We have re-labelled Pope's four stages (from 1-4 to 0-3 & T) to demonstrate that a number of systemic principles are involved.

4.6.1 Level T may be seen as exemplifying the zero-one-infinity process that underlies all knowledge formation (Gaines 1984a).

4.6.2 Level zero is that of the sceptic accepting no hypotheses and is stable.

4.6.3 Level one is that of the dogmatist accepting only one hypothesis and is stable.

4.6.4 Level two is that of the pluralist admitting, and comparing, many hypotheses and is not stable.

4.6.5 If there are two of anything then there are, at least potentially infinity, and the levels increase without limit, until the entire process is itself recognized as such and transcended at level T.

4.7 Hegel's dialectic is also exemplified in Pope's model.

4.7.1 Both thesis and antithesis lie at level one.

4.7.2 The conflict between them is recognized at level two.

4.7.3 If left unresolved it generates an indefinite number of levels of additional complexity.

4.7.4 The synthesis transcends these by recognizing the process of distinction formation and restarting the cycle.

5. SYSTEMS AND WORLDS

Notes on systemic concepts arising as distinctions.

5.1 We have noted that the primitive notion of a distinction is adequate to build a GST when one further connotation is added, that **what** is distinguished is a **system** (Gaines 1980).

5.1.1 This naming the distinguished entity as a system is an auxiliary notion because it requires the ontological supposition that such an entity exists.

5.1.2 The existence supposition is what brings a system into being.

5.2 We may distinguish among distinctions by very general criteria and term the system thus created a **world.**

5.2.1 This is consistent with the sense of a world hypothesis noted earlier in that generality is interpreted as the question of whether the world-creating distinction applies always being admitted as relevant.

5.3 The world of distinctions at level one in section 4.5 will be termed **World 0** (W0).

5.3.1 All that can be said about W0 is that it is the world of systems with no relations expressed between them.

5.3.2 Note that distinguishing distinctions as being at level one is itself a level two distinction.

5.3.3 W0 may be generalized by the level T process of recognizing distinctions at level two as themselves defining systems.

5.3.4 Note the possibility of a fallacy of misplaced concreteness arising from this generalization which fails to distinguish the levels and may fail to recognize that the process of generalization itself brings new systems into being.

5.4 The world of distinctions generated by the level two distinction that a level one distinction is **necessary** will be termed **World 1** (W1).

5.4.1 W1 is generated by replacing the "what is generated?" question by a "why is it generated?" question bringing in the concept of necessity, that a distinction has to be made.

5.4.2 The primitive experience of the necessity of distinctions is that of the physical world.

5.4.3 W1 may be generalized by the level T process of recognizing distinctions at level two as themselves being necessary.

5.4.4 This generalizes the necessity of the phenomena of the physical world to the necessity of the laws of the physical world.

5.4.5 Note the possibility of a fallacy of assuming the existence of universals arising from this generalization which fails to distinguish the levels and may fail to recognize that the process of generalization itself brings new systems into being.

5.5 The world of distinctions generated by the level two distinction that a level one distinction has a **maker** will be termed **World 2** (W2).

5.5.1 W2 is generated by replacing the "what is generated?" question by a "who generates it?" question bringing in the concept of agency, that there is a distinction maker.

5.5.2 The primitive experience of a maker of distinctions is that of oneself.

5.5.3 W2 may be generalized by the level T process of recognizing distinctions at level two as themselves having makers.

5.5.4 This generalizes the making of distinctions to the processes of reflection on those distinctions.

5.5.5 Note the possibility of a fallacy of assuming the existence of mind arising from this generalization which fails to distinguish the levels and may fail to recognize that the process of generalization itself brings new systems into being.

5.6 The world of distinctions generated by the level two distinction that a level one distinction is independent of necessity and a maker will be termed **World 3** (W3).

5.6.1 W3 is generated by realizing that neither the "what?", "who?", or "why?" questions need be asked, bringing in the concept of the independent existence of distinctions.

5.6.2 There is no primitive experience of distinctions in themselves and hence W3 is less readily apprehended than W0 and W1.

5.6.3 W3 may be generalized by the level T process of recognizing distinctions at level two as existing in themselves.

5.6.4 The more natural process is to assume that distinctions at level two exist in themselves, perhaps to avoid problems of assuming concreteness, universals and mind, and generalizing this notion to recognize distinctions at level one as existing in themselves also.

5.6.5 Note the possibility of a fallacy of assuming the existence of worlds independent of mind and physical reality arising from this generalization which fails to distinguish the levels and may fail to recognize that the process of generalization itself brings new systems into being.

5.7 W3 may be seen as formed through the dialectical process outlined in the section 4.

5.7.1 Ascribing distinctions to the necessity or to agency are each non-conflicting distinctions at level one among chaos at level zero.

5.7.2 At level two the distinction between the two sources is noted and seen as a conflict.

5.7.3 The conflict may be resolved by the generation of higher levels that distinguish distinctions that are necessary and made, necessarily made, and so on.

5.7.4 It may also be transcended at level T by negating the question as to the source of distinctions.

6. PHILOSOPHIES, TRUTH AND INFERENCE

Notes on the ways in which different schools of philosophy arise through different distinctions.

6.1 Distinctions may be distinguished as made, occurring or instantiated and this gives rise to notions of truth.

6.1.1 A distinction is true relative to some other distinction if it is made relative to that distinction (the truth criterion).

6.2 Distinctions may be distinguished as named.

6.2.1 A name is a distinction among distinctions.

6.2.2 A name is proper (Gupta 1980) relative to some distinction if the identity of the distinctions named may be inferred relative to that distinction (the trans-world criterion).

6.3 The distinction that one distinction is distinguished as prior to another gives rise to a (partial) order relation on distinctions.

6.3.1 This form of distinction gives rise to notions of inference, time, space, value, and so on.

6.4 An entity is distinguished as a partially ordered sequence of distinctions.

6.5 Different types of philosophical position may be distinguished in terms of what entities are admitted as true.

6.5.1 Materialism admits only the truth of ungeneralized W1 entities commencing with the initial distinction that there is a unique physical world (i.e. the entities have a unique common distinction as prefix).

6.5.2 Realism extends materialism to admit the truth of generalized W1 entities commencing with the same initial distinction.

6.5.3 Theism is similar to realism but commences with the initial distinction of a unique God.

6.5.4 Strict phenomenalism admits only the truth of ungeneralized W2 entities.

6.5.5 Various forms of personal idealism admit the truth of W2 entities and are distinguished by the initial distinctions involved at level one and level two, e.g. the mind, archetypal ideas, God or the physical world.

6.5.6 The lack of a unique initial distinction for W2 entities corresponds to the many forms of idealism and problems such as the existence, and relations between, many minds.

6.5.7 Various forms of impersonal idealism admit the truth of W3 entities.

6.6 The objects admitted as true in each world characterize its rules of inference, nature and application.

6.6.1 In W0 no distinctions as to the source of distinctions are made.

6.6.2 Nothing further can be said but as a rationalization the transcendental inference can be made that these distinctions are useful.

6.6.3 This rationalization leads to pragmatic inference in W0, that an argument is valid to the extent that it is useful.

6.6.4 The distinction of utility is one of value and W0 is basically one of axiology.

6.6.5 In W1 distinctions are true in so far as they are necessary and this is ascribed to correspondence to the physical world.

6.6.6 This ascription leads to causal inference in W1, that an argument is valid to the extent that it follows the processes of the physical world.

6.6.7 The link to physical necessity makes W1 a world of epistemology.

6.6.8 In W2 distinctions are true in so far as they have a maker and this is ascribed to the performative constraints of the maker (role integrity).

6.6.9 This ascription leads to conventionalist inference in W2, that an argument is valid to the extent that it follows agreed constraints (and hence W2 can model W1).

6.6.10 The link to a maker makes W2 a world of psychology.

6.6.11 In W3 distinctions are true in so far as they are coherent with some criterion established in W3 (and hence W3 can model W1 and W2).

6.6.11 This ascription leads to structuralist inference in W3, that an argument is valid to the extent that it is coherent with the criterion.

6.6.12 The link to an arbitrary criterion makes W3 a world of ontology.

6.7 The systems of distinctions and entities discussed is shown in Figure 1 as generating Popper's (1968) **three worlds** and Pask's (1975) **conversation theory.**

7. CONCLUSIONS

7.1 A GST based on the notion of distinctions has been presented and shown to allow many aspects of the philosophies of systems to be analysed.

7.1.1 A few basic distinctions among distinctions allow a wide range of powerful systemic concepts to be generated.

7.1.2 It is suggested that these distinctions be taken as the primitives generating different forms of philosophical position.

7.2 In terms of applications, it is suggested that any situation be analysed in terms of the distinctions being made, whether they are ascribed to necessity or choice, and the inferences possible between them.

7.2.1 This is a generally applicable technique that forms an adequate foundation for all forms of systems analysis, decision making and problem solving, including knowledge engineering for expert systems.

8. ACKNOWLEDGEMENTS

Financial assistance for this work has been made available by the National Sciences and Engineering Research Council of Canada.

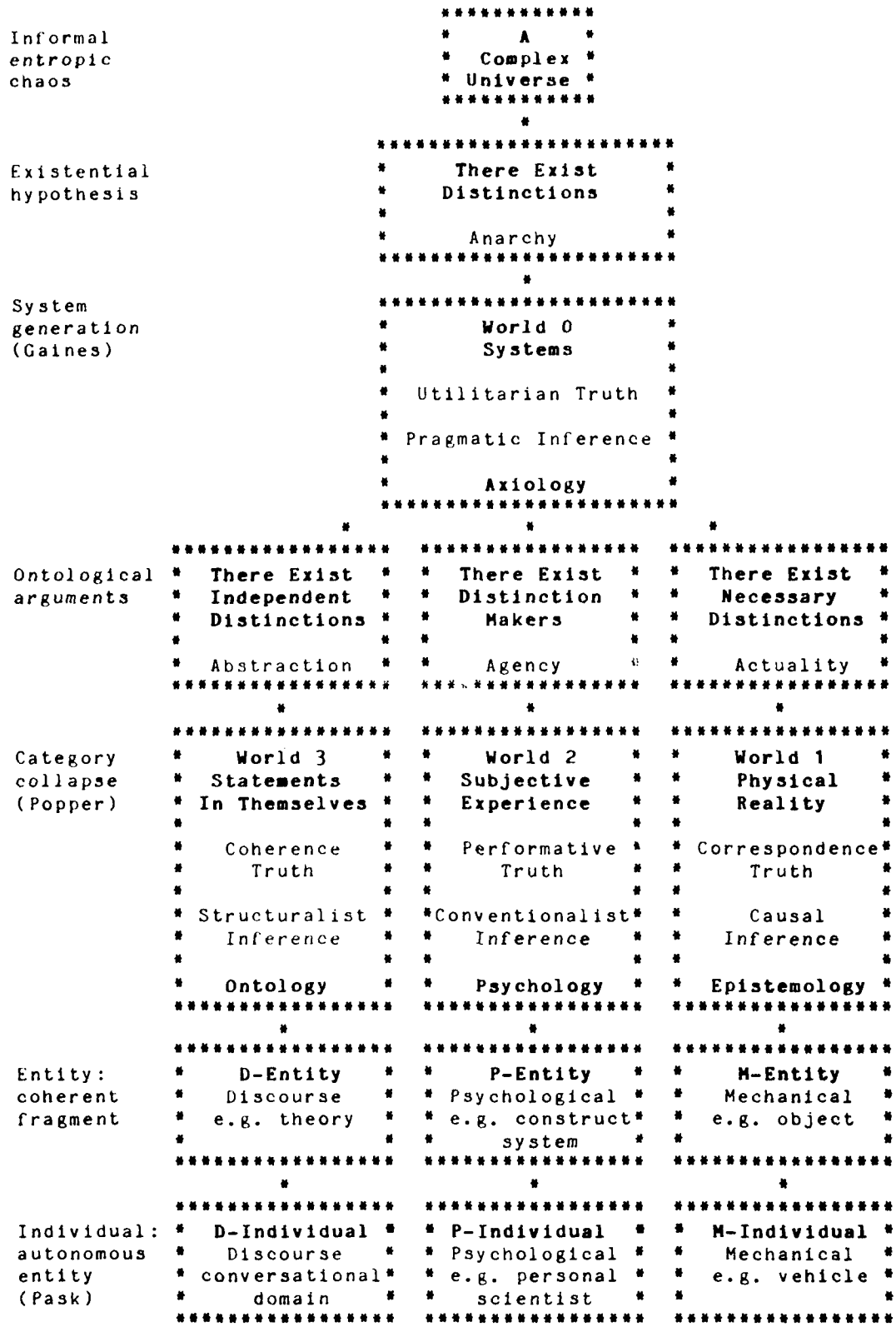

Fig. 1 Distinctions About The Origins of Distinctions Generating Worlds, Notions of Truth and Inference, Conversation Theory and Notions of Entities and Individuals

9. REFERENCES

Ayer, A.J.
1936 **Language, Truth and Logic.** London: Victor Gollancz.

Bahm, A.J.
1982 "Methodologies of five types of philosophy." In Troncale, L.(ed.) **Systems Science and Science: Proceedings of SGSR 26th Annual Meeting.** pp. 128-131. Kentucky: Society for General Systems Research.

Brown, G.S.
1969 **Laws of Form.** George Allen & Unwin.

Burbidge, J.
1981 **On Hegel's Logic.** New Jersey: Humanities Press.

Esposito, J.L.
1980 **Evolutionary Metaphysics.** Ohio U.P.

Feyerabend, P.
1975 **Against Method.** London: NLB.

Gaines, B.R.
1980 "General systems research: quo vadis?." In Gaines, B.R.(ed.) **General Systems 24**: 1-9. Louisville: Society for General Systems Research.
1984a "Methodology in the large: modeling all there is." **Systems Research 1**: 91-103. No. 2.
1984b "Perspectives on fifth generation computing." **Oxford Surveys in Information Technology 1**: 1-53.

Gaines, B.R. & Shaw, M.L.G.
1981 "A programme for the development of a systems methodology of knowledge and action." In Reckmeyer, W.J.(ed.) **General Systems Research and Design: Precursors and Futures.** pp. 255-264. Society for General Systems Research.
1983 "Is there a knowledge environment?." In Lasker, G.(ed.) **The Relation Between Major World Problems and Systems Learning.** pp. 27-34. Society for General Systems Research .
1984a "Hierarchies of distinctions as generators of system theories." In Smith, A.W.(ed.) **Proceedings of the Society for General Systems Research International Conference.** pp. 559-566. California: Intersystems.
1984b "Logical foundations of expert systems." **Proceedings of IEEE International Conference on Systems, Man and Cybernetics**: 238-247. Halifax, Nova Scotia.
1984c "Foundations of expert systems." In Kacprzyk, J. & Yager, R.R.(eds.) **Management Decision Support Systems Using Fuzzy Sets and Possibility Theory.** Rheinland: ISR.
1984d "Systemic foundations for reasoning in expert systems." In Gupta, M.M., Kandel, A., Bandler, W. & Kiszka, J.B.(eds.) **Approximate Reasoning in Expert Systems.** North-Holland.

Gupta, A.
1980 **The Logic of Common Nouns.** New Haven: Yale University Press.

Hegel, G.W.Fr.
1929 **Science of Logic.** London: George Allen & Unwin.
1959 **Enzyclopaedie der Philosophischen Wissenschaften im Grundrise.** Hamburg: Felix Meiner.

Kant, I.
1897 **Critique of Pure Reason.** London: George Bell.
1977 **Prolegomena to Any Future Metaphysics.** Indianapolis: Hackett.

Kelly, G.A.
1955 **The Psychology of Personal Constructs.** New York: Norton.

Kuhn, T.S.
1970 **The Structure of Scientific Revolutions.** (2nd ed.), Chicago, USA: University of Chigaco Press.

Lakoff, G. & Johnson, M.
1980 **Metaphors We Live By.** Chicago: University of Chicago Press.

Mancuso, J.R. & Adams-Webber, J.R.(eds.)
1982 **The Construing Person.** New York: Praeger.

Pask, G.
1975 **The Cybernetics of Human Learning and Performance.** London: Hutchinson.

Pepper, S.C.
1942 **World Hypotheses.** Los Angeles: University of California Press.

Pope, S.
1984 "Conceptual synthesis: beating at the ivory gate?." In Smith, W.(ed.) **Systems Methodologies and Isomorphies.** pp. 31-40. California: Intersystems.

Popper, K.R.
1968 "Epistemology without a knowing subject." In van Rootselaar, B. & Staal, J.F.(eds.) **Logic, Methodology and Philosophy of Science III.** pp. 333-373. Amsterdam: North-Holland.
1972 **Objective Knowledge.** London, UK: Clarendon Press.

Shaw, M.L.G.
1980 **On Becoming a Personal Scientist.** London: Academic Press.

Shaw, M.L.G. & Gaines, B.R.
1981 "The personal scientist in the community of science." In Reckmeyer, W.J.(ed.) **General Systems Research and Design: Precursors and Futures.** pp. 59-68. Louisville: SGSR.
1983a "Eliciting the real problem." In Wedde, H.(ed.) **Adequate Modelling of Systems.** pp. 100-111. Berlin: Springer Verlag.
1983b "Computer systems in the knowledge environment: a new medium." In Lasker, G.(ed.) **The Relation Between Major World Problems and Systems Learning.** pp. 35-41. Society for General Systems Research .
1984a "Deriving the constructs underlying decision." In Zimmermann, H.J., Zadeh, L.A. & Gaines, B.R.(eds.) **Fuzzy Sets and Decision Analysis. TIMS Series Studies in the Management Sciences 20**: 335-355. Amsterdam: North-Holland.
1984b "Some experience in eliciting knowledge structures for expert systems." In Smith, A.W.(ed.) **Proceedings of SGSR** pp. 605-614. California: Intersystems.