TRANSDISCIPLINARY UNIFYING THEORY: ITS FORMAL ASPECTS

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Contents

Summary

This article defines transdisciplinary unification, and gives the reasons why it is pursued. Rationales are taken as constraints, which enable the formal definition of the transdisciplinary problem. In this way rules are generalized, including those referring to independent constraints that apply to complex problem-solving and unification through reduction.

In the third section a unifying language-theory is constructed through assessing the complexity-heterogeneity of both the problem and the solving procedure. This leads to the formal procedure for identifying and solving underlying problems, such as incompatibility, indeterminacy, embeddedness, and reduction. The procedure allows for a specification of rules, and therefore control of the progressive integration of disciplinary and system-based theories under the unifying meta-theory. It turns out that the unifying procedure endorses alternative theories rather than a single unified theory.

However, in the fourth section the solving competence of this procedure is tested by

generalizing the hierarchical treatment throughout the domain of definition of the problem to be solved. In this way the meta-theory, enriched with rules applied to cybernetic-anticipative feedbacks and circularities, becomes the unifier of the unifying theories used so far.

The model of the unifying theory (MUT), applicable to any transdisciplinary problem, is construed in its general form, and sources for improving on MUT are suggested.

1. Introduction

Unification has become a mainstream scientific endeavor as scientists have acknowledged the need to counterbalance disciplinary fragmentation either by inter-, and transdisciplinary approaches, or by unifying and integrating knowledge. The first became a theme for European thought (led by J. Piaget); the second was only really pursued in America. The latter developed in two distinct trends: philosophers of science focused on the formal conditions to be met by unification; whereas others concentrated on discovering new systems or science-wide features such as informational or mathematical modeling. Rapidly, new systems were defined across disciplinary frontiers, and so laid the foundation of the systems sciences. General system theory (in terms of Bertalanffy, Rapoport, or Le Moigne) has been a seed for unification as much as a framework for maintaining unity within the systems sciences. Both trends converged in the logical foundations laid down in the work of, amongst others, R. Carnap in “International Encyclopedia of Unified Science”.

The definition of transdisciplinary unification (ΓU) involves two key concepts—weak ΓU, and strong ΓU. The first of these refers to integrating neighboring/related disciplines (Ds) through bringing bodies of knowledge, such as D-based methods, languages, or theories to bear on the goals, explanations, or solutions concerned with problems lying on the boundaries between Ds. This kind of unification deepens the structural similarities among Ds in order to create an appropriate framework of interpretation and scientific resolution. This defines the weak form of ΓU where the integrative framework, rather than a theory (T), is instrumental in unification.

Strong ΓU is required when a problem exceeds the solving competence of weak ΓU. Here, unifying unrelated Ds generates the need to produce new knowledge. The strength of this form relies on the T that is built precisely to create the foundation for the unification process. The type of strong ΓU that is most relevant here is the T-based type that includes weak ΓU as a preliminary stage.

2. Rationales to Unifying Transdisciplinarily

Disciplinary fragmentation raises barriers that science can try to overcome through unification. However the explanation as to why the fragmentation itself occurs is also significant. What causes all Ds to change, grow, and by doing so, to become the nursery for new Ds is the need to solve new problems. This need for problem-solving constitutes the underlying cause of diversification as well as for unification, and so the ontological and epistemic nature of the problem is what is responsible for a D adopting one of two directions. Ds are presently solely defined by their specialization and occasionally engaged in building unifying paradigms. Yet every stage achieved in unification is rendered insufficient by new findings and new problems, as science as a whole responds with new Ds, Ts, or unifying attempts. Unification, for that matter, does not occur as a simple reaction—it does not copy the unity existing prior to a certain stage of diversification, just as diversification is not simply about the "splitting off" of a new D or T.

Information theory, systems science, and computer science, for example, do not have precisely identifiable parent Ds in the way sub-Ds have. These are not sub-Ds, but results of unification, as Hall pointed out in "Metasystem methodology: a new synthesis and unification". A decisive role in moving from unification in general toward the $\Gamma\mathrm{U}$ is that played by the accelerated growth of instruments for producing new knowledge through observation, experimental technologies and formal procedures of operating differentiation (see *Metamodeling*).

Among these instruments is the procedure for establishing whether or not a new case of problem-solving (PS) requires unification. Accordingly, a problem (P) is new if its solution depends on a newly built solving procedure (Φ). The solving procedure (Φ) designates problems that science identifies and formulates for itself in order to solve P, which means that Φ is not a species of P. On the contrary, the dependence of P on at least one new Ω indicates that such a P is either unique or the first encounter of an eventual category. This is the only kind that the study refers to as P, knowing that disciplinarity (Đ) is engaged in solving new instances of recognized and stable categories of problems.

This distinction satisfies the rule that **the difference between the disciplinary and the non-disciplinary modality is fundamental, because it is rooted in the ontology of the problem to be solved**. As a species of the latter, transdisciplinary problem-solving (ΓPS) cannot be equated, or confused, with the former. This distinction becomes clear-cut when the second epistemic rule is considered—that **a problem is transdisciplinary if its solution depends on a number of embedded scientific procedural problems, one of which is unknown or has not been previously met, such that the solving process becomes transdisciplinary as well.** Applying these two rules in their formal expression (where $\Phi\overline{\varpi}$ designates the unknown term):

$$\text{Đ} \neq \forall \mathrm{P}(\mathrm{new}\Phi) \Rightarrow \Gamma\mathrm{PS} = [\mathrm{P}(\Phi_{\varpi})] \cup [\mathrm{P}(\Phi_i(\Phi_j(\Phi_{\varpi})))] \tag{1}$$

results in proving that a certain P is not solvable disciplinarily. By way of implication, these rules also underline the ultimate rationale to the need to unify, namely that disciplinarity (Đ) represents an entire modality to which a certain finite solvability is ascribed. One of the ways of extending a finite solvability is by changing the modality itself. **The $\Gamma\mathrm{U}$ becomes a necessary modality, if and only if the Đ modality has exhausted its competence in identifying and solving Φs, which is observable in the systematic failure in solving a P**.

The systematic insolvability of a P can have two main sources. One is the aggravation of P during attempts to solve it disciplinarily. The other is an increase in complexity due to implementing inadequate D-born solutions whose unexpected effects turn into additional worsening factors. In general terms, it is far more difficult to correct a scientifically-based partial solution than to search, from the very beginning, for a comprehensive solution.

However, disciplinary attempts to solve Ps are probably the only way of coming to the realization that new Φs have arisen to such an extent and complexity that a new modality has to be considered. This points to a subsequent rationale, namely that knowledge (K) grows from knowledge and not only from the world that is external to science. Acknowledging the insolvability of a P is one of the forms that the knowledge generated by knowledge takes (see *Second Order Cybernetics*).

To the extent that science is itself a system, systems science becomes the second-order (i.e. across first-order Đ) identifier of constraints for the unifying procedure, as visualized below.

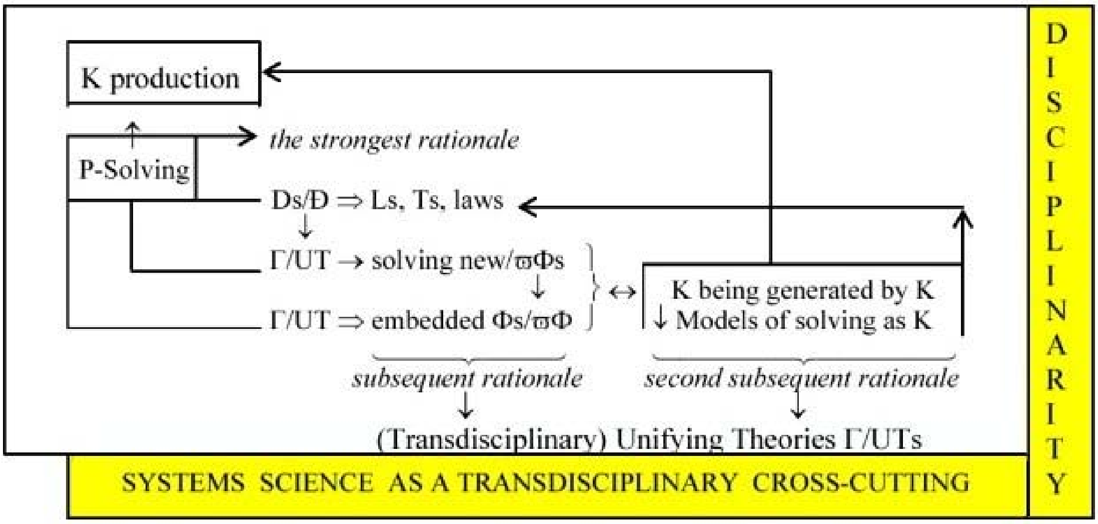

Figure 1. Knowledge production and rationales for ΓU ts.

In this generalized setting the classes of systems are viewed as if they were Đ-like classified. By asserting the general system theory, systems science is a D-like body cross-cutting several, if not all, Ds. On these grounds, it is too early to think of a single ΓUT. Instead, unifying theories (UT) within systems science and ΓUTs derived from reading D-based systems in terms of systems science will be studied in sections 4 and 5.

3. External and Internal Constraints

Since scientists are more inclined to differentiate than to unify, unifying (when it is pursued) is less a natural tendency and more an intended and purposely assumed path. Accordingly, the procedure adopted to follow such a path becomes, necessarily and intentionally, associated with the capacity to theorize. The less natural a procedure is, the more theoretically sound its construction has to be.

Science has two main instruments to use to ensure soundness. The first is to (re)formulate a T or language (L) so that it consists of an alphabet of primary terms, a very small number of axioms, a set of rules of inference, and a domain of reference. In this way, that L or T becomes formal (τ).

The second instrument is the prerequisite of asserting constraints (φ) to the construction, as well as to the applications of a T or L. Ts or Ls that lack axioms, using foundational statements instead, are more likely to compensate for this lack by stating an axiom-like φ. However, an eventual UT or ΓUT would not be axiomatic in the first place, knowing that a general T of how to unify simply does not currently exist. Hence the soundness of UT, whatever it may be, relies heavily on explicit φs.

The dual nature of systems science (attempting to unify itself, but also a potential unifier) means that it is fair to separate internal from external φs. The first is the case when both the unifier and the unified belong to systems science; the second, when only the unifier does. Some φs will be rationales stated in τ form. These apply to two types of Ps of interest here: a P within/of systems science; and a P signalized in Đ and solvable by unifying systems science and a form of Đ. In either event, P is exhaustively defined by four properties occurring simultaneously. P: (a) depends on solving Φs; (b) is due to intervention (whether science- or policy-based); (c) is highly complex; and (d) is heterogeneous.

Obviously, these properties are partially co-extensive. For instance, (b) generates an increase under (a) and (c), whereas (c) and (d) are mutually dependent. While Φs are numerable, complexity (C) and heterogeneity (H) are not. There is currently no definition of C or H other than in direct reference to certain entities or objects. For this reason it is only when P is well-specified that C and H can, and must, be defined. This constitutes the first and most troublesome φ. Since C and H are properties that only the thinking can identify and, because they enclose and determine other properties, they are assigned as supervenient properties (μ). The C and H of an L/T become an internal φ, $\varphi_{\text{C-H}}$, for the domain of reference of that L/T.

Solving through unification means that a modal conjecture relates the unifier to the unified bodies of knowledge, and the complexity-heterogeneity constraint is the qualitative first-order index (necessary specifier) to the reference domain of the transdisciplinary unifying theory.

With the advancement of computer science, it became possible to define C for an outlined system or object, but this cannot be generalized given that computational C covers the parameterized side, while the non-parametric remains a matter for T-building. The computer science definition for H is limited to programming languages, which does not apply to all Ls in systems science or Đ, nor to the semantic incompatibility and intranslability. For the moment it is enough to state that **the degree of C-H approaching the computational maximum** (provided by the disciplinary failures to solve P), **indexes a highly complex-heterogeneous P**. This holds for the amount of Φs as well as for the notions of feedback and circularity that will be introduced later (see *Pansystem Theory and Methodology* and *Klir Methodology*).

3.1 Related Constraints

As is known, UTs cannot withstand unification if they disregard φs imposed by the bodies of knowledge that are about to be unified. Specific φs referring to D-based or system-based objects (Ω), methods (Þ), or Ls/Ts are accounted for. The φs referring to Ls/Ts are stronger than those referring to Ωs and Þs, given that the latter are identified on the basis of Ls/Ts (see section 4.3 below). The formal (τ) Ls/Ts make the $\varphi(\tau \mathrm{L})$ or $\varphi(\tau \mathrm{T})$ prevail over other φs, except the $\varphi_{\text{C-H}}$. When L and T form a unity, as is the case with formal sciences and systems, then $\varphi(\tau \mathrm{LT})$ equals or may prevail over $\varphi_{\text{C-H}}$. As the Ωs, Þs, Ls, and Ts are related, φs issued by them are related too, which draws the attention to the important distinction between related and independent φs.

Because of their relatedness, φ_{Ω}, $\varphi_{\text{Þ}}$, φ_{L}, and φ_{T} cannot become independent, while $\varphi(\tau \mathrm{LT})$ has to specify whether it is external or internal to the bodies that are to be unified. The precise order of relatedness can be specified when it is known which is the unifier and which the unified. For instance, when the composition of a P becomes intelligible so as to make sense of the phrase “the Ω of P is…”, then the $\varphi_{\mathrm{P} \approx \Omega}$ might be thought of as independent with respect to $\varphi_{\text{Þ}}$, and approximately equal to $\varphi(\tau \mathrm{LT})$, whereas the Ωs of Ds can no longer press φs of any kind.

3.2 The Independent Constraint

There is a good reason for aiming at the independent φ, which is to avoid two reciprocally incompatible knowledges both qualifying as correct within the same LT. To assign the independent φ, an UT or $\Gamma \mathrm{UT}$ is construed by satisfying those φs that derive from describing P as a $(\mathrm{P} \approx \Omega)$, and from μs identified in this stage. Because knowledge is time-dependent, there is no independent φ in absolute terms, but the φ imposed by $\tau \mathrm{LT}$ can be provisionally assigned as independent. This means first, that the UT or $\Gamma \mathrm{UT}$ is built in stages by strengthening φs and simulating their solving competence while one or another φ is taken for the independent one; and second, that the result may well become definitional for the research modality itself. For instance,

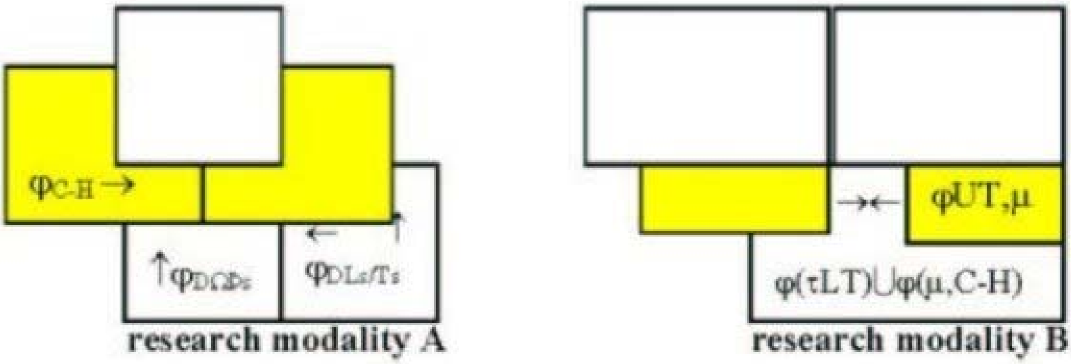

Figure 2. Searching for the independent constraint.

The search may be cut short by trying to reduce related φ s up to the point at which the resulted φ becomes irreducible. Many system scientists sustain that reductionism is inappropriate for systems science. However, reduction is a very solid and rigorous procedure to apply in order to overcome deadlocks or ambiguity. It is true that when reductionism overtheorizes on classes of systems, it becomes counterproductive. But the method of reduction enables, for example, the construction of models across formal systems. If not abused, reduction does not turn into reductionism, and it is always better to reduce than to simplify through avoidance.

Certainly, the L/T that is unable to reduce the number of candidates for the function of φ to a maximum of four, one of which is the independent φ, would not be able to assist unification, and would therefore be unable to solve a P by unifying. The difference between modality A and modality B in Figure 2 indicates that reduction will inevitably be used to obtain the independent φ concerned. Largely, the irreducible φ qualifies, almost automatically, as the internal φ to the ΓUT domain of reference, whether this is system-born or not (see also Figure 4).

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Internet resources:

- www.snf.ch/transdisciplinarity/home.html [For the latest research reports, theories, and case studies.]
- www.unibas.ch/mgu/ [This is a presentation of transdisciplinary curricula applied effectively.]
- www.perso.club-internet.fr/nicol/ciret/ [For those interested in the epistemological and knowledge-theoretical foundations of transdisciplinary thinking.]

Biographical Sketch

M. Lunca Ph.D is a former researcher and fellow of ISOR Utrecht University. Recent publications include research reports on the Computation of large-scale social research programs (1988-1990), Theory for intervention for managers (1992), Interdisciplinarization as a programmed process (1993–1995), and Social segmentation and virtual communities (1997-1998); studies on Model Theory and System Theory Involved in the Tendency toward Interdisciplinarization, Semantic Completeness of Unformalized Languages, Interdisciplinarity, and Cybernetics of Complexity Applied to Problem-solving; and books entitled *Information, Semantics and Formal Languages* (as editor), and *An Epistemological Programme for Interdisciplinarisation* (published in 1996). Dr. Lunca is currently preparing a course on an interdisciplinary methods package to be introduced in the curriculum of the newly formed Institute of Information Science, Utrecht University; tentatively cooperating with the Department of Management and Systems Science at Hull University to organize a summer school on “Problem-solving at the cross-roads” of General System Theory and Information Theory; and preparing for the International Conference of Joint Trandisciplinary Problem-solving, Zürich (“Crossing and Unifying Disciplinary Languages”); and the Second International Conference of Sociocybernetics, Panicosta, Spain (“N-valued Semantics for Undecided Actors”).