Stress and Related Concepts
in Physics and the Social Sciences

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Stress and Related Concepts in Physics and the Social Sciences [3]

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ABSTRACT [5]

In psychology and the social sciences, *analytic* issues, *i.e.,* issues that are decidable by choosing definitions of terms and by selecting a formal calculus, are often treated as *synthetic, i.e.,* as if they could be decided by ontological disclosure or by observation. Among these are many issues relating to 'stress'.

In this paper I describe a family of concepts of which the term *stress* is a member. Then I outline a theoretical approach within which issues concerning behavioral stress can be formulated and resolved. Drawing on the physical theory of matter and on phenomenology, I consider the conceptualization of stress within the psychological and sociological theory of action.

The locus of the concept of stress is established within the theory of *motivation*; the primacy of the idea of the *deformation of the surface* of a system is asserted; the principle of *management of tension* is introduced; and a systematic classification of stresses resulting from *normal* and *abnormal loads* (situations) experienced by an actor is referred to.

Finally, the place of the theory of motivation in the contexts of the theories of action and of living systems is identified, and the difference in the formalization of the theory within a classical and a postmodern system paradigm is indicated.

INTRODUCTION

Conceptualization

When one attempts to conceptualize a domain of phenomena, there are no intrinsic rules available to guide the enterprise. While the *dictum* in the platonic tradition is that there is a distinct, proper way to articulate each particular phenomenon (e.g., the proper way to carve a turkey is at the joints), I believe that a preferred conceptualization is one that best satis-

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fies the cognitive interest of the person(s) concerned (although a turkey carved at the joints may be satisfying at a feast, it would not please a neuro-anatomist).

In practice, the conceptualization of a domain of phenomena is the result of the range of experience, interests, conceptual repertory, basic metaphors, formal skills, and the intended audience of the conceptualizer(s). As a result, early formulations of any domain of phenomena are largely parochial. Eventually, fundamental 🕮 *60* abstract similarities of apparently dissimilar concrete phenomena are recognized, and the appreciation of the power that could be derived from a common conceptual framework and a general theory motivates attempts at unification. My interest is along these lines, and I have tried to benefit from intellectual efforts in other disciplines, notably in physics, biology, and economics, when approaching conceptual problems in psychology and sociology.

Analogy

In drawing analogies, one can start either with formal or with conceptual similarities between phenomena. In this paper, I shall proceed from conceptual similarities, noting formal resemblances only when they seem necessary in order to define the concepts[6] under discussion.

Phenomenology

One of the fundamental concepts, which could phenomenologically ground an interdisciplinary domain of inquiry, is ‘stress’. Different families of concepts that bear striking resemblance to each other characterize the experience of ‘stress’ in physical bodies and in living systems. These resemblances will be now explored.

CONCEPTUALIZATION OF STRESS

Received distinctions

‘Stress’ is experienced in a great variety of units. The received distinctions between the units to which we now wish to apply the same conceptual network may, for the purpose at hand, be classified, for example, as follows:[7]

A. INDIVIDUALS [8]

A.1 Extended and bound in physical space-time, *i.e.,* systems of matter / energy: BODIES

A.1a Physiological systems: ORGANISMS

A.1b Mechanical systems: MACHINES

A.2 Extended and bound in some other (telic[9]) state space-time, *i.e.,* systems of meaning / information: ACTORS

A.2a Psychological systems: MINDS

A.2b Cultural systems: TEMPLATES

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6 Strictly speaking, constructs.

7 For a discussion relevant to this classification, *cf.* JUNG (1987).

8 For the distinctions between individuals, groups, aggregates, and plena, *cf.* JUNG (1983) and (1989a).

9 *Cf.* JUNG (1965b).

B. GROUPS, AGGREGATES, AND PLENA

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B.1 *of bodies (material, ecological, and technological systems*), here called CLUSTERS

B.2 *of actors,* here called SOCIETIES

These and other more detailed distinctions generate domains of inquiry, in which the differences in the experience of 'stress' and other related experiences are emphasized, and domain specific concepts and theories are formulated. The *differentia specifica* stand out. Was this or another similar classification taken as a point of departure, the resemblances between the 'stress' related terms employed in the various domains would appear as merely semantic, e.g., as homonyms. No *genera* – and therefore no compelling reason for, or apparent way toward, a unified conceptualization of the distinguished domains – are disclosed.

Phenomenological grounding of the domain

Yet the time-honored strategy of unification presupposes the identification of a crucial common phenomenon. Is there a way to reverse our fragmented impression? Is there a common, general feature that can be found among all the unit- and domain-specific conceptualizations of the experience of 'stress'?

The essence of stress is that it is an experience arising NOT in the different kinds of individuals, groups, aggregates or plena, BUT ONLY in the situated individual,[10] *i.e.,* any kind of individual[11] situated *vis-à-vis* himself, another individual, a group, an aggregate, or a plenum. With this shift of perspective from a phenomenal to a phenomenological conception of 'stress', the FIRST decisive step toward common conceptualization of the 'stress' domain has been taken.

The 'stress' domain of scientific inquiry can now be analytically constituted by the same basic *concepts* and fundamental substantive, methodological, and theoretical *problems*, whether the systems studied are physical, physiological, psychological, ecological, or sociological.

Unified formulation

Formulating a fundamental substantive problem — and the methodological and theoretical problems related to it — objectively constitutes a domain of scientific inquiry. These paramount problems are appropriately stated in the most abstract and general basic terms available. Concepts and relations peculiar to the domain of inquiry are defined subsequently, and only if necessary to solve domain-specific problems.

Let us first adopt the following ancestral family of *concepts:* a system, its 🕮 62 boundary or surface,[12] its environment, its interior, and forces.[13] The first conceptual offspring is a distinction between external and internal forces. Of the external forces, only those acting on

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10 For a discussion of situated individuals, *cf.* JUNG (1983), (1985c), and (1989a).

11 Individual, group, etc, are analytic, not real entities. The distinctions imply a different way of predicating a system on the respective common sense referent or *thing. Cf.* JUNG (1985b). Thus a molecule, a cell, an organ, an organism, a person, a family, a community, or a galaxy can be formalized as an individual system situated *vis-à-vis* any other system. Since it has been argued that 'stress' is an experience peculiar to individual members of a family, but not applicable as a concept to the family as a whole, I wish to make clear that such is **not** an implication of the term *individual* as used here.

12 Depending on interpretation.

13 *Force* in the present context is a term for the relation on, or an exchange between or within, the entities designated by the previous concepts.

the surface of the system are of interest here; they are called loads. Among the internal forces we shall distinguish those called strain and those called stress.[14]

The two related *substantive problems* are:

1. Knowing the deformation of the surface (boundary, shape) of a body, what is the distribution of forces within it?
2. Knowing the distribution of loads, *i.e.,* forces acting on the surface of a body, what is
    a. the resulting deformation of its surface, or
    b. the distribution of forces within it?

The basic *methodological problems* are:

1. How to observe the actual forces within an intact body without interfering?
2. How to describe adequately the characteristics of the body that are relevant to, but independent of, its actual deformation or subjection to load?
3. How to measure, independently of each other, the loads and the deformation of surface?

The basic theoretical problem arises because a deterministic explanation or prediction of the behavior of bodies under load is often impossible.[15] Instead, deductive inference from data obtained by a case-historical method of analysis becomes necessary.[16]

Common concepts

The *conceptual* apparatus originally developed by physicist to study the above problems in solids and fluids is also fully relevant to the study of these problems in organisms, actors, clusters, and societies. Once their physical meaning and their logical status are fully appreciated, the concepts evoke immediate intuitive meanings denotative instances from psychology, sociology, and economics. This is not only the case for the distinction between *strain* and *stress,* between *loads* as forces (vectors) and strain and stress as force-fields (tensors), and between *rigid, elastic, plastic,* and *rupture* types of behavior, but also for many other concepts, such as *softening, fatigue,* and *work hardening.*

The elementary conceptual picture drawn by the physical theory of matter, that is also directly relevant to the analysis of stress in living systems, is extremely simple. It is only its further elaboration and formalization that requires special knowledge and mathematical skills, and is not necessary in the present context.

An external force called load acts on the surface of a body. This manifests itself in various kinds and amounts of change in the shape of the body, called deformation of the surface of the body. The kind, amount, and duration of the deformation depend, of course, on the magnitude, direction, and duration of application of the external loads on the surface of the body.

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On the other hand, the specific deformation is only explainable by also taking account of the internal forces within the body (which we may think of as caused – or modified – by

[14] It will turn out that components of strain and stress can be regarded as internal loads on the surface of the system or the surfaces of its subsystems.

[15] It would require knowledge of the initial states of infinitely many variables, and the solution of an infinite set of simultaneous equations.

[16] A mathematical deductive system that is applicable to this problem is the integro-differential calculus.

the external load). These internal forces can be classified into deforming forces called STRAIN that seem to be propagating the load within the body, and restoring forces called stress that seem to resist the deforming effect of the load, and under special circumstances may to some degree restore the original shape of the body when the load is removed.

Whether, under a particular load, the body

- retains its original shape without significant deformation (*i.e.,* exhibits *rigid* behavior),
- yields and becomes deformed, but upon the removal of the load almost restores its original shape (*i.e.,* exhibits *elastic* behavior),
- yields and after the removal of the load retains the deformed shape(*i.e.,* exhibits *plastic* behavior), or
- disintegrates under the load (*i.e.,* exhibits *rupture* behavior)

depend entirely on the distribution of the internal forces within the body.

The relevant distribution of the internal forces can be expressed as a ratio of restoring over deforming forces. This ratio is called the elastic modulus of a body. Thus:

ELASTIC MODULUS = STRESS / STRAIN.[17]

The distribution of the internal forces in a body under load(s) — given a load of a specific magnitude, direction, and duration — is explainable with reference to the distribution of matter within the body (its organization). One thinks of the architecture of the body as consisting of various parts (ultimately points). As a load acts on a part (point) on the surface, the local deformation of the impacted part acts as a load on the neighboring parts (points), thus causing them in turn to deform (and to translate, rotate, and vibrate). In this manner components of the force of the external load are propagated throughout the body, causing the deformation of the total surface of the body (and not only a local deformation at the point of application of the external load). Each part of the body (for complete analysis, each point) is therefore treated and described as a body under load.

The criteria of classification of bodies are based on the values of additional variables and relations, which determine or characterize their behavior under various loads. Among the criteria that appear equally suitable for the classification of organisms and actors in this context are:

- the characteristic values of their *elastic limits,* yield points, and breaking points;
- the various *coefficients* expressing their resistance to deformation and their restoring tendencies as functions of type and magnitude of load, the extent of the already realized deformation, and the duration of application of load;

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- description of their *anisotropy, i.e.,* distribution of the above characteristics relative to different directions within the body; and
- description of their *heterogeneity, i.e.,* distribution of the above characteristics with respect to different locations within the body.

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[17] According to Newton's Laws of Forces, the elastic modulus of a material body is always *equal or smaller than 1*, but when Bolzman's (Second) Law of Thermodynamics, as well as other considerations are taken into account, it is always *smaller than 1*. That means that in a material body that has been subjected to a load, the restoring forces (stress) are always smaller than the deforming forces (strain), and the body will not completely return to its original shape after the removal of the load. When stress and strain are considered as *tensors,* the expression would read STRESS * STRAIN^{-1}.

APPLICATION TO BIO-(PSYCHO)-SOCIAL SYSTEMS

These concepts and principles of classification also seem capable of partitioning differences between the behavior of bodies, organisms, and actors under load into those that are only a matter of degree and complexity (explained by the pervasive anisotropy and extreme heterogeneity within organisms and actors), and those that appear to be fundamental.

Bio-(psycho)-social systems as hyper-matter

Among the differences that seem fundamental and that can be expressed and explained precisely and elegantly within the general formulation, are:

- The apparent HYPERELASTICITY of organisms and actors under certain kinds of loads.

  Matter in its elastic range is only partly successful in resisting deformation, and only partially restores its original shape.

  Organisms and actors, however, often appear to over-restore their form, sometimes even while the load is still being applied.

  This results in secondary deformations and gives rise to various cycles of successive deformations.[18]

- The apparent HYPERPLASTICITY of organisms and actors.

  In the plastic range, matter flows only while a sufficient load is applied, and freezes into a permanent deformation once the load is removed.

  Organisms and actors, however, often continue to flow and deform even after the load has been removed.

  This general type of response receives various interpretations in the behavioral sciences, among which the ideas of internalization of external forces (delayed learning) may be mentioned.

- Both types of behavior are explainable by a fundamental DICHOGENEITY that seems characteristic of organisms and actors.

  Two media with basically different rigid, elastic, plastic, and rupture properties are *laminated* into one system. One medium functions as a receptor / information / control subsystem, the other as an energy-amplification / effector subsystem.[19] The interaction of these two subsystems makes a joint over-compensating response possible.

  In the hyper-elastic case, a minimal load is sufficient to deform the information-control subsystem. Its response activates the energy subsystem, which provides the amplification of the total response.

  In the case of hyper-plasticity, the energy for the continuing deformation of the information-control subsystem (after the external load has been 📖 *65* removed) is provided by the energy subsystem. This in turn explains the continuing changes in overt responses, even though no external load is present.[20]

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[18] Among the many examples that suggest themselves, perhaps the processes described by SELYE (1956) as *diseases of adaptation* are most striking.

[19] The primary differentiation of MOST organisms into an ectodermic and an endodermic layer is worth noting in this context.

[20] It may also be possible to explain the apparent hyper-rigidity and hyper-fragility in the behavior of organisms and in the actions of actors in this way.

Forces, loads, surface

Problems concerning not only mechanical, but also electrical and chemical forces can be formulated and solved in this conceptual framework. Can the same framework be more than a language for a systematic general discussion of the problem and a scheme for collation of essentially qualitative information, when it comes to biological, ecological, psychological, and sociological 'forces'? The answer depends on our ability to define the nature of these forces, and then to identify individual forces in terms required by the conceptual formulation outlined in the preceding pages. We can regard the physical conceptualization of matter as a format for the isolation, identification, and specification of forces. This should make our task easier than if it were approached as an unfocussed general problem.

Before such conceptualization is attempted, several general issues must still be clarified:

FORCE is simply an abstraction focusing our attention on the possible effect of the relation of an entity (be it a physical body, an organism, an actor) on other entities. We may interpret the behavior of an organism as a set of exchanges with its environment, or the actions of an actor as exchanges with his/her situation. The exchanges may be interpreted as 'forces,' whatever the items exchanged, are they objects, energies, information, relations, attitudes, characteristics, and so on.

LOADS can be any *external* forces acting on the surface of an organism or of an actor. They are generally conceptualized as originating in the environment of the organism, or in the situation of the actor. However, components of STRAIN (deforming forces) and STRESS (restoring forces) can also be regarded as *internal* loads acting on the surface.

Loads can be *positive* as well as *negative* forces, *i.e.,* external (environmental, situational) as well as internal surfeits or deficits. We can often understand the activity of a system as being 'driven' by various changing loads, or as 'seeking' a balance at its surface between internal and external surfeits and deficits. When integrated over time, this balance can be employed in training effects due to prior overloads, and conversely, prior underloads may result in the atrophy of the ability of the system to resist previously normal and reversible deformations. 'Work hardening' as well as 'fatigue' is adaptation to a history of loads.

Another important distinction is between *normal* and *abnormal* loads. Loads are called normal when they act perpendicularly on the surface of a body, and abnormal when they act at another angle. In the ideal case of a perfectly homogeneous body we can expect that the internal forces elicited by a normal load will have the same orientation as the load, and the restoring force (stress) will tend to restore the body to its original shape. Abnormal loads, on the other 🕮 *66* hand, are likely to induce shearing[21] strain and/or stress within the body, with resultant peculiar internal and external deformations and responses as a result.

An application of the above distinction to organisms and actors requires a specific description of the surface of the organism, behavior, actor, or action in terms of the planes on which the loads act.[22]

Sometimes even extreme loads are incapable of modifying certain responses. This is not only the case with inherited responses, but also with learned ones. Freud discussed this phenomenon as neurosis: the neurotic nucleus cannot be 'dissolved,' but one can learn to live with it (secondary adaptation).
Similarly some behaviors are extremely fragile, and they may shatter under minimal external loads.

21 From Latin *cernere,* to separate.

22 I have attempted such definition in JUNG (1965b).

MOTIVATION

The conceptual apparatus of the physical theory of matter may be fruitfully applied to the analysis of biological, mental, and social stress, within the larger context of the theory of motivation. The rudiments of the relevant physical concepts have been exposed, and some analogies to similar phenomena in living systems were drawn.

The actual application depends on the conceptions of mental and social phenomena one holds, and will differ for different students of the phenomena. The present paper is an invitation to independent applications of this framework. In the following sections, I shall describe my own efforts in this direction and highlight some aspects of a complicated and detailed enterprise.

Key analogies

To apply the formulation outlined above to physiological and psychological systems,[23] two further analogies have to be drawn.

Motivational state

The distribution of internal forces within the organism, *i.e.,* the relation of strain to stress, can be interpreted as its *motivational state.* Of particular interest are two types of motivational states:

- A state in which the strength of the forces within the organism / actor is increased or decreased, but the forces remain in equilibrium (analogous to a heating or cooling of a physical body reflected in changes of its phenomenal properties such as pressure, volume, and/or color).
- A state in which there is an imbalance of internal forces and there is a coherent set of forces acting in a given direction (analogous to a state of a physical body capable of work).

The first motivational state could be interpreted as *arousal,* while the second state as *specific motivation*[24] *of an organism or an actor.*

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Tension

The last analogy requires that some principle governing the behavior of forces within organisms or actors be postulated. Elsewhere,[25] I have postulated a *principle of the management of* tension that regulates all motivational processes. According to the principle, each action of an actor is (partially[26]) explainable in that it is compatible with *the reduction of the maximum possible amount of tension* (it being understood that among the constraint on what is possible are processes within the actor other than motivation).

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[23] The application of the framework to stress in social systems shall not be considered here.

[24] E.g., drive.

[25] In my formulation of the *Special Theory of Motivation. Cf.* JUNG (1981). For a compatible formulation of the principle of the management of uncertainty, *cf.* JUNG (1965b) or (1989d).

[26] An action of an actor is explainable by his intention, which is composed of three components: *orientation, motivation,* and *decision.*

The theoretical context

To avail itself of more general formulations and to contribute in turn to their development, the theory of motivation is located within the theories of living systems and of action.

Theories of action

Some of the results that I have so far outlined are reflected in my formulation of a Special Theory of *Motivation*. As the Special Theory of *Orientation*[27] and the Special Theory of *Decision*,[28] the Special Theory of Motivation is conceived as one of the three components of a General Theory of *Intention*, which, together with the General Theories of *Interaction*, *Transaction*, and *Transformation* would comprise a Unified Theory of *Action*.[29] The Unified Theory of Action would express the theoretical perspective on living systems anchored in the Metaphor *Mind*.[30]

Choosing the metaphor mind as my starting point, I develop a mentalistic (rather than a naturalistic) account of the actions (rather than behavior) of an actor (rather than of an organism). All the systems, subsystems, processes, and transformations have as their substance meaning (rather than energy). The actor is seen as a system of meanings and so is his/her situation. The actions of the actor are seen as the result of his/her intentions within a situation. The intentions are the resultant of three semi-independent internal processes: orientation, motivation and decision, which are influenced by each other and the situation. Each process, e.g. motivation, is the product of the interaction of six[31] subsystems.

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The special theory of motivation

The format chosen for the formulation of the Special Theory of Motivation[32] is the physical theory of matter.[33]

Within the theory, the boundary of each of the six subsystems can be regarded as a different *plane* of the motivational surface of the actor. All the loads acting on the same plane constitute a sector of the actor's situation.

When subjected to a normal load, the actor experiences (in the relevant subsystem) states that can be phenomenologically identified as, for example, pleasure, pain, mystery, endurance, mastery, solidarity, or antagonism. When, however, the actor is subjected to an abnormal load, and motivational conflicts occur as a result of shearing strains and stresses,

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27 JUNG (1965b) and (1989d).

28 JUNG (1965c).

29 For a systematic exposition of the structure of the Unified Theory of Action in outline form, *cf.* JUNG (1987). An updated version is forthcoming as JUNG (1989b).

30 To provide a comprehensive view of life, three other theories would have to be developed, based respectively on the metaphors *organism, machine,* and *template*. I call these theories of *behavior, performance,* and *conduct*. *Cf.* JUNG (1987).

31 Twelve (and then 36) subsystems in a more detailed analysis. *Cf.* JUNG (1965b) and (1962b). A substantially revised, integrated, and expanded version is forthcoming as JUNG (1989d).

32 Other Special Theories employ different formats.

33 Which is adequate only for an initial, classical formulation of the theory. As indicated below, for an adequate, postmodern formulation, other formats must also be included.

the actor experiences (in the relevant subsystem) states that can be phenomenologically interpreted as, for example, irritation, insignificance, absurdity, impotence, anomie, or loneliness. Of particular interest are abnormal loads that activate shearing forces that separate the different subsystems. These give rise (depending on which subsystems are dislocated with respect to each other) to motivational states that are experienced as guilt, shame, or anxiety.[34]

Historicity

As has been known for over a hundred years, all macrophysical complex systems (bodies) retain traces (engrams[35]) of their previous experiences, and in that sense posses memory and are teachable, *i.e.,* susceptible not only of 'genetic,'[36] but also of 'didactic'[37] programming.

In response to loads (positive or negative, normal or abnormal), the surface of the actor becomes deformed (whether the response is elastic, plastic, hyper-elastic, or hyper-plastic). Therefore, each subsequent application of the objectively same load has different effects. Another way of stating this is to say that the motivational system exhibits *historicity, i.e.,* it develops as the result not only of its present, but also of its past experiences. Thus objectively identical loads may now impact different planes of the surface of the system or its subsystems than they did earlier, and loads that were previously experienced as normal may now be experienced as abnormal, or *vice versa.* The meaning of the loads often changes with successive applications. For the prediction of future responses, it may be important to distinguish between a mere deformation of the surfaces of the system and the sub-systems (e.g., in response to normal loads) on the one hand, and a concomitant 📖 *69* deformation of the structure of the system (e.g., in response to abnormal loads) on the other hand.[38]

Prosthetic subsystems

Sometime these changes can be reversed (deliberately or accidentally) by the application of corrective loads, but often they are irreversible. In the latter case the original response to a given load can be only obtained by the addition of prosthetic compensatory subsystems.[39] These can be external, such as the cooperation of another actor (e.g., therapist, friend, counselor, dog), or become internal by the 'implantation' of an artificial response system. If we were concerned with the analysis of organisms, we could think of external prosthetic devices such as lenses or sound amplifiers, or in the case implants conjure up visions of cy-

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[34] For a systematic discussion of the thirty-six subsystems and the relevant experiences, *cf.* JUNG (1962b) and (1965b) or (1989d), especially Table 8.

[35] The term engram has been coined (in German as *Engramme*) in the late 19th Century as a hypothetical construct to explain the historicity of matter in the context of *"die allgemeine Irritabilität der Materie"*. In biology it is still sometime used to describe the durable mark caused by a stimulus upon protoplasm, while in psychology it has assumed the meaning of a postulated memory trace in neural tissue.

[36] I am using the term genetic here in its general sense, *i.e.,* determined by construction, as in 'hardware' or 'hard wired'.

[37] From Greek *didactos,* capable of being taught; all such systems are in some respects docile (from Latin *decere,* to be fitting), adaptable, externally controllable, and therefore not fully autonomous.

[38] The distinction between short-term and long-term memory could be formulated this way.

[39] In this context, a prosthetic subsystem is designed to convert a load experienced by the system as abnormal (resulting in shearing stress and further non-adaptive deformation) to a load to which the system will respond with adaptive behavior, be it rigid, elastic, plastic or rupture. In general, a prosthetic subsystem is designed to change the parameters of the total system so that the responses to loads become adaptive.

borgs. As we are concerned with actors, a vision of 'socio-orgs' is quite appropriate, since much of the development of actors consists of the 'implantation'[40] of cultural artifacts (templates, institutions) as drilled, over-learned response subsystems to specific loads (e.g., multiplication tables, karate, typing, taboos, etc.). In the language of the physical theory of matter, this would not be called conditioning, education, or socialization, but pre-stressing.

CONCLUSION

To move from the varied conceptualization of stress in physics, biology, psychology, and sociology to a unified conceptualization and eventually to a common theory appears possible, but requires a long series of analytic decisions. As old analytic problems are dissolved, new synthetic problems are defined. That is the task of theory.

Definition of a common domain

Striking resemblances exist between the families of concepts used to describe stress and related notions in various disciplines. However, a phenomenal classification of the domains to which similar terminology is applied fails to reveal a common conceptual basis. Phenomenological grounding of a joint domain of inquiry is first made possible by the recognition that the common referent of all the relevant terms is the *situated individual*.

What then becomes apparent is that 'stress,' 'strain,' etc. are epiphenomenal. Phenomenologically, the pivotal, real experience is the *deformation of the surface* of the individual system (body, organism, actor). The replacement of 'stress' by 'deformation of surface' as the root concept is the second shift needed to phenomenologically ground the joint domain of inquiry.

The interpretation of the terms *deformation of the surface of a situated individual* — for bodies *a priori* interpreted as living systems of energy (organisms) or as systems of meaning (minds, templates, actors) — becomes then the fundamental conceptual problem for the joint theory. Among the steps in dealing with the 📖 70 problem is the decomposition of the surface of the individual system into planes; a corresponding decomposition of its relevant environment (situation) into sectors; and a complementary decomposition of its interior into subsystems. This enables a consistent classification of loads.

The observation of the deformation (*i.e.,* change of form) of the surfaces of organisms and actors without introducing artificial loads becomes the fundamental methodological problem. That many such procedures already exist, and would only need to be modified to fit the new conceptualization, is obvious.[41]

The fundamental theoretical problem becomes the general explanation of the particular deformations of surfaces of particular situated individuals.[42] Here the conceptual apparatus of the theory of matter[43] comes into play, not only in enabling us to form biological, psycho-

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[40] In psychological terminology, *internalization*.

[41] Perhaps the measurement of skin temperature as a diagnostic tool for 'disease,' or the use of physiognomic and kinesiological criteria and/or polygraph records for 'lie detection,' may serve as elementary examples.

[42] Clearly we do not expect the physical theory to explain the behavior of organisms or the actions of minds. There is, however, every reason to try to formulate the bio-(psycho)-social theory in as homologous way as possible, if only to establish what is different.

[43] The key concepts have been discussed in the preceding sections.

logical, and sociological concepts by analogy, but also in guiding us to formulate compatible constructs.[44]

It is here that the last major analytic choice is to be made. It is customary to allocate the source of explanation for the phenomena of interest either to the environment of the system as loads (situations) or to its internal composition (personality, character). Instead, I shall try to allocate the source of explanation to the interface of the two, *i.e.,* to the *dynamics of the surface* of the system. To realize this, the system has to be cast in the functional form.[45] So reformulated, external loads become boundary conditions, relevant internal stated and structures become functional subsystems, and the deformation of the surface becomes the essential variable. The value of the essential variable is governed by an extremal (variational) principle, *i.e.,* a principle of *optimal form.*[46]

Interpreted in terms of the common conceptualization, the principle of optimal form becomes the principle of management of tension. This principle is compatible with the phenomenological grounding of the joint domain, with psychological and sociological intuitions,[47] and with both the classical and relativistic theory of matter. It also makes possible the seamless integration of the theory of motivation into the general theory of action within a common system-theoretic and cybernetic formulation.

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Classical theory of motivation

The analysis suggests that bio-(psycho)-social phenomena can be conceptualized, at least in the domain of motivation, in a way analogous to the conception of physical phenomena. Drawing on the analogous system in physics enables a conceptual clarification of the bio-(psycho)-social system of motivation. Beyond providing a new abstraction (metaphor), it reveals the theoretical and methodological problems that need to be solved in order to develop an adequate 'classical' theory of motivation, formatted on the classical theory of matter. This is by itself and important theoretical advance. The problems are not produced by the new conceptualization, but defined by it. They are inherent in the analysis of any very large, heterogeneous, and anisotropic system — which any living thing (whether seen as an organism, a mind, a machine, or a template) clearly is.

Postmodern theory of motivation

A reconceptualization of motivation, in terms analogous to those employed in classical physics for the analysis of experiences of a material system under loads, would locate the prob-

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[44] *I.e.,* concepts, the relations of which to other concepts are formally specified. The descriptive construct 'hyper-matter,' exhibiting properties such as hyper-plasticity, and explanatory constructs, such as lamination, dichogeneity, control, and amplification, are examples.

[45] For a discussion of the functional form, *cf.* e.g. JUNG (1981). For a more extensive discussion of the four forms of systems, *cf.* JUNG (1989a).

[46] *Cf.* JUNG (1985c) and (1989c).

[47] One may be tempted to describe the operation of the Principle of Motivation (Management of Tension), in paraphrase of POWERS (1973), by asserting that motivation is the control of tension, and action (in part) the control of deformation. However, the similarity is somewhat misleading. The appearance of the casual connection between behavior and perception, and the inversion of the normal belief that perception controls behavior (rather than *vice versa* as Powers asserts) is one of the consequences of operating within the functional form, where, in the present case, tension has been assigned the status of the essential variable, and motivation the status of a functional subsystem that maintains the value of the essential variable at an extremum within a set of boundary conditions. Since regulatory processes are notoriously circular (*cf.* the German term *Regelkreis* for feedback loop), the picture could be erased or reversed by appropriate formal transformations.

lem within the 19th Century system paradigm.[48] An analogous 'classical' theory needs to be developed first. However, an adequate theory of bio-(psycho)-social systems seems only possible within a 20th Century, postmodern system paradigm.[49] This would involve an application of a thermodynamic formulation not only to aggregate systems, but also to the 'inside' of individuals; a reformulation of the loads and deformations of surfaces in relativistic field-theoretic terms; and a reconceptualization of the experience of the individual from a quantum-theoretic perspective. While I made progress in dealing with these issues, their discussion is beyond the scope of this paper.[50]

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[48] JUNG (1989c).

[49] *Ibid.*

[50] I have dealt with some of the issues in conference papers and am preparing Working Papers on the relevant topics. The difference in analyzing the situated individual when the substratum is an individual, a group, an aggregate, or a plenum is defined in JUNG (1983) and will be dealt with extensively in JUNG (1989a). The emergence of psychological and social forces I have discussed most recently in JUNG (1985c). The necessity of radically different geometrodynamic formalization of identical deformations of the surface of living systems has been mentioned briefly in JUNG (1985c) and discussed in technical detail in my lectures to the Center for Systems Research Faculty Seminar at the University of Alberta in the Fall of 1987. From a more general point of view, it will be discussed more extensively in JUNG (1989c), the contents of which have been presented in a series of seven lectures to the Center for Systems Research Faculty Seminar at the University of Alberta, May – June 1988.

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[51] In order to minimize the need for extended quotation from my other texts, and to enable the interested reader to put the present text in its theoretical context, I have included cross-references to my relevant conference papers, publications, and work in progress.

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