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Bottom-up and *top-down* changes reconsidered

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Contents

In brief:

Can a whole change its components *top-down*?

With a whole constituted of components (or parts), *top-down changes* should originate at the whole (assigned to system level n) and affect the components at the level below (level n-1, "the bottom"). *Top-down experiments* search for such changes in natural mechanisms. They require (a) primary interaction of a peer object with the mechanism as a whole, which is (b) followed or accompanied by a change among its components. It is often claimed that such experiments or observations (of swarm behaviour, for instance) have shown that a whole can indeed change the properties of its parts. However, all the *top-down* experiments and observations considered here turn out to have alternative explanations of the *bottom-bottom* plus *bottom-up* type.

To account for this disconcerting result, I argue that a constituted whole necessarily depends in existence and all properties on its components and their relations and only on them. This restriction implies that, contrary to expectation, a constituted whole (a) cannot be subjected to a not-constitutive *top-top* change. Nor can it then (b) effect a *top-down* inverse-constitutive change, as the constitutive relation of mechanisms is shown to be asymmetric (*bottom-up* only). (The proof given avoids mereological axioms.) Nor can the whole (c) effect a *top-down* causal change, as a whole cannot encounter the components, which it inseparably contains, for interlevel interaction.

For these reasons mutual manipulability of whole and components of mechanisms, which the literature claimed repeatedly, is not possible, *top-down* changes directed from whole to components remain elusive in theory and practice. Related issues, foremost the nature of constituted wholes and the nature of system levels, are discussed.

1. Introduction

The following statements concerning parts and wholes are commonly taken to be true:[1]

(1) *A whole is more than the sum of its parts.*

(2) *A whole may affect the behaviour of its parts.*

The first is the 'over-sum principle' attributed to Aristotle: '*The whole is something apart from the parts. It is more than their mere sum.*' [2, 3] . Alternative translations and interpreting phrases are '*The whole precedes [not 'is more'] the unification [not 'sum'] of its parts*' [2] and "*Wholes, unlike heaps, have in them something else besides ... matter, namely form or essence...*" [43:715]. Thus 'over-sum' goes beyond the basic material aspect of parts, it is form, essence, structure [44:6].

In ontology 'structure' usually means the collection of relations [e.g. 14:35, 15:277]. In this sense we refer to 'over-sum' as *relational structure,* over-componential with parts working concertedly. The yield of such over-sum structure, at least in mechanisms, is a property-emergence, as will be explained.

In a hierarchy of system levels the step from parts to whole is directed upwards, '*bottom-up*' (see Figure 1).

The second statement, which proposes *top-down* effects, can be traced to Seneca and other stoic and holistic authors.[3] While more problematic than the first, it is also considered well established even in the recent literature.

1 e.g. B.O. Küppers, 1986, page 175; quoted in [23:36].

2 See Roland Müller in: http://www.muellerscience.com/SPEZIALITAETEN/Ganzheit/G_historisch/GanzheitlichesDenken_Geschichte.htm

3 As quoted by F. Ast [4], J.C. Smuts [59].

Several modern authors concede *top-down* causation.[4] Disinclined towards *top-down* or *bottom-up* causation are Bechtel and Craver, who argue for constitutive interlevel changes instead [18, 19].

The justification of the two statements by *bottom-up* and *top-down* observations, experiments and theory is topic of this treaties. Apart from some common reasoning it will require a combination of basic mereology and systems theory,[5] as informally used by Bechtel, Craver [18, 19] and others before them.

2. Conventional Rules

A few interrelated rules[6] entering into the conceptual framework of the two statements are listed in Table 1. Regarding real objects, rules 1-5 are (with a partial exception in rule 3, brackets) conventional and fundamental for our common understanding of everyday phenomena and for macro- and mesoscopic physics. Their acceptance is or was shared by leading physicists.[7]

The first part of rule 6 is not conventional but a surprise. It seems to contradict the "self-evident" notion that an object constituted of real parts is a real object, thus capable of interaction. The contradiction will be resolved in Section 7 and 19.

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4 e.g. [30:178]; several chapters in [1]; [35:128]; [60:249ff].

5 Required concepts will be explained, the reader need not have a background in formal mereology [e.g. 17, 44, 57, 58] or systems theory [e.g. 10, 41, 52].

6 Rules 1-3 may be viewed as assumptions or premises, rules 4-6 are justified in the text.

7 Especially rule 1 (separability) and 3 (near-range effects) was upheld by Einstein [24:321, 26:198].

Table 1: Rules regarding real objects.

1	The world contains real,[8] separate objects of independent existence, possessing intrinsic properties.
2	The objects are ordered in space and time or spacetime.
3	Only separate objects (if simples[9]) can encounter each other in space and time. They may interact causally by means of applied forces, changing object properties.
4	An object cannot causally interact with itself.[10]
5	A composite object as a whole is inseparable from its components[11] and parts. It cannot encounter them for interaction.[12]
6	An object constituted of parts cannot interact as a whole with peers.[13] Rather, interaction with peers will occur through a part, provided the part is a simple.

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8 A real object is concrete (ordered in space and time) and exists independently from objects of different location (separability), thus can encounter them for interaction. In agreement with Alexander's dictum [e.g. 25] only real objects are interactive, have causal power. The independent existence includes independence from any neuro-mental activity [e.g. 15:150,242]. See Appendix.

9 Simple objects (mereological atoms) are without parts (on which they would depend). To objects which are not simple but composite, rule 6 applies .

10 It is not separable from itself, thus cannot encounter itself. The denial of interaction of A with A is attributed to Aristotle. See [35:2].

11 Components are distinguished parts which remain individually available. They are the 'working' parts of mechanisms [29:138]. Components do not overlap as their interaction requires independence.

12 Because it cannot encounter what it contains, what it consists of. Rule 5 is in agreement with C.F. Craver's account [19:552].

13 Peers are separate objects on the same system level.

The conventional rules did not remain unchallenged. In quantum physics [e.g. 26:197ff] properties such as location, as well as interaction by encounter in space and time loose their meaning or are redefined. Quantum-mechanics is indeterministic, non-causal and non-local [e.g. 5:25f]. It is an open question to which extent quantum behaviour is relevant for macro- and mesoscopic phenomena. Notably M. Esfeld concludes that, after all, quantum theory does not contradict our everyday realism [26:215].

The rules of Table 1 distinguish separate and inseparable objects. Simple separate objects are independent, can encounter each other for interaction. Inseparable objects (a whole and its parts) cannot encounter each other to interact (rule 5). Further, a whole cannot interact with peers (rule 6, justified below).

3. Constituted Whole (CW)

A 'composite object' is a double concept, at once one and many.[14] A *whole* is the integral or unifying aspect of this. It consists of a full *sub-system* (holon,[15] mechanism[16]) with components, their properties, activities and their over-sum relational structure. Therefore, a whole depends on its constituents, on its components, their activities etc.

In mechanisms 'over-sum' implies a roadmap specifying concerting relations connecting material components

14 See Aristotle's "problem of the one and the many", e.g. [44:125].

15 A. Koestler coined the term 'holon' to designate a sub-system of relating components [42:45f, 52].

16 A physical device made of interacting, concerting components, optimized to alter its environment in a characteristic and quantitatively more or less predictable way by over-sum emergence. Designed by man or evolved in nature. Further definitions of 'mechanism' are found in [7, 14:20f, 20, Lindemann, 2014 #1026, 29, 50].

[10]. The components will be arranged in a *cycle* to allow steady-state performance [32:5]. The relational structure can be formalized in a state-transition-diagram as used in chemical kinetics and engineering.

The relations cause a special behaviour of the whole, emerging when the parts interact (in machines 'as designed'). This *emergence* [17] is not shared by individual parts and cannot be expected from a mere heap or sum of poorly related parts. Due to (dependent on) the over-sum relational structure guiding concerted causal interaction of parts, it becomes a property possessed and represented by the whole. In natural mechanisms the emergence is the *explanandum*, in designed machines it is the construction goal.

Every whole is necessarily in *constitutive relation* to its components and parts, meaning that it is constituted by them, their properties, relations and activities[18] and by nothing else. Non-componential dependencies of the whole are not possible. I shall emphasize this by using the term *constituted whole* or CW for short. A CW comprises all constitutive items and features specified in the constitutive relation, which is a parts-whole relation (Section 5).

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17 See G.H. Lewes [46] and C.D. Broad [13]. Here a weak or 'innocent' emergence is meant, one which is reducible [22].

18 This usage of 'constitutive' is due to W.C. Salmon "... the fact to-be-explained is constituted by underlying causal mechanisms." [53:270]. Accordingly C.F. Craver specified: "I mean by 'constitutive' a relationship between the behavior of a mechanism as a whole and the organized activity of its individual components." [18:108].

Table 2: Dependence of a constituted whole (CW) on its components.

Attribute	Detailed meaning
1. Inseparable	A CW and its components are not separate objects, thus cannot encounter each other for interaction.
2. Unilateral, asymmetric [19]	Changes are registered *bottom-up* only. Plausibly components constitute the CW, not *vice versa*. Proof in Section 5.
3. Permanent, lasting	The CW did not arise from the components in the past, to become an independent object. Rather, its dependence lasts permanently, as long as the components are engaged in their relation of concerted interaction.
4. Synchronic, instant	The CW registers changes of components and their activities without delay, by relation. The resulting *bottom-up* synchrony means that *top-down* changes of parts are impossible (see Sections 5, 8).
5. Complete	With the CW's existence all over-componential properties (which are based on component properties) are included in the dependence.
6. Exclusive	The CW on level n depends only on its components on level n-1. This excludes interaction of the CW with peer-objects on level n, which would result in a not-componential change of properties.

Further, the whole is given a name which refers to the sub-system, it is 'about'. As a symbol it stands for its denotate and, much like an avatar[20] it reports and represents

19 Petri Ylikoski referred to this dependence by „asymmetry of existence“ [67]. Max Kistler also maintained that the constitution relation is asymmetric [40]. Ramiro Glauer, Bert Leuridan and Samuel Schindler concluded that 'mutual manipulability' is doubtful [29:74ff, 45, 55]. I agree with an asymmetric constitutive dependence and stress that the dependence of CW on components is *exclusive* (also Section 4, 5).

20 Representative, virtual agent.

features of interest from the CW. This symbolic whole (SW) will be discussed in Section 19.

As the CW consists of its components, their properties, relations and activities, its existence depends on them, CW and components are *inseparable.* The dependence, which also includes all over-componential properties (Section 6), may be described further as *unilateral, lasting, synchronic, complete* and *exclusive*.

This intensional definition lists 6 attributes defining a constitutive relation and, therefore, characterising a CW (Table 2). The inseparability (attribute 1) means that CW and the assembly of interacting components are aspects of the same. Attribute 1 excludes any causal-interactive relations between CW and components, including *top-down* causation. Note that the attributes are interrelated, they cannot be chosen freely. For instance, attribute 6 is based on attribute 1 and 2. It implies that a CW can be changed only by changing a component. This 'supervenience' justifies rule 6.

4. Supervenience and Mereology

Supervenience[21] is a dependency-relation where a change in A, the supervenient, cannot occur without a change in B, the subvenient. The reverse may, but need not hold, the relation may be symmetric or asymmetric,[22] to decide this requires further reasoning.

If A supervenes over B “there cannot be an *A*-difference

21 [e.g. 21]. The supervenience concept was not generally welcomed [e.g. 15:279].

22 http://plato.stanford.edu/entries/supervenience/, section 3.2

without a *B*-difference",[23] a certain distinct change in B (not just any change in B) results in a distinct change in A and A cannot be changed except by changing B. This matches the *exclusivity*-attribute of Table 2.

Jaegwon Kim introduced the *mereological supervenience* relation (MS) as "the dependence of the properties of a whole on the properties and relations characterizing its proper parts." [37:582]. MS implies that a whole supervenes over its proper parts.[24] This MS relation is asymmetric, *top-down* changes are impossible as proper parts cannot supervene over their whole.

The asymmetry of MS is a consequence of choosing proper parthood or irreflexivity as axiom. Without this stipulation a different mereology is obtained. How was this choice of axioms justified, how do we choose our mereology?

Mereology is the theory of parts-whole or parthood relations x**P**y.[25] The variable on the left of P denotes a part and the variable on the right the whole of all parts, while nx, ny specify the number of parts represented by x and y.

Parthood relation P:[26] x**P**y \\ x is a part of y (nx ≤ ny).

'Proper part' means: ¬ x**P**x \\ nothing can be a part of itself [57:106]. (nx < ny).

Proper parthood relation: x**PP**y = $_{\text{def}}$ (x**P**y ∧ ¬ y**P**x) \\ asymmetry: x is a part of y and y is not a part of x.

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23 http://plato.stanford.edu/entries/supervenience/, section 3.2

24 'Proper parthood' requires at least 2 parts.

25 http://plato.stanford.edu/entries/mereology/ and [e.g. 17:36, 36:2, 44:11, 57:106].

26 The parthood relation P is taken as a primitive (has no definition).

'Proper parthood' requires at least 2 parts. Since the whole counts or represents all parts, single parts are different from their whole [57:26], thus cannot be part of themselves, i.e. reflexivity (part = whole) does not hold [57:106] and asymmetry results.

Some well-known principles (or formal properties) of relation _**P**_ are:

Reflexivity: x**P**x \\ x = y, x is a part of itself. Or

Irreflexivity: ¬ x**P**x \\ x is not a part of itself (also one definition of 'proper').

Symmetry: x**P**y → y**P**x \\ Parts and whole are interchangeable. Or

Antisymmetry: (x**P**y ∧ y**P**x) → x = y \\ (= identivity) Symmetry holds only if x and y are the same. Or

Asymmetry: x**P**y → ¬ y**P**x \\ If x is part of y then y is not part of x.

Transitivity: (x**P**y ∧ y**P**z) → x**P**z \\ If x is part of y and y part of z then x is part of z.

These principles are treated as axioms or follow from axioms or are excluded. Their different combinations give rise to a variety of mereologies. 'Ground Mereology' is based on the triad reflexivity, antisymmetry and transitivity [17:36]. But when postulating proper parts first one arrives at transitivity, asymmetry and irreflexivity [36:2, 44:11]. The mereology may be chosen by postulating different axioms. These are justified by plausibility or intuition or by result.

Instances of parthood are the mereological sum SU:

x**SU**h \\ x is a part of the heap h.

and the constitutive relation CR of mechanisms:

x**CR**w \\ x is a concerting part of the constituted whole w.

Mereological sums relate to heaps (or fusions), aggregating their unrelated or poorly related parts.[27] They are constituted wholes of the most simple kind, contiguous but lacking the over-sum feature, the concerting relational structure. Can such heaps affect their parts *top-down*?[28]

In a heap of motorcycle components intra-level relations trivially concern properties like shape and volume of the parts. A cyclic sequence of relations and events resulting in a property-emergence like 'driving', familiar from the intact motorcycle, is absent. Yet the heap depends on the parts alone, it can be changed only by changing the parts. When choosing PP (nx < nh), asymmetry will hold: the parts cannot be changed *top-down* based on a change of the heap. (This and the remaining case nx = nh = 1 is discussed in Section 5.)

Non-trivial constitutive relations of mechanisms[29] are over-sum relations, where the concerting parts or components with their properties and relations constitute the whole w and give rise to a property-emergence, as discussed in Section 3. Again, choosing PP (nx < nw) as an axiom or as a primitive, **asymmetry results** [36:2, 44:11]. To choose PP is justified for natural mechanisms, which will have more than 1 component.[30] For components of a mechanism to interact with each other requires at least 2 of them. From the asymmetry resulting from PP we expect that the components of a mechanism cannot be changed *top-down* based on a change of the whole.

27 For simplicity all parts of h and w are disjoint, do not overlap.

28 Whether mere mereological sums can change their parts (not 'affect their parts') was asked by P. van Inwagen [61] and D.H. Sanford [54] without obtaining a simple answer.

29 'Constitutive' in the sense of C.F. Craver [18:74,108].

30 Single-component mechanisms are viewed as not-realistic models.

5. Proof of Asymmetry

Note that the concluded asymmetry is already obvious from the initial definition x**PP**y $=_{def}$ (x**P**y ∧ ¬ y**P**x). Have we pre-determined our result by choosing PP as an axiom, thus "begging the question"?

An alternative approach, avoiding considerations of PP, is this: We accept the fact that 2 or more components are needed for their causal interaction within mechanisms. Thus we divide nw ≥ 1 into a large range nw > 1 and a singular nw = 1, which is to be excluded. The large range, clearly applicable to natural mechanisms, is dealt with as follows:

The list of parts or components of a whole w or of a mereological sum h is: p1, p2, ...pn. The total number of parts represented by p1, w and h is np1, nw and nh.

Relation constituting a mereological sum:

The sum relation SU: p1**SU**h \\ p1 is one of the not-concerting parts p1, p2, ...pn of the heap h.

Relations constituting an over-sum whole are:

The general parthood relation P: p1**P**w \\ p1 is one of the concerting parts p1, p2, ...pn of the whole w.

The constitutive relation CR: p1**CR**w \\ p1 is one of the concerting parts or components p1, p2, ...pn which, with their properties, relations and activities, constitute the whole w of a mechanism. CR is a special case of P.

SU, P and CR have much in common:

Rule (a): The list p1, p2, ...pn is *exclusive*: only the items on the list are parts. It follows that:

Rule (b): The heap h or the whole w depends on p1, p2, ...pn and on nothing else.

Rule (c): A change of h or w can be effected only by affecting one of the parts.

Rule (d): The h or w 'registers' all changes of parts instantly by relation (*bottom-up* synchrony).

By way of example we consider the constitutive relation _**CR**_. Symmetry of CR must hold to answer the initial question “A whole affects its parts?” in the affirmative. Thus we want to know whether CR is symmetric or asymmetric. Per trial, let us assume symmetry of the *bottom-up* and *top-down* versions of CR.

The up-relation of CR is p1**CR**w, in which p1 is a part of the constituted whole w. Further, np1 and nw are the total number of parts represented by p1 and w.

Symmetrically, the down-relation is q1**CR**v with nq1 and nv being the number of parts represented by q1 and v. Further nq1 < nv.

	up	down	
Symmetry of CR	p1**CR**w	q1**CR**v	1
For mechanisms	nw > 1	nv > 1	2
For CR to hold	np1 < nw	nq1 < nv	3
With numerical identities	nq1 = nw and np1 = nv		4
Eliminate np1 and nq1 from (3), (4)	→ nw > nv and nw < nv		5

Assuming symmetry we state the numerical identities (4). After eliminating np1, nq1 from (3), (4) we obtain (5), which states a contradiction. Therefore, symmetry is not compatible with a constitutive relation applicable to mechanisms, which necessarily have more than 1 part. Antisymmetry can be excluded because identity of part and whole is not possible with np1 < nw, **asymmetry is the remaining possibility.**

In this reasoning we did not use or arrive at a mereology with axioms and derived principles. We merely excluded the case nw = np1 = 1 as not applicable to natural mechanisms. Further, we used the mereological concepts of symmetry, antisymmetry and asymmetry. They were required because we wanted to decide which of them is compatible with a CR. The decision was forced by the 3 definitions and an algebraic decider. The same strategy applies to the general parthood relation and to mereological sums with the restriction nw > np1 ≥ 1.

In the excluded case the equalities nw = np1 = 1 and nv = nq1 = 1 replace (2, 3). Then elimination of np1 and nq1 does not yield an algebraic contradiction, the result is compatible with symmetry and antisymmetry (both reflexive), part and whole are identical. Then *bottom-up* synchrony and rules a to d are trivially true or do not apply. Clearly such a case of improper parthood (reflexivity) is without interest for mechanisms, where interacting components require at least 2 of them.

Thus certainty about *top-down* changes is obtained without the need to initially choose an axiom like 'proper parts' or irreflexivity. We merely restrict nw to > 1: Per trial we postulate symmetry and after a few steps of algebra we find that symmetry is not compatible with a relation of more than 1 part. Having excluded antisymmetry, asymmetry is the remaining possibility. Thus constitutive *top-down* changes are impossible for mechanisms.

Generally then, provided the number of parts nh or nw is > 1, **the heap of a mereological sum or an over-sum**

whole cannot alter its parts *top-down*, cannot change its own constitution. Thus, with rule 5 (Table 1) in addition barring interactive *top-down* changes, statement (2) of the Introduction[31] is theoretically not tenable.

6. Overview of Properties

Which properties are owned by or represented by a CW? Apart from component properties and an *emergent* or over-sum property, resulting from the concerted action of the components ("The radio plays"), a CW may have *resultant* properties ("The chorus sings"). These are shared by whole and components ("Mary sings") as emergent properties on lower levels [16, 46]. Further there are population-average properties (like temperature), cumulative properties (like mass and volume) and others (like structure [44] and shape). These properties are over-componential[32], though derived from the components and their relations (arrangement, interactions guided by structure etc.).

Let us briefly consider the *constitutive arrangement* of components of a mechanism. All components, and only these, constitute the whole. But there are differences.

a. Components arranged serially in a cycle are capable of steady state performance [32:5]. Here all components are essential for the concerted action, which gives rise to an over-sum property-emergence. To remove a component from a serial arrangement means to disrupt the causal chain of the mechanism, to change over to the trivial case of a not-concerting aggregate.

31 If the 'whole' of statement (2) is constituted, which seems well justified.

32 Not explained by behaviour or properties of a single component.

b. However, when millions of these cyclic arrangements work in parallel, which is typical for molecular systems (e.g. a multitude of ion conducting, but functionally independent channels in a cell membrane), the removal of a few of them changes performance by degree only.[33] Ion transport of the ensemble of independent channels is a *resultant* property. It results from the emergent transport property of individual channels.

In any case the existence of a CW is *exclusively* dependent on the existence of all components and their relations. The properties of a CW cannot contradict this fact. Thus all properties of the CW, including over-componential properties, are exclusively dependent on the components and their relations.

Similarly, in M.A. Bunge's CESM definition of a system [14:35] we find that composition (C, collection of parts), structure (S, collection of relations) and mechanism (M, collection of processes) depend exclusively on components. Only the environment (E) does not, it is necessarily outside the system.

7. Overview of Dependencies

Dependency-relations are either identitiv, constitutive or causal [31:67]. The dependence of a CW on its components is not identitiv (since in mechanisms there are at least 2 interactive components for 1 whole) and not causal (since the CW cannot be separated from its components, rule 5) but constitutive (as 'CW' indicates). The dependence is accounted for by ordering the relata with levels (Figure 1). In a vertical hierarchy of levels, the

33 This provides one way to grade the performance of a molecular mechanism.

holon of components would be on level n-1 and the constituted whole above on level n [e.g. 18, 42, 52]. Then a *top-down* effect is a change from n → n-1, while a *bottom-up* effect is directed oppositely: n ← n-1.[34]

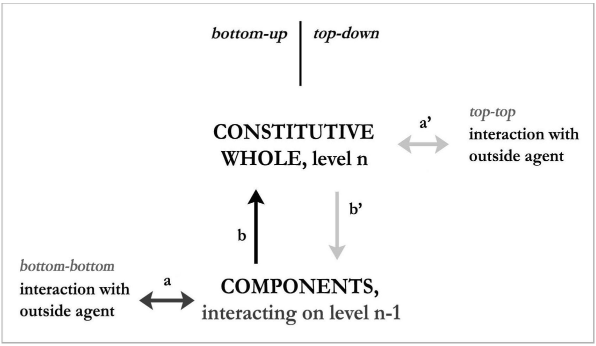

Figure 1: Overview of dependencies and changes. A *bottom-up* experiment involves the *bottom-bottom* interaction (a, delayed) with an external agent or object (peer), provided the components are simple. The change is accompanied by a constitutive adjustment (b) of the CW (*bottom-up*, instantly 'by relation'). A *top-down* experiment features steps (a') and (b'). However, (a') and (b') are both problematic. Further, an interactive step instead of the inverse--constitutive (b') is also problematic (rule 5 and Section 15).

Statement (1) of the Introduction, the over-sum principle, implies that a non-trivial working system (e.g. a natural mechanism) generates an over-componential property, the emergence. It is due to the relational structure of the parts, guiding their over-sum concerted *bottom-bottom* in-

34 The term *top-down* refers to a hierarchy of system levels. Not meant is e.g. the effect of a functionally 'higher' brain module acting down on a lower stage of neuronal processing.

teraction on level n-1. In possession of the emergence by the constitutive *bottom-up* relation, the whole is "more than the sum of the parts". It is on a higher level of organization (level n).

Statement (2) of the Introduction is about a *top-down* effect. It maintains that the particular case, where the constituted whole affects *its own* components, is possible.

The above definitions of whole, system and emergence are in accord with statement (1). For justification of statement (2) the literature refers to the (arguable) observation of *top-down* changes and the outcome of *top-down* experiments. The paradigm of such experiments is to affect directly the constituted whole and observe resulting changes of its components[35] (Figure 1).

But is it possible "to affect the constituted whole" by processes on level n? As mentioned, the CW is conventionally considered to be a real object capable of interaction with its neighbours on level n. Only real, separable objects, defined in space and time, can interact, as interaction requires encounter in space and time. However, if we view constituted wholes as interacting objects, we obtain a contradiction with attribute 6 of a CW (Table 2). The *exclusive* dependence on components bars any causal dependence[36] due to interaction with outside agents or objects. In fact, it bars any not-constitutive change on level

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35 According to Bechtel and Craver [18, 19] the *top-down* changes are not due to causal interaction (here already excluded by rule 5 (Table 1)). Rather, they are argued to occur by constitutive relation.

36 Horizontal (*top-top*) causal dependence: The change of a property is an effect depending probabilistically on a cause-event of physical interaction with a peer object. For instance, a component property represented by a CW could be changed by *top-top* causation. Such horizontal dependence interferes with the exclusive *bottom-up* dependence of a CW.

n. Thus a CW is not a real object capable of interaction with its peers on level n. Attribute 6 of a CW justifies rules 3 and 6.

A real object may interact directly with peers on level n provided the object is without parts (is a simple). If the object is composite (a CW), interaction happens indirectly with one of the components. For the *exclusive* dependence on components bars any not-constitutive change of CW properties.

Thus a CW may be taken for a real object capable of direct interaction only if its constitution is disregarded (Section 18, Table 3), that is, if it is treated as a simple. Otherwise the CW interacts indirectly via components, provided these are simple. A CW is 'about' components and their interaction on the level below.[37]

8. Overview of Changes

If the whole is constituted of its components, their properties, relations and activities, a change in the components is accompanied by an adjustment of the whole. The *bottom-up* change in the CW occurs not by interactive mechanism but by instant registration, by constitutive relation. The coupling is rigid and synchronic.[38] Any change of CW properties is *exclusively* due to a change of one or more of the interacting components.

The reverse is not possible. For reasons detailed below, a change in a component cannot be due to a change of the whole. Such a change in a component can only result

37 As Franz Brentano famously observed, this *about* is the highlight of (I add: many) mental phenomena [12:124].

38 while in interactive relations there is typically a small delay between cause and effect.

from causal interaction with another component or with an outside object (peer) on level n-1, always provided the components are simple. This *bottom-bottom* change goes along with a *bottom-up* constitutive readjustment of CW properties on level n.

Below is a summary of constitutive and interactive effects (see Figure 1).

Bottom-up:

(a) Causal interaction of components with components or with peers (*bottom-bottom*) is possible if the components are simple (rule 3). It is accompanied by (b).

(b) constitutive changes CW ← component are implied. They are instant *bottom-up* adjustments of CW properties in response to (a). The components constitute the CW and determine its properties *by constitutive relation*. The constitutive dependence of the CW on the components is *exclusive*.

(c) Causal-interactive effects CW ← component are not possible, because the components are inseparable parts of the CW. They cannot encounter their own CW in space and time, as would be necessary for interaction.[39] However, components interact with each other to produce the emergent over-sum property of the CW.[40]

Top-down:

(a') Causal interaction involving the CW and peer agents *top-top* is not possible (rule 6), being not compatible with the CW's exclusive dependence on its components.

39 See Section 2, rule 5. In agreement with [19:552].

40 Here the components are taken to be capable of interaction. But how is this possible, if the components are themselves wholes constituted of components? See Section 18.

(b') Constitutive *top-down* effects CW → component are not possible because the constitutive relation is asymmetric. An independent proof of the asymmetry was given in Section 5. Thus the components constitute the CW but the CW does not constitute the components. Therefore a constitutive change directed from CW to components is not possible, a whole cannot change itself.

This conclusion is also supported by the following argument: Suppose a component, by peer interaction, changes its binary state from 0 to 1. The change should be accompanied by an instant adjustment of the corresponding whole-property to 1. This *bottom-up* synchronisation by constitutive relation is the only way the whole can be changed. If in addition there were a symmetric *top-down* adjustment from whole to component, two cases can be considered.

(aa) The adjustment takes effect after the whole was synchronized to 1. Then it would be without effect because whole and component are already in the same state. (bb) It takes effect before the whole is synchronized. Then it may alter or abolish the initial change of the component, rendering *bottom-up* synchronisation by relation impossible.

Thus the supposed *top-down* influence is either without effect or it interferes with the constitutive relation. This is clearly impossible. There is no functional *top-down* pathway, a whole cannot change its components.

(c') Causal interactions between CW and components are not possible because the components are not separable from the CW. The CW cannot encounter them in space and time for interaction.[41]

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41 Section 2, rule 5. Of course, interaction changes properties of both

Correct is, since the whole *is* constituted of its components, that changes in components are always registered (by relation) by an adjustment of the whole. But this is due to a constitutive change in the direction CW ← component only. There is no constitutive change in the direction CW → component. And a CW cannot experience any not-constitutive change.[42]

Yet such *top-down* changes appear to be common and *top-down* experiments are quoted in support of statement (2) of the Introduction. Examples of such changes and of *bottom-up* effects will now be considered in detail.

9. Excitable Membrane ***Bottom-Up***

In *bottom-up* experiments the experimenter primarily alters a component and records resulting adjustments in properties of the CW, the *explanandum*. As an example, consider an ensemble of sodium and potassium channels in the plasma membrane of a cell, capable of generating action potentials. The ion channels with their relations of causal interaction and the membrane capacitance are the components. The functional plasma membrane containing channels and capacitance is the CW. Its emergent property is electrical excitability, evidenced by the time course of the membrane potential V(t) in the shape of repetitive action potentials. Because of V(t) the channels are functionally dependent on each other.

Following a control period the sodium channels, say, are

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partners: any *top-down* interaction would also be *bottom-up*. Yet causation, though based on interaction, is directed from cause to effect.

42 The question whether (not over-sum wholes but) mere mereological sums (aggregates) can change their parts is asked in [54, 61] and Section 4.

blocked with tetrodotoxin. One observes a dramatic change in V(t): the generation of action potentials has ceased. Thus the interference with components has altered a property of the CW, the cell membrane has lost its emergence, the electrical excitability. The *bottom-up* experiment apparently was successful.

Note that, because of the constitutive relation, the CW must have readjusted “instantly” once the channels were blocked by tetrodotoxin. It is true that time delays accompany the sequence of molecular causal events of the blocking mechanism. Yet, the CW adjusts instantly *by constitutive relation* once a channel is blocked.

Here we may use the directional term *bottom-up* with confidence, because we can prove that we have primarily interacted with a component: By the addition of tetrodotoxin we have interfered with one well known component, the sodium channel. The effect of tetrodotoxin on such channels was previously elucidated in numerous experiments, using e.g. sodium channels isolated from the particular CW in question.

10. Excitable Membrane *Top-Down*

To demonstrate a *top-down* change in the same system, one has to (a') cause interaction with the CW (the cell membrane) and (b') look for resulting adjustments of components, such as ion channels, and their relations.

Here we meet a characteristic difficulty: There seems to be no practical way to affect the cell membrane without primarily interacting with one of its components. For instance, if we were to change ion concentrations, we would alter the conductance of a subset of channels. Or if we were to apply a voltage clamp [33], we would prevent that ion currents passing individual channels influence each other by means of the membrane potential common to all of them. This would also be an interference with components rather than with the CW. Even if we change a thermodynamic state variable like temperature, we primarily affect component properties, like kinetic energies of molecules (see below). The *top-down* experiment chosen does not seem possible, for its target is illusive, the CW is not responsive to intra-level interaction with peers.

11. Temperature *Top-Down*

Among the properties of a constituted whole are thermodynamic state variables like volume or temperature. Therefore, it is sometimes argued, *top-down* experiments can be initiated by changing the over-componential property "temperature" of a CW. To give an example, in case of colony-forming insects like bees the stock temperature has significant effects on larvae and adult bees, apparently showing that a property of the whole (of the stock) affects the components [e.g. 60:249ff].

To investigate this temperature argument, let us choose a familiar and simple model system, a container filled with an ideal gas. The CW is "the gas", the temperature is its emergent property at system level n. The components at level n-1 are the gas molecules. The container is placed in an oven or thermostat and its temperature increased. Seemingly as a result of the increased temperature the molecules move faster. Is this a valid *top-down* experiment?

Generally, the temperature T is a population-average, proportional to the mean of kinetic energies of the molecular components. For an ideal gas, if e is the kinetic energy of individual molecules, n the number of molecules and k the Boltzmann-constant, then

$$T = (3/2\ k)^{-1}\ (e_1 + e_2\ ...\ +e_n)\ /\ n$$

Here the kinetic energies e of gas molecules are the only variables besides T, while n and k are constants. The equation is to be read from e to T. Any value of T is multiply-realizable, when knowing T alone it is not possible to deduce the particular values of the e.

The temperature is seen to be *exclusively dependent* on the set of e, as only the change of one or several of the e will change T. Thus T supervenes over the set of e. The change will be an instant adjustment "by relation".

(1) Definition: $T = (3/2\ k)^{-1}\ (e_1 + e_2\ ...\ +e_n)\ /\ n$. The over-componential property T, possessed by the CW, is *exclusively* dependent on the kinetic energies e of molecules. The dependence is constitutive rather than causal-interactive. For the values of the e are simply added, no further mechanism is implied.

(2) Denial of *top-top* interaction: T cannot be changed directly, i.e. it cannot be changed by causal interaction of the "gas" with outside agents or objects, without changing one of the e.

(3) Reason: Such interaction would contradict the exclusive dependence of point (1).

We thus arrive at the almost trivial result that T is proportional to *a mean* and that a mean can be changed only by changing its individual elements.

Turning from an ideal gas to a real gas, more complex equations than the one above will be used. Yet as long as T is related to a *mean* property of the components, the same argument applies: One cannot change a *mean* except by changing its constitutive elements.[43] The rise in temperature is effected by *bottom-bottom* causal interaction between molecules of the container and molecules of the gas. There is no other way to change the *mean*. Therefore, *top-down* experiments by primary change of gas temperature are not possible, the CW "gas" is an illusive target.

Similarly, in case of a stock of bees, the stock is an illusive target. Its temperature can be changed only by changing components, like molecules of bees and air. It is the kinetic energy of such molecules which transmits heat *bottom-bottom* from individual bees to larvae.

12. Generalization

The argument applies to any constituted whole, as the existence of any CW is *exclusively* dependent on the existence of all components. The properties of the whole cannot contradict this fact. Thus all properties are exclusively dependent on one or more of the components and their relations. Further, the dependence is not one to be ordered in time. It is instant (synchronic) by relation, rather than delayed as in causal interactions.

(1) Definition: Existence and properties of a constituted whole are *exclusively* dependent on the components and their relations. This is already implied by the term "constituted" and has no alternative.

(2) Denial of interaction: A constituted whole cannot interact *top-top* with external objects (step a' of Fig.1).

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43 Generally, one can change an over-componential property only by changing a component.

(3) Reason: An outside agent or object is not one of the constitutive components. Such interaction would establish a dependence in addition to the dependence on components. This would contradict point (1).

Top-down experiments require as a first step the direct interaction of a peer agent or object with the constituted whole, thus changing a property of the whole. For the reason given, such interaction is not possible, it implies an additional dependence which is incompatible with the exclusive dependence on components. Further, the subsequent step from whole to components is not possible due to the asymmetry of the constitutive relation (attribute 2 in Table 2 and Section 5). There is no constitutive relation directed from CW to components.

13. *Top-Down* Mind-Brain Relationship

Suppose the mind of a soldier were a whole constituted of interacting neuronal components. The verbal command "*at ease*" triggers a neuronal reaction within the soldier so addressed. Is this a mind → body or *top-down* reaction? And further, is the constituted whole "mind" involved causally?

Certainly the initial steps are neuronal, the command-sound is heard and its neuronal response conducted to the temporal cortex. Cortical imaging may indicate the subsequent neuronal events, including motor reactions. When we look for neuronal events, we see just these, *bottom-bottom* causal interactions. They explain the at-ease response. After all, access to mind is only via neurons.

Yet it is part of our common understanding that we can wilfully and without effort initiate movements of our body. This suggests that causal effects from the mental to the neuronal level readily occur. When placing the mental above the neuronal level, such effects are in the *top-down* direction: apparently *top-down* causation is possible.

Indeed, in our everyday realism we are all convinced to have mind → body executive power. But this conviction is not proof. Experiments show that we assume mental authorship even of processes which arise and propagate *bottom-bottom* within the brain [e.g. 62:68, 63]. Therefore the case is not altogether clear, it cannot be used as evidence for *top-down* effects. Fortunately a convincing *bottom-bottom (*plus *bottom-top)* alternative explanation is at hand.

But our everyday experience firmly tells us that *top-down* executive effects are common. This notion is deeply engrained in our concepts and our language. It makes it so challenging to argue to the contrary.

14. *Top-Down* Activation in Mind-Brain Experiments

Several ways to directly affect a mental constituted whole *top-top* - and thus initiate *top-down* effects - are suggested in the literature. A very detailed account was given by Carl F. Craver [18]. This author marshalled the paradigm of *top-down activation*: Somehow the activity of a mental mechanism as a whole is turned on or is increased. Then the activities of neuronal components are recorded and a correlation between these activities and the mental task performed is obtained. Several examples are given.[44] The scenario of the first examples is the mind-brain relationship, with mind phenomena being on level n and phenomena of the brain on level n-1.

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44 See page 151 and 159 and schematic on page 146 of [18].

On a given signal a human subject starts a mental activity like counting or multiplying numbers, while the local metabolism of cortical areas is observed by functional imaging (fMRI). Or on a given signal a trained animal engages in some cognitive task while the electrical activity of neurons, or the synthesis of proteins or the activation of neuronal genes is being monitored.

The signal given is the activating trigger of the intended *top-down* activation. One notes, however, that any signal will be picked up by a sensory organ. Thereby the signal affects neuronal activity first. It may cause events in a *bottom-bottom* direction on level n-1, activating the mechanism in question (that of counting or multiplying numbers). Thus, instead of the intended *top-down activation* experiment one had done a *bottom-bottom* plus *bottom-up* experiment. Without exclusion of this troublesome possibility, *top-down* activation cannot be considered an established procedure.

For to validate a *top-down* experiment, with mental activation triggered externally, one has to show that the activation is not shunted from the sensory neuronal system to the neuronal component engaged in the task, bypassing the mind. Unfortunately the activation sequence neuron-s → mind → neuron-t-activation was never established and the alternative neuron-s → neuron-t-activation with collateral neuron-s or -t → mind was not excluded.

Or suppose no external activation is used, but we simply compare a period of neuro-mental activity with one of rest. There will be no question that the neuronal mechanism supporting this mental activity is active. Indeed, we obtain a correlation of experienced mental activity with the activity of the neuronal mechanism. Yet, if it cannot be shown by further evidence that the internal activation was *top-down*, then not a *top-down* but a *bottom-bottom* activation may have taken place, followed by a *bottom-up* conscious registration.[45]

Note that in these examples of fMRI experiments the correlation of mind and brain phenomena is obtained irrespective of the way the mechanism was activated. The mere correlation, valuable as it is, is not proof of a *top-down* approach.

In principle it does not matter whether one attempts to interfere directly or uses external or internal activation. In any case one has to prove a *top-down* effect by showing (with exclusion of alternatives) that primarily the CW was altered and the components respond or adjust. Such evidence is not at hand (nor is it theoretically expected).

45 In case of neuron-t → mind the mental registration will be preceded by activation of the task-engaged neuronal mechanism.

15. *Top-down* Causation?

Interaction of a whole with its components, resulting in *top-down causation*, is a much discussed possibility [e.g. 1].[46] We now ask whether *top-down* causation has actually been observed.[47] Such observations would challenge the theoretical conclusions that a CW cannot interact with itself or with what it inseparably contains[48] and that it cannot undergo *top-top* interaction,[49] to be followed by a *top-down* change.[50]

a. A mechanical clock

Consider an old-fashioned mechanical clock. The clock itself is the constituted whole, while the sprockets, gears, weights, rubies etc. are its components. Their functional arrangement is mostly serial. The emergence or the construction goal is the rotation of each arm in a certain angular velocity, related to the rotation of our planet. None of the components alone can produce this property-emergence, it is over-componential. Only the concerted action of all parts, each in its place, will achieve it by following the causal chain stipulated in the construction plan.

Can the whole influence its parts, can the clock as a

46 It must be distinguished from Craver's *top-down* change (b' of Figure 1) due to a (disputed) symmetrical reversal of the constitutive relation rather than to interaction.

47 Note that, strictly speaking, such interactive steps would at the same time be *bottom-up,* as interaction involves both partners. Causation, while based on interaction, is directed from cause to effect.

48 See Table 1, rule 4, 5. Carl F. Craver and W. Bechtel already doubted *top-down* interaction because what is contained in a CW cannot be encountered by it. See page 552 in [19].

49 Table 2, attribute 6.

50 Some of the cases considered are from chapter 10 of [47].

whole have a *top-down* interactive influence on its sprockets? No, because when we open the clock, we find perhaps several feedback mechanisms linking the action of one component with the other, but we find no mechanism which links “the clock” with one of its components, influencing the component's behaviour.

“The clock” is not present in the clock. As a CW it cannot interact with what it inseparably contains. Its dependent existence denies any power of interaction. “The clock as a whole” appears to be a symbol representing a holon (including its emergence).

b. Product inhibition

The turnover of some enzymes is down-regulated by their reaction product. One example is citrate-synthase, which catalyses the condensation of oxalacetate and acetyl-coA to citrate. Here the product citrate competes with the substrate oxalacetate, causing the product inhibition. We may view the mechanism, the machinery consisting of enzyme parts, substrates and products as a constituted whole. The property-emergence is the over-componential ability to synthesize the product with a limitation in rate.

Does the constituted whole or mechanism interact with one of its components in a *top-down* fashion, using negative feedback? No, it is the component citrate which interacts *bottom-bottom* with the enzyme's substrate binding site, another component. The CW itself cannot interact with what it contains.

c. Epigenetics and feedback

Alicia Juarrero writes on page 107 of “Dynamics in Action":

> *"It is known that two animals with the same genotype can be phenotypically different depending on the environment in which they develop. Is this not a form of self-cause whereby the distributed whole influences its components?"* [35].

But why should environment interact *with the distributed whole*? Rather, such (epigenetic) influences involve component molecules, in particular genes, distinct derivatives of genes and their molecular wrappings. They are *bottom-bottom* influences.

Similarly on page 5:

> *"...complex adaptive systems are typically characterized by positive feedback processes in which the product of the process is necessary for the process itself. Contrary to Aristotle this circular type of causality is a form of self-cause."*

However, positive feedback appears to be a "self-cause" of the CW only in simplifying block-diagrams where known details remain hidden. Such diagrams are insufficient models, lacking structures. A sufficient model explains in terms of explicit structures and mechanisms.[51] This is also shown in the following example.

d. Feedback amplifier

In feedback amplifiers the feedback loop does not connect "the amplifier" with itself. Rather, a distinct output

51 "To explain X is to propose the mechanism(s) that give(s) rise to...X." "A mechanism is a set of processes in a system, such that they bring about a change – either the emergence of a property or another process - in the system as a whole". From M.A. Bunge in [14:20,23].

component connects to a distinct input component. Electrons flow through the connection, showing that the output voltage is different from the input voltage. In contrast, an object connected *with itself* would have to be homogeneous, lacking structural components. Then, however, there is no voltage gradient, no flow of electrons, no feedback. Feedback requires components, requires difference.

In a *bottom-bottom* feedback-causation among components it is not the whole ("feedback amplifier" or "complex adaptive system") which interacts. Statements to the contrary disregard known details. Based on an insufficient model they then make a mechanistic claim, letting a CW interact with its inseparable components.

e. A biped walking

Here the CW is a "biped being" (e.g. a human, a humanoid robot, an ostrich), the components are the two legs and also the leg-controlling electronic or neuronal system, the emergence is the behaviour "biped walking", an over-componential property, one leg alone cannot do this. Does the CW tell the legs, by means of the controlling system, what to do? No, the control rests *bottom-bottom* with the electronic or neuronal system, which is a component. Any feedback connects components, it does not involve the CW "biped being".

The 'biped being' may be viewed in two ways: Viewed as a constituted whole it is inseparable from its components and, therefore, cannot encounter them for interaction. Viewed as a symbol it cannot encounter its inseparable denotate.[52] *Top-down* causation is impossible.

52 The reference, what the symbol refers to, here the holon including its emergence.

f. A human being as a whole

Ludwig Wittgenstein is often quoted with [53]

> *"Only of a human being and what resembles (behaves like) a living human being can one say: it has sensations; it sees; is blind; hears; is deaf; is conscious or unconscious".*

This sounds like a normative statement about what we may say. Certainly we may state the above because it was checked experimentally and found to be correct?

No!, say M.R. Bennett und P.M.S. Hacker, to check it is not necessary.[54] They read the quotation mereological and conclude:

> *"Psychological predicates, which apply only to human beings (or other animals)* ***as a whole*** *cannot intelligently be applied to their* ***parts****, such as the brain."*

But do the predicates apply only to the whole, and why? The reason given is that tradition and the use of language prescribes the correct application of predicates to a 'human being as a whole' and not to the 'parts'. We humans[55] have always perceived this, we all feel this to be true.

This may be so, many nod agreement. That, however, does not guarantee correctness. Because, as John Heil critically comments, language (and representations generally) may not picture reality correctly.[56] Indeed, use of traditional language has a tendency to preserve the state of knowledge of our elders, in part obsolete, and to pre-

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53 [66] as quoted by [8, 9].

54 Extensively covered by [8, 9]

55 At least we English-speaking humans...

56 See chapter 3 in [31].

serve our pre-scientific (naive) realism. No, for statements that can be checked, judgement rests with the experiment and not with the present use of language.

Thus, language aside, we will have to find out empirically whether the “human being as a whole”, taken as a constituted whole, is more than the representation of its holon. Is it indeed an interactive agent - or is it merely claiming authorship[57]? Is the whole causally connected with, say, the process of seeing? In theory, if this implies *top-down* or *bottom-up* interaction, it is not possible because the CW “human being as a whole” cannot interact with the components which it inseparably contains (rule 5). In practice no evidence for such interaction has come forth, apart from our subjective impression of executive causal power, as reflected in the use of language.

g. A chorus, a crowd

The system 'chorus' is constituted of the singing members. Their functional arrangement is parallel. The emergence “choral music” is created only when the members sing together. Then the chorus sings, but its singing is derivative, it depends on and results from the singing of the members.

While singing, the members hear the music and are influenced by it both cognitive and emotionally. Are these *top-down* effects? No, for the members hear the acoustically additive singing arising from individual singers. Most loudly they may hear the singing of their direct neighbours. None of the singers hears the true choral music itself. Their interaction is *bottom-bottom*.

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57 [e.g. 62]

Can the constituted chorus interact with its members? No, because by relation the members are inseparable from the chorus. The chorus cannot encounter them in space and time, as would be necessary for interaction.

This applies to any crowd of people - in church, in a sports arena, anywhere. Many individuals send the same kind of emotional signal. All are influenced by it and attribute this influence to the 'crowd', the CW. But actually the influence arises from many interacting individuals, while the chorus, the crowd as constituted wholes represent their holons without having the power of action. CWs cannot affect their constituents causally, the chorus, the crowd cannot encounter what they contain.

h. Swarm behaviour

Birds, fishes and many other animals move together in union, giving rise to the CW 'swarm', a community. It owns the emergence 'collective swarm behaviour'. Does the swarm have an influence on its members and does this influence make swarm behaviour possible?

Modelling of bird swarming has shown that each bird needs to see only up to seven of its nearest neighbours (and feel the air stream of their flight) in order to integrate itself into the swarm [6]. Such limited interaction among agents (components) suffices for rapid coordination of hundreds of animals. Inheritance and training of this ability may play an important role. *Top-down* interaction from swarm to members is not needed. Nor, for the reasons given, is it theoretically possible.

i. Society

Karen Gloy writes in her book “Die Geschichte des ganzheitlichen Denkens”:[58]

> *„Properties and behaviour of individuals are determined by the whole, for example by their living in a capitalistic or marxistic society.“*

Here the constituted whole is the politically organized group of people. The individuals who are members of this group are components of the whole, mostly arranged in parallel. The property-emergence is to be a society with capitalistic or marxistic laws and rules. We easily see that individuals interact and influence each other as agents. But the laws and rules of society, do they not have an influence on the people too, establishing *top-down* interaction? No, for laws and rules were not put up by society but by certain individuals.

Laws and rules are content of messages, conceived, published and broadcast by some individuals to influence others *bottom-bottom*. If one country declares war on another, it is really the president of one country who, in the name of his people, declares war on president and people of another country. If your society forces you to pay tax, another putative *top-down* influence, it is really the individuals who issued the tax-law who exert this influence in the name of the people.

Society as a whole merely attains prerogatives by representation. Like any whole it has a dependent existence. By constitutive relation it contains its individuals inseparably. It was not shown to interact with them and theoret-

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58 Page 178 in [30]. Translation by B.L.

ically it cannot do so.[59]

16. Theoretical Justification

In summary, then, we have not found an unquestionable *top-down* interaction, change or experiment.[60] All these presumed *top-down* changes have *bottom-bottom* plus *bottom-up* alternative explanations. And we have not found a way to alter the constituted whole of a given mechanism, except by interacting directly with a component. We may say that up to now we found no basis to talk confidently about interactive *top-down* changes.

An explanation for the absence of valid *top-down* changes was provided in Sections 5-8. Briefly, a component (if simple) can be changed by interaction with another component or with a peer object. Such a *bottom-bottom* change is paralleled by a synchronic readjustment in CW properties *by relation*. The CW, however, being *exclusively* dependent on its components, cannot interact with peers (objects on level n). This would introduce a not-componential change of CW properties. Nor can the CW interact with its components, since by relation the components are not separable from the CW. Nor can it affect the components by constitution, since there is no constitutive relation extending from CW to components.[61] We

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59 It may be asked whether groups of people smaller than society, like the government or the army, have the power to act. Certainly not if they are constituted wholes, but yes if they were simples (Table 3).

60 If the reader can nevertheless identify a valid *top-down* experiment, interaction or effect, the author shall be much obliged to receive a brief description.

61 John Heil, discussing Jerry Fodor's text, states as a common notion that “higher levels asymmetrically depend on lower levels” [31:29]. However, Carl Craver makes a strong point for symmetry, that 'mutual

may restate the empirical and theoretical rule:

> *A whole changes with its components by constitutive relation and in no other way*

(based on rule 6, Table 1; attribute 6, Table 2; asymmetry, Section 5). Any not-constitutive change of the CW is barred. Yet the conclusion that a CW cannot interact[62] clashes with our everyday-realism and generally remains ignored.

Thus an external agent or object has to interact with a component on level n-1 in order to change the whole and cannot directly change a constituted whole on level n. Further, a change along the path CW → component is impossible in view of the mereological considerations in Section 4 and 5. The shortest reasoning calls on *bottom-up* synchrony (Section 8): The whole of a mechanism is continuously synchronised to the parts by constitutive relation. This bottom-up synchrony would be impossible if in addition the parts were to adjust to the whole. The relation must be asymmetric, as it was shown to be in Section 5. Thus a whole cannot change its parts.

Therefore constitutive 'mutual manipulability' of whole and components of a mechanism does not exist. Unfortunately these conclusions oppose Carl Craver's extensive arguments for constitutive *top-down* changes and experi-

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manipulability' of whole and components of mechanisms is in fact given [18:159]. In contradistinction, Max Kistler maintains that the constitutive relation is asymmetric [40]. Petri Ylikoski, too, makes the point that the relation is asymmetric and concludes that 'mutual manipulability' is not given [68]. Ramiro Glauer, Bert Leuridan and Samuel Schindler, too, took a critical view [29:74ff, 45, 55]. D.H. Sanford concluded that a mereological sum cannot change its parts [54]. For considerations of basic mereology see Section 4, 5.

62 Symbolic representation and interaction will be discussed in Section 19.

ments and for constitutive mutual manipulability,[63] if I understand his case correctly.

17. *Top-Down* Genesis?

When viewing the CW as the 'gestalt' or 'idea' of a mechanism, one may suppose that the idea has shaped the components during genesis of the mechanism, thus optimizing the result in a *top-down* direction. Such a process would contradict the unilateral, synchronic and exclusive dependence of a CW on its components (Table 2). However, while an idea or plan may precede the realisation, a CW does not precede its constituents, it is not an idea or plan.

(a) In the *evolution* of species and their bio-mechanisms there is no idea to guide the changes. Rather, random alterations of the genomes occur, often minute, which vary the ability to survive in a given environment. Evolution is not planned.

(b) During *ontogenesis* of evolved bio-mechanisms the CW is not an idea preceding the components. Rather, there is a 'material construction plan' contained in the genome and epigenome. Largely according to this plan autopoietic growth assembles specified components in a *bottom-bottom* interactive process [e.g. 48:49f].

(c) In *designed* systems the human constructor has the idea of his construct in mind and assembles his construct according to a plan. Then, in a recursive process he compares emergent CW-properties to his idea and improves components of his construct accordingly. Idea and plan

63 as detailed on pages 151 and 159 and in his figure on page 146 in [18].

are not the CW which remains characterized by its asymmetric, synchronic and exclusive dependence on components. *Top-down* changes are not supported by a CW.

18. Ultimate and Pragmatic Basal Level

The unfolding scenario suggests that we describe the world with constituted wholes which we order in system levels. The wholes are our constructs, exclusively dependent on their components, thus cannot interact with peers nor with components. Yet, in the analytical work of science and in common thinking the constructs interact. The armies clash, the chorus sings, the herd drinks at the lake. Do we *assign* interactive power to these CWs?

The inability of a CW to interact on its level is exemplified in the "causal drainage" argument, controversially discussed in [11, 38, 39]. The argument results from rule 6 applied successively to all levels containing composite components. Then causal interaction inevitably drains down to (is of necessity restricted to) an ultimate level, where objects are not constituted wholes but simples. These do not represent any parts or holons. Being not dependent, they may encounter for interaction. This ultimate bottom-level of interaction may be described by sub-particle physics or something even more fundamental and, characteristically, is not known very well and nearly incomprehensible.[64]

64 At this level several familiar concepts lose their conventional meaning. Even 'interaction', which requires encounter in space and time, may have to be replaced by a more suitable concept.

Table 3. Parthood relation and interaction with peers.

Case	Object on level n is a	with parts which	Interaction with peers on level
1	CW	are composite	ultimate by drainage
2	CW	are composite but are treated as simples	n-1 (pragmatic basal)
3	CW	are simples	n-1
4	CW treated as simple	are disregarded	n
5	Simple	none	n

How can we proceed if, working in a field of science, we do not know the ultimate level, where interaction presumably may take place, sufficiently well? - Actually, for much of the practical work we need not know the ultimate level. For we may *choose* a level of interaction pragmatically, simply disregarding the fact that its objects are themselves constituted of components.[65] To avoid unnecessary detail we pick this level as high as possible, yet as low as necessary for reductive explanations (Table 3, case 2).

For instance, when interested in biological phenomena, we choose a sub-biological level of molecules as the interactive basal level. Then all our interactive objects are molecules and their peers. When interested in neuronal networks, we chose neuronal biophysics as the basal

65 Further minutiae in [48].

level, explaining in terms of synaptic strength and membrane potentials. When interested in biochemistry, we choose chemistry (or interaction of atoms) as the basal level. The pragmatic basal level brings along the power of interaction in terms of assumed simple parts, explaining the phenomena observed on the level above.

By assigning components to a *pragmatically chosen* basal level we allow them causal interaction at this level, because they are taken to be simple, i.e. not exclusively dependent on their own components. Above the chosen level will appear higher levels containing CWs. These lack the power of interaction with peers, being exclusively dependent on their components.

19. Symbolic Whole (SW)

A CW, constituted of all parts, properties, relations and activities derived from a holon, is something 'large'. It is dependent on its inseparable constituents and cannot interact. Yet the term 'whole' has a second connotation, that to be 'about'. This aspect may be called the symbolic whole or SW. A name is associated with the CW-concept as a symbol representing (referencing) the CW and through it its holon, or selected features thereof. For instance, the SW 'Venus' may stand for the whole planet and all its relations, while selected features are captured by 'morning-star' and 'evening-star'.[66]

Also dependent and not interacting, the SW is a shorthand, something 'small' representing something much larger. The advantage of referencing complex holons by a single symbol is that much less information need be kept

66 For a semantic classification as *meronyms*, *metonyms* etc. see [36:15, 56].

in working memory during processing of upper system levels.[67]

The SW may reference features of interest, foremost the over-sum emergence, but also the *bottom-bottom* peer-interactions of components, which now appear as *top-top* interactions of a virtual agent or avatar. Of course, any symbolised peer-interaction necessitates that interaction of the symbol's denotate (or reference) can and does occur, requiring that the components referred to are simple or pragmatically taken as simple (Section 18). Only then is symbolic *top-top* interaction justified.

Such a the symbolic *top-top* change represents or 'stands for' a *bottom-bottom* change involving components. This 'stands for' does not imply a readjustment of components in a *top-down* way. A downward readjustment is not possible, for a symbol (SW) cannot change its denotate and a CW not its components.

20. Conclusion

Initially we asked whether wholes can affect their parts. Is statement (2) of the Introduction true? The answer is a clear No!, there can be no *top-down* change, be it causal-interactive or inverse-constitutive, if the number of components is > 1[68]. In the course of our arguments other issues arose, foremost those concerning the nature of constituted wholes and the nature of system levels.

67 Cognitive processing is limited by our neuronal resources to few items, working memory can handle less than 10 items at once (Miller's number [51]). See 'Principle of limited cognition' in [48:74].

68 ...as it must in mechanisms with interacting components.

We argued that theoretically

(1) A whole (a CW), for instance the whole of a natural mechanism, is constituted only of its interacting parts, properties, activities and relations. This *bottom-up constitutive relation* excludes any other dependencies of the whole.

(2) Over-sum properties emerge by *bottom-bottom* concerted interaction of the parts. The synchronic *bottom-up* readjustment of the CW occurs by constitutive relation.

(3) A whole cannot be separated from its parts and components, thus cannot interact with them causally.

(4) Nor can the whole of a mechanism influence its parts *top-down* by inverse constitution, as the constitutive relation (like the proper parthood relation generally) is asymmetric, *bottom-up* only, at more than 1 parts. (Proof of this asymmetry in Section 5 and a discussion of *bottom-up* synchrony in Section 8.) Such a *top-down* effect requires that a whole would change itself - quite impossible.

(5) Nor can a whole interact *top-top* with peers. The *exclusive* dependence of existence and properties on components bars any not-constitutive change of CW properties (as already denied by conclusion 1).

(6) A whole may represent, as features of interest, *bottom-bottom* peer-component interactions. These are mirrored symbolically as *top-top* peer-whole interactions (provided the components are simple or are pragmatically taken as simple).

(7) The ontological status of constituted wholes (as the integral aspect of composite objects) and symbolic

wholes is one of neuro-mental constructs and representations. These assume component prerogatives (like the power to interact) and mirror over-sum property-emergences and other features of interest.

(8) Simples (mereological atoms) do not have any parts to represent. Being not symbols of parts and relations, they may themselves encounter for interaction. The causal drainage of CWs to simples, downward across system levels, is inevitable.

Note that statement (1) of the Introduction is justified by conclusion 2 while statement (2) is denied by conclusions 3 and 4. In theory, therefore, *top-down* changes are impossible.

Regarding conclusion 5, commonly a whole constituted of real, interactive components is considered to be a real object capable of interaction with peers. This is intuitive and plausible, but contradicts our definition that a constituted whole is *exclusively* dependent on its components by relation (Table 2, attribute 6). Then any seeming *top-top* interaction involving a CW cannot be real, it must by symbolic, representing *bottom-bottom* changes of components (conclusion 6).

Thus, having agreed that a CW is in existence and properties dependent on its components only, a constituted whole cannot be taken to interact, except via its components.[69] It appears that a CW is not independent-real. Rather, not only a SW but also a CW is a representation, it is *about*, a construct of our mind (conclusion 7). In this sense a CW attains holon prerogatives by representing a holon, or, in case of SW, selected features thereof.

69 Table 1, rule 6 and Table 2, attribute 6.

Empirically statement (2) of the Introduction remains unsupported, reliable observations of changes initiated *top-down from a CW* are not on record. Such changes, though looking back on a long history, are a philosophical myth.

Theoretically the lack of support is to be expected from basic mereology (Section 4, 5). It is plausible already from the very definition of a constituted whole: It is constituted only by its components and their relations. This exclusivity is implied by the term "constitutive relation" linking a mechanism to the "mechanism as a whole" and not a matter of choice. As stated, a CW can interact with peers only through its components, it is without interactive power on its own level. Further, wholes are without interactive or constitutive effects on their components. These conclusions are contrary to the use of language and to parts of the philosophical literature.

Appendix.

System Levels and Dependencies

System levels order phenomena into palatable chunks. This is required because cognitive processing is limited by our neuronal resources to few items at once.[70] Thus our entire system of levels is not independently real, but built by our thinking machinery, taking limitations of this machinery into account. Wholes, representations and symbols generally are 'about', exist only in the mind, created by neuro-mental processes.[71] Upper levels are stages populated by avatars interacting symbolically.

In detail, we make order by representing any holon symbolically with a constituted or symbolic whole. The whole is an avatar, a representation 'about' selected features of the holon and its emergence from the level below. The advantage of symbolic wholes referencing features of interest is that much less information on the holon need be kept in working memory during processing.

Note that a symbol cannot exist without its denotate but the denotate can exist without its symbol (asymmetry of existence and of dependence). Asymmetry also holds for CWs (asymmetry of the constitutive relation, Section 5).

In *universal systems* basic items are identical across levels and change synchronic on all levels. The level-specific objects arise from different grouping of the basic items. Context and idiom are also level-specific. Any further coupling of levels is not needed, coupling is already complete, each level having the same basic items [48:38].

Vertical (constitutive) dependencies: *Bottom-up* changes are mediated by constitutive relation. 'Constitutive' means that components with their properties, activities and relations are essential parts of the constituted whole (CW). The constitutive

70 Working memory can handle less than 10 items at once (Miller's number [51]). See 'PLC' in [48:74].
71 See [12:124].

relation specifies how a CW is dependent on its components. The dependence is complete (components and their properties, activities and relations, also those derived over-componential properties and property-emergences are all included) and exclusive (only these are relevant). *Top-down* changes are impossible due to the asymmetry of the constitutive relation (Section 4, 5).

Horizontal (causal) dependence of an object results from interaction with peers. This is possible if the objects are simple (have no parts). If they have parts, the objects are CWs. Then such an interactive *top-top* dependence might interfere with the complete and exclusive dependence of a CW on its parts (definition of a CW). For instance, a component property represented by a CW could be changed by *top-top* causation. Therefore CWs cannot interact with peers (except symbolically).

Where parts are constituted of their own parts, the inability to interact horizontally (with peers) drains down from system level to system level, exempting only an ultimate bottom level, where entities have no parts (are simple). Here they may presumably interact.[72]

With quantum phenomena (or something more fundamental, like information) at the ultimate bottom level, we expect that only these phenomena are real and interactive, while everything above is vertically dependent, is in a way illusionary.

However, even at the ultimate bottom independence is doubtful. For can there be independent reality if the observer plays the decisive role observed? Truly independent reality may not be found even at the ultimate level, all knowable things then being dependent on observation.[73]

Several concepts familiar from upper system levels (matter, interaction, causation, determinism) do not apply at the ultimate quantum level, which is highly probabilistic. Here single

72 'Causal drainage', as discussed in [11, 38, 39].

73 Compare Jackson's Kantian physicalism [34:23], as quoted in [26:205].

events cannot be predicted reliably, there occurrence is described by probabilities. In the quantum world, quoting Anton Zeilinger, basic concepts of reality are not matter, spacetime or interaction but information [69, 70].[74]

In view of this prevalence, are the concepts of matter, spacetime, interaction, causation or determination obsolete, are they 'wrong'? No, above the ultimate level they remain *essential and valid concepts*.[75] But their validity is not general but level-specific. It is out of epistemic necessity that they continue to be useful at upper levels: Reduction across many levels has little explanatory value, the conceptual connection can hardly be comprehended if intermediate explanations are skipped.[76]

In practice, as mentioned, scientific analysis in many fields need not rely on a drainage to nearly incomprehensible ultimates: Analysis chooses an intermediate, more familiar level as the basal one, ignoring the fact that its objects have components. To this level the power of interaction is pragmatically assigned while the level-specific concepts are applied.

In this context the question what levels are - how they and their constituted wholes arise from and relate to each other - may gain new interest.

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74 The prevalence of information over substance or matter was proposed by prominent authors for more than 40 years [e.g. 27, 28, 64, 65, 71], as discussed in [49:82-85].

75 See also M. Esfeld who argues that quantum theory and common realism are compatible [26:215].

76 See 'Principle of limited cognition' [48:74].

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