Frontiers of Manipulation

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What are the limits and conditions of material manipulability? More importantly, is there a connection between the concept of the material and the function of manipulation in the sense that the latter decides the former? Drawing on some of the recent discussions in the field of engineering with regard to models, cross-level causal manipulation and intra-level intervention, renormalization groups, morphogenetic analysis (the science of forms) and non-extendable explanatory and functional levels, this presentation aims at providing a concept of material organization beyond but reconcilable with the level of appearances. Whilst claiming that (1) material descriptions are blind to explanations and (2) only causal and functional explanations are capable of rendering the material intelligible and making material intervention possible, a robust concept of construction and manipulation cannot dispense with descriptive resources of appearances and macro-level domains. Once approached through local possibility spaces opened up by deep explanatory levels or the scientific image, the powers of abductive inference implicit in the manipulation conditionals at the level of ordinary descriptions enable a mode of construction that expands its frontiers from the top and from the bottom. This marks an encounter with the material that is neither quite speculative nor quite empirical while it is both abductive/non-monotonic and under real constraints.

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This presentation is built around one claim: manipulation is able to make sense of materiality, its organization and intelligibility. In order to elaborate this claim, I would like to introduce a formalism of manipulation and for this purpose, it is necessary to impose certain limits and regulatory restrictions on the scope of materiality we aim to examine.

One of the most consequential developments in the field of modeling and intervention (namely, intervention at the levels of structural and functional organization) and in the domain of 'engineering epistemology' is the radical change in the definition of the system. According to this this shift, system is no longer understood by the analysis of its intrinsic systematic architecture. In order to know the system and in order to be able to act on it, we do not require ideas such as intrinsic architecture, foundation and essential constitution. Even the duality of part-whole relationships which was previously used to describe a system is no longer necessary. Instead, the system is identified in terms of tendencies as abstract properties that determine the behavior of the system, in terms of the functional organization of the system and its overall behavior. In other words, 'what a system is' cannot be studied independently of 'what a system does', and what a system actually does cannot simply be understood as what it appears to be doing. That is to say, for a complex system what a system appears to be doing is hardly ever what it actually does, insofar as the surface character of the system's function is realized by qualitatively different sets of individuating powers and activities (qua realizers) to which we do not have immediate access. According to this definition of the system, the totality of the system is not real, it is only a side effect of the integration of the system's functions. In short, there is no totality but only functional integration.

Here, I approach the term function in a technical sense. Firstly, a function is attributed not to an item or a thing but to the item's behavior and what a thing does. Function of X being Y does not explain X directly; it explains the system to which X contributes. Functions are marked by their plasticity in the purpose-attainment of a system or its various undergirding mechanisms. But here the purpose-attainment should not be interpreted in the sense of an inherent purpose but simply a state of activity. Functions are not determined by their structural constitution. They can be reconstituted in different material substrate as long as specific material-organizational criteria for their realization are fulfilled. This is the basis of multiple realizability thesis.[1] In short, functions are multiply realizable while multiply constrained. These constraints are set by various organizational levels which play a role in the individuation or realization of functions.

The multiple realizability of function is not pure abstract realizability. In other words, a function cannot be fully abstracted from its material organization so that it can be implemented in a limitless number of material substrates. Nevertheless, the embodiment of the function is not an impediment against its multiple realizability and cannot be used as an argument against functionalism. A function can be realized by different realizer properties and for different purposes as long as organizational constraints associated with the embodiment of the function are taken into account. While a function cannot be abstractly realized insofar as it is individuated by different levels of material organization, the multiple realizability of a function implies the weakening of the determining influence of the structural constitution over function. Hence the definition of the system in terms of 'what it does' and 'what it can do' can be elaborated without recourse to constitution or an account of 'what the system *is*'. This shift suggests that in order to render the system intelligible, the activities of the system at various levels must be highlighted. But the examination of activities requires complex modes of intervention at different levels of the system's organization so as to determine how these activities are effected and to what dimensions of the system they are attributed.

In order to explain a system by way of its tendencies, in a similar way, first we have to single out tendencies or abstract properties which individualize the behavior of the system. But we cannot identify these tendencies, unless we amplify them, in a sense identifying them by manipulating parameters responsible for their behavior. Consequently, obtaining information regarding tendencies and functions requires modes of intervention and manipulation. A system can be rendered intelligible, its organization can be mapped and its local-global picture can be acquired by identifying tendencies and functions through various modes of intervention and manipulation. Models accordingly are not just analytical tools, they are interventive tools that entangle with the structural-functional organization.

Throughout the last three decades, the rigid account of system theory that has its roots in the early gestalt theory and has developed by the likes of Ludwig von Bertalanffy has fundamentally changed. The advent of robust conceptions of the functional organization, hierarchical complexity, generative entrenchment and tendencies has allowed us to understand and examine

[1] According to the *multiple realizability thesis*, the realization of a function can be satisfied by different sets of realizing properties, individuating powers and activities. Therefore, the function can be realized in different environments outside of its natural habitat by different realizers. Multiple realizability usually comes in strong and constrained varieties. The strong version does not impose any material or organizational constraints on the realizability of a specific function, therefore the function is taken to be realizable in infinite ways or implementable in infinite or numerous substrates. The constrained variety,

systems in a new light. The epistemology of the system—which is to say, the knowledge of the system—no longer focuses on the question of what a system is but instead closely examines and interacts with what a system does and what it can do. Since as mentioned earlier, the totality of the system is in fact nothing but its functional integration—its qualitatively distinct activities and individuating powers distributed across various levels of its organization—then in order to know the system one must examine the functional organization of the system. But epistemic insights into the functional organization of the system is not a matter of simple analysis. Functional links between various organizational levels of a system cannot be correctly localized and characterized unless through online interaction with these functions—that is, by way of manipulating the system and its functional parameters through action-based modes of inference. The epistemology of the system, accordingly, is understood as an armamentarium of complex heuristics that study the system (qua functional integration and tendencies) by manipulating it (intervening with its functional organization and tendencies). This constitutes a new model for understanding materials and examining their organizational dimension, i.e. what makes them intelligible as materials.

However, we should note that the origin of this manipulative or interventive mode of epistemology is not inherently new. The roots of the idea that in order to know a thing we need to intervene and manipulate that thing can be traced back to the origin of philosophy, especially the Socratic tradition of ethics. In the classical program of ethics, the self is regarded as a material from which the philosopher should navigate both the landscape of truth and the landscape of goodness. Self is the veritable material of the philosopher that has the characteristics of a problem. It is a problem because one cannot take it as a given nor from the outset pretend as if one is free from the self. Whereas the former leads to illusions irreconcilable with reality, the latter only reinscribes selfhood under the illusion of freedom from the self. Therefore, the self is treated as a problem that needs to be worked out procedurally. As the primal material of the ethical philosophers – such as the Cynics and the Stoics – in order to know the self qua the immediate material of the philosopher, you must organize the self, but one cannot organize the self unless through construction and individual-collective manipulation of the self. This becomes Socratic dictum that shapes the origin of the ancient Greek ethical program: A philosopher should not exert influence on others unless he first attends to himself but he cannot attend to himself unless he knows himself, (ergo, the oracular dictum 'Know thyself'). Yet he cannot know himself unless he constructs himself, which is to say, treat the self as an object of understanding-via-construction—a manipulable problem or what is called a non-explanatory hypothesis.

Accordingly, ethics becomes a program for the design of conduct that allows for the constructability of the self as a material that is no longer bound to a fundamental constitution (an intrinsic meaning or identity, a prior state of affairs, etc.). Ethics is then defined as a program for the knowledge of the self in the sense of working out the problem of the self by way of procedurally constructing it and manipulating its traits and boundaries. Correspondingly, ethics becomes a project which is not moral, codified, voluntaristic or contractual but is rational and destinal. Destinal in the sense of self-realization, because once one understands these conducts or activities as functions, then they can be repurposed, recontextualized and even furnished with their own functional autonomy. This is what a function is, a designated activity, a role that is capable of escaping the straitjacket of its constitution and by doing so, realizing itself in different organizational substrates. The ancient program of ethics in this sense can be regarded as an initial gesture for understanding the system through manipulation. For after all, what is a system other than an integration of functions into a canonical subjectivity.

Now what I would like to discuss is how engineering approaches materiality by way of manipulating its structural-functional organization. But before that, it is beneficial to this discussion to give a very brief introduction about what we mean by materiality here. Materiality is about a certain form of organization, a nested hierarchical complexity of structure and function, and their mutual influence over one another. This hierarchical organization—which is hierarchy both in terms of the structure and the function—is the register of complexity in material systems and marks the frontiers of manipulability or what we can do to a given material. Obviously, the depthwise complexity of this hierarchical organization is directly associated with not only how much we can manipulate something but also and more importantly, where does the manipulation takes place (i.e. where in the organization the results of our manipulation register). The relation between manipulability and complexity is not by any means straightforward. More complexity doesn't essentially translate to more manipulability. Where there are numerous functions already accumulated and integrated into an entrenched functional organization, then manipulability is much harder. Similar intricacies arise on the level of structure. Our manipulations do not essentially spread all across different structural levels. These are all aspects of the relation between material organization and manipulability that need to be taken into account and of course, explaining them far exceeds the scope of this presentation.

The realist account of material complexity is the statistical expression of nested hierarchies where true decentralization takes place and mechanisms are stabilized into different levels of the functional organization. A good example for understanding the hierarchical account of complexity is the biological organization which is comprised of various phase spaces and biological hierarchies. The most important thing to know about these biological hierarchies is that they have distinct explanatory levels and their governing principles are not the laws of physics proper. This is why the biological domain cannot be thoroughly reduced to the physical domain. The relation between the two is that of unification rather than strong reduction. The organization of materiality at the level of physics proper involves the so-called geodetic principles or Lagrangian optimality—the law of the least action for a given trajectory. For example, a river always runs along the shortest path (the geodetic curvature) toward the sea. This type of optimality however is absent in biological organizations because biological evolution is not about geodetic optimization insofar as biological evolution is not simply evolution along a specific trajectory. Biological evolution deals with an entirely different concept, the ecological fitness which is optimal selection in terms of generic rather than specific trajectories of evolution.

However, just as the explanatory and descriptive levels of biological organization of matter cannot be stretched or reduced into those of physics, different explanatory levels of a physical organization cannot be overextended to one another either. Both the intelligibility of the material and its limits of manipulability are determined by the physical organization of materiality. But the physical organization is neither flat nor homogenous. Instead it is distinguished by qualitatively different and non-extendable strata or levels of structure and function. It is precisely the organization or the intricate interactions between these levels which render the term materiality intelligible both from the perspective of what it means for something to be or behave as material and what it means a material to be manipulable. Lacking a multi-level account of material organization, the concept of materiality is merely a metaphysical curiosity if not a contentless term.

The first important point in investigating the logic of hierarchies in material organization is that these organizational levels have their own specific rules of manipulation, precisely insofar as they are qualitatively different. In this sense, each level is endowed with different explanatory and descriptive resources. The concept can no longer be applied to the material x all the way down. In fact, the concept cannot and should not retain its semantic content across different strata because that would amount to the flattening of various organizational levels which render the material intelligibility and allow for designated manipulability. This is why conceptual patchworks are used in studying materials and their organization and the conceptual behavior changes from one level to another.

Within the hierarchical-organizational framework of materiality, extreme modes of top-down and bottom-up approach—such as strong eliminativism and strong emergentism—are revealed to be models built on elision of different levels. It is this elision or incorrect merging of different organizational levels which (erroneously) permits the overextending of conceptual, descriptive and explanatory resources from macroscopic levels to microscopic levels or from lower level to upper level phenomena. Both reductionist and emergentist models contribute to the understanding of the material organization by either uncovering the richness of lower levels or the complexity of higher levels. But once the top-down or bottom-up approach is universally privileged to the exclusion of the other, the multi-level account of explanation is flattened, richness of reduction turns into impoverishment and complexity of emergence becomes so ubiquitous that signifies its banal vacuity. Short of the multi-level account of material organization and the differentiation of explanatory-descriptive levels, we are exposed to a wide array of fallacies and metaphysical biases in defining, modeling and manipulating materials. Not only identical conceptual resources cannot be mobilized from one level to another, rules of manipulations or the so-called manipulation conditionals cannot be overextended from one level to another either.[2] For example from the perspective of material manipulability, there is no necessary continuity between macroscopic levels, microscopic levels and dimensions at atomic scale length.

Explanatory resources, descriptions, concepts, individuating powers and properties, rules of manipulations and functions cannot be overextended from one level to another because there is a discontinuity between organizational levels. The criterion for the classification of these organizational levels is usually the scale at which the phenomenon is active. The question of scale is addressed through the concept of length scale or the length determined by one or a few orders of magnitude. Physical phenomena or material configurations of different length scales cannot usually affect one another. In order words, connections between different length scales of a material organization are complex and not fully differentiable. The discontinuity between different length scales requires a different mode of examination, one that would be capable of decomposing the material into its organizational levels and subsequently, recomposing the information gathered from these distinct organizational levels into a robust conception of materiality.

Therefore in the wake of the discontinuity imposed by different length scales, the question of materiality becomes the question of integrating various structural-functional levels without overextending their conceptual resources, descriptions and explanatory valences. In the same vein, if the concept of materiality is comprised of different non-extendable organizational levels, then how can we have a robust account of material manipulation (or intervention at the level of material) that does not simply overstretch specific modes or methods of manipulation from one level to another. It is in this sense that lacking explanatory differentiation and an account of inter-level discontinuity or complex continuity results in trivial material manipulation. In other words, absence of multi-level explanation results in explanatory impoverishment, while impoverishment

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[2] Manipulation conditionals are specific forms of general conditionals that express various causal and explanatory combinations of antecedents and consequents (if… then…) in terms of interventions or manipulable hypotheses. For example a simple manipulation conditional would be: If x were to be manipulated under a set of parameters W, it would behave in the manner of y. For a theory of causal and explanatory intervention, see *James Woodward, Making Things Happen: A Theory of Causal Explanation* (Oxford: Oxford University Press, 2003).

at the level of explanation and description culminates in inconsequentiality at the level of material intervention.

In classical modeling, the question of studying the material organization and the question concerning the relation between material and manipulation are answered by way of infinite idealization. Since in classical modeling, the explanatory differentiation of various organizational levels doesn't exist, infinite idealization is the most optimal solution to picture the organization of materiality and accordingly, devise solutions for material intervention. But what is infinite idealization? We have a steel beam. We endow this beam with a zooming function capable of zooming in and out of the fabric of the beam. Once we zoom in on the steel beam, we see the structure of grains, the further we zoom in, we still see the same structure and the same organization all the way down. This is infinite idealization. Zooming in and out of the material x yields the same or similar picture, only contracted or dilated. Some minor organizational features might differ but main characteristics are preserved as we zoom in or out. The infinite idealization brings about a construction-friendly picture of materiality, precisely because it uniformly deepens the domain of the ordinary language which is specific to the stabilized surface phenomena of macroscopic length scales. Since the domain of the ordinary language is rich with manipulation conditionals and enjoys a maximal stability at the level of form, it is applied all the way down or idealized as the constructive model of the material organization. But the morphogenetic stability of form and the conceptual mappings of the ordinary language are exclusive to the macroscopic surface phenomena and the world of appearances. They cannot be treated as ubiquitous features throughout different levels of material organization. It is for this reason that engineers cannot solely rely on models built on infinite idealization.

Any model of material organization or material manipulation should be able to incorporate three domains of hierarchies or span across three length scales: (1) Macroscopic level, which is often associated with surface phenomena and affordances, and can be adequately defined by the resources of the ordinary language adequate to describe the familiar world; (2) Mid-level or meso-scale where various bridging microscopic levels are located. In the steel beam example, it can be the domain of crystals; (3) Beneath the microscopic levels there is the atomic length scale. At this lower dimension, the descriptive, structural and functional continuity completely breaks down. Rules, descriptions and modes of intervention specific to the upper hierarchies can no longer be applied to this level. Structures and behaviors of grains and crystals in the steel beam cannot be extended to the atomic scale where the material behavior radically changes.

The inter-level discontinuity is also discontinuity at the level of the concepts applied to the material organization. One cannot make a conclusion by way of conception at the level of surface phenomena and extend its conclusions downward to the microscopic levels. The same also applies to bottom-up conceptual inferences. Conceptual behavior should reflect the complex inter-level discontinuity. Concepts which retain their semantic content across different domains in the material organization are favored by speculative philosophers precisely because they are building blocks of big ideas where speculation can be exercised at whim. But as far the material ontology is concerned big ideas are either the products of flat pictures of the material organization or the infinite idealizations of one domain and its overstretching into everything else. In short, when it comes to material ontologies, big ideas are results of global trivialization. In the same vein, models lacking an account of the three general scales (macroscopic, microscopic and atomic or upper, meso and lower dimensions) present weak, inadequate and biased interpretations of what materiality consists in and how it can be manipulated or constructed.

Since the morphogenetic stability of macroscopic levels is suitable for construction and also descriptive resources of the ordinary language are specific to surface phenomena, it is then obvious why models of material intervention tend to apply the key features of the macroscopic dimensions to every other level. But this is also why engineers are also wary of all-encompassing models or any formulaic account of material organization. In studying and manipulating a steel beam for example, engineers do not seek a picture of the beam that remains similar regardless how far we zoom in on the beam. What they are interested in is how the behavior of the material organization of the beam changes as we zoom in or move from one level to another. In other words, what they need are multi-level perspectives. But these perspectives are intrinsic to the material organization and must be capable of disassociating or stratifying the causal fabric into mechanisms and specific structural-functional hierarchies. Only then it is possible to correct the application of concepts and implement change in the material organization. However, these perspectives are not subjective viewpoints, they are special tools, modes of online manipulation of the material organization and the causal fabric. They are heuristic tools that allow for the stratification and designation of the material organization and its causal fabric. Their task is to distinguish the explanatory layers of a material organization, how one level explains another and how a specific behavior of the material organization is explained by structural and functional components. But explanation in what sense? This is explanation in the sense of elucidating the relation between explanans and the explanandum.

A rudimentary example of explanation would be a shadow on the wall. When we try to explain a shadow on the wall by itself i.e. by referring to its own characteristics, we are merely describing the shadow. In order to explain the shadow it is necessary to intervene or manipulate what casts the shadow. By manipulating the wooden pole, we decide if it explains the shadow or not, and if yes, then in what way. This is what is called the manipulationist account of explanation: X explains Y, if and only if had we intervened with X, Y would not have been produced. Intervention becomes synonymous with explanation. What is intervened with here through complex heuristics is the invariance, because the relation between explanans and the explanandum can be studied in terms of the thresholds of invariance preservation under given modes and conditions of intervention. If the invariance is not preserved under certain parameters of intervention, then there is no explanatory relation. The failure of explanation is in fact advantageous in picturing the material organization, because it points to other hitherto unobserved or unknown mechanisms or explanatory levels.

In order to construct robust and nontrivial models of materiality, it is necessary to have multi-level perspectives capable of crosscutting the material organization into different explanatory strata through deployment of complex modes of heuristic intervention. The model in this sense not only explains the material organization, elucidating what materiality consists in but also manipulates and intervenes with it. The concept of materiality cannot be rendered intelligible without an account of material organization. But the material organization cannot be coherently pictured without deployment of complex modes of manipulation and interventive heuristics.

Manipulation techniques and interventive heuristics required for the navigation of the different levels of the material organization must be specific and parameterized. Since as it was argued earlier, manipulations at the level of atomic scale cannot be overextended to other levels, their effects do not essentially translate into effects on macroscopic or microscopic levels. Accordingly, any complex explanatory-interventive model must have specific forms of designated manipulation capable of targeting a specific strata or length scale. This is where engineering comes to play because in the broadest possible sense, engineering is the armamentarium of complex heuristics and manipulative modes of inference for online interaction with the material organization or the system under study. This is heuristics not simply as trial and error techniques, but instead manipulation as inference and designated intervention as thinking-in-doing. Here, however, the mode of inference is neither deductive nor inductive but rather what Charles Sanders Peirce calls abductive. It characterizes a mode of inference that is non-monotonic and revisionary. It permits error-tolerant rules, that is a fallibility that is required for interaction with dynamic systems and complex organizations.

Engineering's abductive inference treats materiality as a manipulable hypothesis. Intervention begins with a designated patch of the causal fabric. Then information acquired as the result of intervention is used to synthesize various possible explanations in the manner of new arrows pointing to the possibility of new levels, observables and behaviors. This deepening of behaviors in turn demands the design of new models, perspectives and conceptual patchworks or maps. As the picture of the material organization is deepened beyond the level of appearances or the surface characters which are usually associated with forms, the demand for updating and expanding the scope of manipulation also increases. This is expressed by the reinforcement between the deepened picture of the material organization and the expansion of the manipulative tools and techniques, between what the material is and how it can be manipulated, between the definition of the system and how it can be constructed.

The heuristic approach, accordingly, does not preserve any foundational account of what the material or the system is, it makes sense of the material organization in a piecewise manner. For this reason, it uses logical procedures which do not entail truth, but instead simultaneously preserve and mitigate ignorance. In this fashion, the constructability implicit to the abductive manipulation becomes isomorphic to the understanding of what the system or the material organization is and how it can be modified in any meaningful sense. Correspondingly, expanding the scope of intervention and enriching the armamentarium of manipulation techniques results in the deepening of epistemological insights into the workings and the organization of the system. Just as the logical structure of the abductive inference does not preserve truth, interventive heuristics of engineering epistemology do not preserve the constitution of the system either. In a certain sense, they implement the logical structure of abductive inference (non-entailment, non-monotonicity and non-preservation of truth) in the very material organization they interact with. Rather than studying the system or the material organization by focusing on the constitution as the main point of reference, the complex heuristics intervene with the constitution. In other words, as a material equivalent of abductive inference, the interventive method does not identify the system on the basis of its constitution, it does not transfer or axiomatize the material constitution; instead it changes the constitution in the course of its epistemic operation. For this reason, interventive heuristics are synthetic operators rather than analytical tools.

As synthetic operators, interventive heuristics treat materiality as a problem. But they do not break the problem into analytical elements for the purpose of study, explanation and devising solutions. They literally transform the problem into another problem by manipulating and interfering with its parameters. If the invariances of the problem are preserved over the course of transformation, then they can be approached, analyzed and solved on more optimal levels. The synthetic transformation disperses the epistemic fog that prevents us to coherently approach and solve the problem. On another level, the interventive heuristics dissociates different strata of material organization, thereby reducing the risk of eliding different explanatory levels without which we cannot understand or solve the problem. From a certain perspective, interventive heuristics remove the lower bounds of materiality, that is to say, the privileged role of constitution in studying the system or a material organization, fundamental assumptions with regard to how a system behaves or how a material system can be modified. Once the foundationalist role of the constitution is removed, by virtue of its hypothetical dimension, the system can be constructed further. Therefore, also the upper bound of the system—that is, the limit of its evolution—is also removed. It is in this sense that the evolution of the system in terms of exploring the possibilities of its (re)construction is integrated within the explanation of what materiality is and what the system, its behavior, consists in. The understanding of the ontology of system becomes tantamount to understanding the behavior of the system which is itself a register of its constructability. In the same vein, materiality is approached by way of heuristics which not only map its organization—what makes material, material—but also intervene with its fabric. The interventive or the manipulationist account of the system or the material organization, however, does not require an a-priori understanding of a law or systematicity in order to explain and construct, since what is needed for designated manipulation is information regarding invariance. But in order to identify invariants, one does not need to know laws. Inferential reckoning or tracing of spatiotemporal continuities and recognition of processes is sufficient for the identification of invariants. The concept of materiality is empty without its material organization. But the material organization requires information regarding both intra-level and inter-level activities, mechanisms, configurations and structural-functional links. Yet again this information cannot be obtained without intervening with the material organization.

However, one question still remains: If the manipulationist / interventive account of materiality removes the lower and upper bounds of material organization, then how can we generally construct anything given that construction requires both regulatory constraints and dynamic stability? How does engineering work if it does not establish any lower and upper limits? The answer is that construction primarily requires access to the surface characters and descriptive resources of macroscopic phenomena. For example, the stress field of a steel beam, the solidity of a wood and its tolerance for pressure. At this level, construction can be carried out using the rich descriptive resources and manipulation conditionals of the ordinary language. In order to embark on construction, to make something that functions, the engineer does not need the knowledge of the atomic scale. The engineer can use the descriptive resources of the ordinary language which are specific to macroscopic characteristics and morphogenetic stabilities. By using the manipulation conditionals of the ordinary language characteristics of surface phenomena, the engineer is able to make things which can still function: For example, 'if this amount of pressure is applied to a steel beam, it bends in this manner.' But the *if…then…* structure (the manipulation conditional) associated with the bending of a steel beam is exclusive to the macroscopic levels and morphogenetic stabilities of upper levels which cannot be extended to the lower dimensions.

However, construction is not solely about stability; it is also about expansion, modification and fine-tuning. In order to expand the scope of the construction, to fine-tune the construction and if necessary to modify and revise what has been constructed, the engineer must access the scientific concept of materiality by searching for mechanisms, navigating different levels of the material organization and extracting new observables. It is this scientific conception of materiality that is continuously undergoing changes and constitutes the space of possibilities for the expansion and modification of the construction. In this regard becomes, the task of the engineer becomes how to connect or more accurately extend the local domain of construction at the level of the macroscopic to the ever-deepening space of possibilities, descriptive materiality to the scientific conception of matter. To do so, first engineer uses procedures of localization and conceptual mapping to restrict the scope of construction to specific set of parameters or problems on the surface level (associated with descriptive resources of the ordinary language and stable behaviors). Subsequently, these maps of construction must be located within the space of possibilities and lower-level behaviors opened up and uncovered by science. But this bridging of the stabilized and readily constructible upper-level domain with the lower-level space of possibilities cannot be understood in terms of a rudimentary continuity. The discontinuity between different length scales does not allow a simple bridging between upper-level stabilities and lower-level behaviors where possibilities of further expansion, modification or revision of the construction lie.

The constructive mapping of local spaces of the macroscopic level within the space of possibility of lower levels calls for a view from the bottom and a view from the above. In other words, only the simultaneous deployment of the top-down and bottom-up approaches can ensure both the stability and the expansion of construction in the absence of any upper and lower limits. While lower levels expand the possibilities of construction and revise the higher-level models, the upper levels normalize and orient the deepening of lower levels and correct their speculative dimensions under real constraints. The conjunction of both views allows for the stabilization and expansion of the construction by gluing upper-levels' capacities for orientation and stability with lower levels' powers for deepening the possibilities of construction. It is through the gluing of the top-down and the bottom-up that manipulation of lower levels contributes to the intervention at upper levels and the manipulation equivalents of upper-level interventions can be located or developed at lower levels.

For example, in order to synthesize a perfume with the fresh scent of the sea, a perfumer first locates and develops the manipulation conditionals of his perfume in the domain of the ordinary language associated with the macroscopic level. At this level, the manipulation conditions are developed out of the rich descriptive resources and the metaphoric plasticity of language: Since the smell of salt and algae on the skin is suggestive of seawater then in order to synthesize a fresh sea scent, we can use compounds found in algae and salt combinations. The next task of the perfumer is to find the mid-level equivalent of such manipulation conditionals. This entails the translation of the metaphoric language of the perfume into the mid-level chemical reactions and compounds. The final stage required to construct and optimize the perfume is to find the lower-level equivalents of the mid-level manipulation conditional specific to chemical reactions. At this stage, construction is carried out using the highly technical language and complex manipulation techniques at the level of molecules. The material organization of the perfume, its language and manipulation techniques at the level of molecular chemistry are fundamentally discontinuous to the language of materiality and construction methods peculiar to the domain of ordinary language.

Rather than overextending the constructive potentials of the upper levels to the lower levels, the engineer finds the equivalents of manipulation conditionals of macroscopic levels on microscopic levels, and subsequently locates the manipulation conditionals specific to meso-scale spectrum of the material organization in lower dimensions. The constructive navigation is as much on each level as it is between and across different levels. The engineer's space of possibility is the depth of the construction—the stereoscopic coherence between the stability and observable properties on the one hand and manipulable lower-level behaviors and parameters on the other. Here, the depth of the construction is the very map of the material organization that must be brought into focus by realigning various models of intervention with regard to one another.