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Dialogue Across Chasm: Are Psychology and Neurophysiology Incompatible?

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To establish a genuine scientific discourse, we must accept a long due departure from the habit of neatly arranging things in a hierarchy where "macroscopic" psychological mystery awaits explanation in terms of "microscopic" neural objects. Instead, a relational scientific methodology is wanted, accompanied by a dialogic mode of conversation between the disciplines.

The term depth psychology, where the word depth implies "below the surface," was coined by Eugen Bleuler (1857–1939) to denote the cluster of psychological theories focusing on the unconscious and its relationships with the conscious ("surface"). For almost one hundred years, depth psychology and neurophysiology kept a safe distance from each other and avoided a genuine dialogue. Psychological theories courageous enough to make bold statements concerning dynamics of unconscious human motives and conflicts shied away from issues of matter and developed a rich conceptual framework that is independent of the underlying physiological machinery. At the same time, neurophysiology had restricted its interests to matter, with minimal allusion to the issue of mind. The barrier has begun to lift recently. Advanced technology, taken together with an atmosphere that rewards interdisciplinary discourse, have brought neurophysiology and depth psychology to seek contact and to dialogue (Kandel, 1999).

Ernst Mach (1838–1916), a Renaissance man—eminent physicist, philosopher, and physiological psychologist—referred to cases where two separate intellectual fields meet each other. In an essay on the relation of the physical to the psychical (1914), Mach writes: "It often happens that the development of two different fields of science goes on side by side for long periods, without either of them exercising an influence on the other. On occasion, again, they may come into closer contact, when it is noticed that unexpected light is thrown on the doctrines of the one by the doctrines of the other." In such cases, he continues, "… a natural tendency may even be manifested to allow the first field to be completely absorbed in the second." This seems to be the present state of the art, at least if one searches Google Scholar for highly cited papers on the neural basis of (for instance) altruism, empathy, love, religious belief, or repression. However, Mach continues,

> … the period of buoyant hope, the period of over-estimation of this relation which is supposed to explain everything, is quickly followed by a period of disillusionment, when the two fields in question are once more separated, and each pursues its own aims, putting its own special questions and applying its own peculiar methods. But on both of them the temporary contact leaves abiding traces behind. … [T]he temporary relation between them brings about a transformation of our conceptions, clarifying them and permitting of their application over a wider field than that for which they were originally formed (Mach, 1914).

This short essay is a comment on "abiding traces" that the present contact with depth-psychology might leave with neurophysiology, i.e., transformations that survive the disillusionment that brain physiology is supposed to explain everything psychological.

As scientists, we think in terms of hierarchical levels of organization where every phenomenon or model or theory pertaining to a given scale must conform to the constraints imposed by the smaller scales below. We keep in mind the difficulties inherent in the hierarchization of our subjects of analysis. To illustrate a potential confusion about levels of organization and the origin of constraints, let's consider this simple question: "WHY are polar bears white?" One may first think of "looking inside." Close examination of their skin reveals a transparent fur with mutations in a particular protein involved in carrying melanin. This is the same protein that is mutated in other animals with white fur and in human Albinism. Now consider another answer category, which would turn the lens outward: "look outside, it is all snow white!" This could explain the abundancy of mutations ("heavy selection pressure") that are present in this particular protein. The dynamic relation between the bear with its environment—the living and the nonliving—is a formal answer that gives meaning to the molecular-biological concrete mechanistic-causation description as well. From this viewpoint, to the extent that "macroscopic" depth psychology is about the meaning of thoughts or experiences, there is very little, if any at all, that it can make with neurophysiological explanations to its abstract concepts.

Another difficulty related to hierarchical structures in science was analyzed by Philip Anderson (1923–2020) in a landmark paper where he coined the slogan "More Is Different" as a consequence of symmetry breaking. Using insights from his own field (condensed matter physics), he concluded that when the scale of a system is changed—from the microscopic to the macroscopic or from a single object (for

example, atom, or cell, or organism) to a population of objects (e.g., molecule, organ, or society, respectively)—fluctuations dictate paths taken at critical branching points, leading to a qualitative change in the nature of macroscopic phenomena: "… [T]he whole becomes not only more than but very different from the sum of its parts." Hence, "… entirely new laws, concepts, and generalizations are necessary, requiring inspiration and creativity to just as great a degree as in the previous one. Psychology is not applied biology, nor biology applied chemistry" (Anderson, 1972).

Cutting deeper into the essence of biology reveals that not only "More Is Different", but also "Less Is Not Simpler." This becomes clearer as the resolution of our measurements and the means to handle large datasets are constantly improved. Complexity goes all the way down, regardless of how it is estimated and regardless of the level of organization observed or the method used (e.g., functional MRI, electroencephalogram, multisite recordings from large scale networks, single neuron, or single channel measurements). "Less Is Not Simpler" taken together with "More Is Different," entails an unfathomable number of paths connecting microscopic processes to macroscopic ones, such as bi-directional many-to-one, or one-to-many, or any strange loop one wishes to contemplate. Defining mechanisms under these circumstances, in particular of complex behavior, is not trivial and may not lie at the microscopic, molecular level.

In spite of these problematics, we naturally accept schemes of the kind pervasive in neuroscience textbooks showing levels of organization hierarchies with behavior at the top floor, genes or cellular processes at the bottom, and the intermediate levels occupied by brain, network, neuron, and synapse. In what sense are the dynamics of an organism's behavior macroscopic to dynamics of neural populations? Indeed, disassembling a neuron to its elements leaves us with genetic material and many other kinds of atoms and molecules arranged in heterogeneous clusters. Equally true is that neural networks are built of neurons. Brains are built of neural networks that interact with each other and are connected to sensors and muscles; dissect a brain and you are left with clusters or networks of neurons. Yet behavior is not built of brain. Separating behavior down to its components does not naturally leave us with a brain at hand; this is probably the most formidable barrier for a dialogue, that is, the idea of extending forms of discourse that might fit nearby levels in a structural hierarchy to the jump between brain and behavior.

So, are we doomed? Is the very idea of explaining the mind by using physiological terminology invalid? Maybe, but it does not imply that there is no space for dialogue between neurophysiology and psychology, a dialogue that—as suggested a century ago by Mach—has a potential to bring about "… a transformation of our conceptions, clarifying them and permitting of their application over a wider field than that for which they were originally formed" (Mach, 1914). To do so, we—psychologists and physiologists—should be willing to let go of the hierarchical view, adopt a relational mode of scientific exploration and discourse, and become less possessive of the subjects of our analyses. This entails acknowledgment that physiology and psychology—the sciences of the body and the mind—are systematic languages *about* the body, thoughts, and experiences; they are not *the* body nor *the* thoughts or experiences. Constructing relations between systematic languages involves identifying domains within the two that may be congruently mapped to each other; not everything in one is mappable to the other. This is not different from the standard means we implement in the construction of model relations between systematic languages and the world of phenomena, and this is what scientists do: interpret (encode, measure) and project (decode, predict) into each other, completing a cycle while keeping in mind that what we choose to interpret and project to are culturally and technologically (but not ontologically) dictated. At times, blinded by fancy measurement technologies, we tend to forget the main directive of model relations, which is that truth—a valid statement—is congruent relations between the two systems or completion of a full interpretation-projection closed-loop (James, 1907; Rosen, 1991). Thus, for instance, understanding the "dopamine hypothesis" as a mechanism of schizophrenia is projection without interpretation; the fact that reducing dopamine receptors activity (a statement in the physiological language) alleviates symptoms of psychosis (a statement in the psychological language) is not in itself an indication for the role of overactive dopaminergic system in psychosis; it would be like claiming that fever is due to lack of paracetamol (acetaminophen, Tylenol) in the brain. Interpretation without projection or projection without interpretation are bases for wild language relations, which (I submit) is the case of many findings belonging to "the neural basis of…" genre. Meaning should be infused into our neurophysiological statements about behavior by considering the dynamic relations between the subject and its environment.

We must be fair to history. A relational approach to brain and behavioral sciences is not original. It is nothing but a version of the functional school in psychology, traceable back to Dewey's manifesto (Dewey, 1896) where he criticizes the generalization of the stimulus-response reflex arc concept in psychology, a framework according to which the "sensory stimulus is one thing, the central activity, standing for the idea, is another thing, and the motor discharge, standing for the act proper, is a third." Such undue generalization of the reflex arc framework to psychology, says Dewey, "gives us one disjointed part of a process as if it were the whole. It gives us literally an arc, instead of the circuit; and not giving us the circuit of which it is an arc, does not enable us to place, to center, the arc. …." The circuit he is talking about is that which involves both the subject and the environment. Thus, behavior does not represent the endpoint of some stimulus-response arrow. Rather, it reflects the subject's attempts to explore the environment. In Dewey's words, "[t]he stimulus is something to be discovered …," a par-excellence relational approach. A classic demonstration of Dewey's functional approach is the Held and Hein (1963) kitten carrousel experiment where two kittens—tangled to each other in a carrousel—are exposed to exactly the same world of visual stimuli, but one actively generates the stimuli by moving the carrousel, whereas the other experiences it passively (carried in its cradle not being able to touch the floor). The vision of the active kitten develops normally; the other passive kitten becomes

limited in its capacity to interpret visual scenes.

We lack the comprehensive methodology to study such relational contexts, and more so when closed loops between dynamical entities at different levels of organization are involved (e.g., Maturana and Varela, 1987; Noble, 2006; Rosen, 1991). This is a huge challenge for physiology. The study of a given system under well-defined and largely static environmental constraints is a natural extension of traditional paradigms in engineering and physical sciences. One can optimize the design of experiments, perturb, or displace the system, and one can know what to measure, how to build mathematical models of the system, and how to do the right statistics to optimize the models. From the very early stages of our science education, we are instructed to define independent variables and how to carefully record dependent variables that characterize the observed state of the system. Yet, to uncover relational aspects of systems that are embedded in interactive environments—i.e., to expose the impacts of discontent, the resulting symmetry breaking, the entailed relational objects and their adaptive potential—new experimental concepts are called for. These should reflect acknowledgment that the individual brain is a cluster of cells and not much more; all the "rest"—all things that are psychologically meaningful—are "out there" in the relations of the embodied brain with the environment through its exploration using motion (Marom, 2015). Such an acknowledgment makes obvious the need for a dialogic mode of conversation between physiology and psychology, establishing genuine language relations between these disciplines.

The inability to separate the system's dynamics from those of its environment stands at the basis of our limits in the study of the brain and its relations to behavior. Vygotsky saw it, almost one hundred years ago: "[t]he search for method," he said, "becomes one of the most important problems of the entire enterprise of understanding the uniquely human forms of psychological activity. In this case, the method is simultaneously prerequisite and product, the tool and the result of the study" (Vygotsky, 1978). In its broader sense, these problematics go far beyond physiological stimuli; they touch upon what relational psychologists have tried to tell us over the past forty years on the developing mind.

Some believe that there are no limits to the explanatory power of modern neuroscience, which is determined only by technology that allows looking closer and closer, finding "the" machinery, "the" particle, or "the" coordinates of complex behavior inside the brain. Admitting the relational context, the dynamics between entities, or between the brain, objects, and subjects in the environment, opens a much wider vista where abstract and universal theories and notions rooted in mathematics, physics, chemistry, biology, cybernetics, and engineering—for instance, theories of dynamical systems and control, the field of system identification, or conceptual frameworks such as self-organization, critical phenomena, distributed representations, or the study of complex hierarchical networks and their development—are far more relevant than rules of synaptic plasticity or activity of neurons in this or that brain area, at least when the theoretical foundations of psychology are considered.

In ancient times, fear and confusion tempted humans to (re)search simplistic answers, leading to naive determinism; in modern times, where science and scientists are most often judged and ranked by the extravagance of their statements, our narcissistic tendencies might push us to seek simplistic and catchy naive reductionistic answers by using fancy technology, the price of which is ever growing. We are endowed with public trust and responsible for the education of our students to develop their own intellectual integrity. When it comes to negotiations between depth psychology and neurophysiology, the burden seems heavier than ever and needs to be handled with much care. I am not sure we are careful enough.

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