THE METAPHYSICS BEHIND STUDIES OF NEURAL MOTOR CONTROL

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ABSTRACT

Present day biology is full of metaphysical assumptions. Many neuroscientists, for example, are looking for the neural basis of mental activity without realizing that mental terms are nothing but adjectives to classify the result of some behaviors. In this work we make a clear distinction between movements and actions, the second being movements plus their result. Therefore, it is not possible to explain actions just by describing the mechanisms of movements; to do so introduces conceptual mistakes. One common mistake is to think that, for example, a detailed description of a mechanism, say that of the movement of an arm, is equivalent to the "discovery" of the causal source of the action performed by the arm. We show that these kind of conceptual errors are not exclusive to the "bad scientist" because we find them once and again in a review of Apostolos Georgopolous, a prominent neuroscientist.

KEYWORDS

Motor control; metaphysics; neurosciences; behavior; movements; actions.

INTRODUCTION

It is the aim of this article to show that some of the questions that seem to be important to biological scientists are either consequences of embracing some misleading metaphysical doctrines, or assumptions that can neither be proved nor disproved. These doctrines or assumptions prevent the serious advances of some important research, most of all because they decieve researchers, leading them to try to find elements or mechanisms that do not exist. Some researchers, for example, are looking for the neural basis of mental activity, without realizing that there are no such things as "mental activities". Mental terms are employed to explain the result, end or goal of a certain kind of behavior, but they are not extra items of behavior, they are adjectives used to classify the results of a sort of tasks.

The term 'behavior' refers either to actions or to movements, even though actions and movements are not synonymous. Let us illustrate the difference between these terms with an example. An arm can perform certain movements which can be used to execute learned actions, but actions are more than just movements. The difference between just performing a movement with the arm and executing the same movement to achive a goal (*e.g.*, to reach objects, to move them, etc.) is the difference between movements and action.

Once we learn a result which can be obtained through certain movements, we perform those movements to obtain that particular result. Therefore, the combination of movements together with their result is what properly constitutes an action. Notice that the former are part of the latter, but movements by themselves cannot explain actions. Actually, there is no logical connection between specific movements and specific actions, since we can achieve the same actions with different movements and *vice versa*.

The result or, what Aristotle call 'final causes', have nothing to do with the intentions, desires, wishes, etc. of the system. Results or final causes are only what is expected to obtain when certain movements are performed by the system. Notice that explanations of actions necessarily requires the use of final causes, while the study of movements is nothing but a description. Therefore the search for mental activities (*e.g.*,

purposes, desires, or intentions)

It is obvious that to move an arm it is necessary to have one. In the same line of thought, to move an arm it is necessary to have all the physical elements and mechanisms. It is known from scientific work that if some of those mechanisms are not working properly the arm will not be capable of performing those same movements. Nevertheless, to accept that normal performance of the mechanisms of the arm (at the level of organs, tissues, cells, etc.) is necessary in order to move the arm, is not equivalent to saying that the causal source of the arm movement is its mechanisms. The normal performance of the mechanism of the arm is another level of description of the very same movement of the arm, not the causal source of the movement. Unfortunately, when people believe that the description of the mechanisms some day will reveal us the causal source of the performance, what they do not understand is that this causal statement is the one which transforms scientific descriptions into metaphysical statements.

Those who employ metaphysical statements usually introduce two conceptual mistakes. The first is that they think that through the scientific description of the mechanisms it is possible to explain both actions and movements. The second is that when they are able to describe on scientific grounds, let us say, the movement of an arm in terms of the movements of its muscles, tendons, nerves, brain activity, etc., that description is equivalent to the "discovery" of the causal source of the action performed by the arm.

We may sumarize the whole problem as follows. Any finality is the conceptual construction of the observed (and usually known) result of some actions. Remember that actions are nothing but movements plus their results. Now, the first metaphysical assumption is that behind any movement with finality there is a mental activity such as a purpose or an intention, which in turn produces both movements and their finalities. Those mental activities, in principle, should be the product of an agent (the mind and its mental processes). Thus, when people talk about minds or brains as agents, there is another metaphysical assumption: that there has to be some physical basis for that agent. In our time, the description of neural activity is often accepted to be the causal source of two different things: muscular movements and mental activities. This is harmful, because we have to bear in mind that neural activities are part of the mechanism that is necessary for both movements and actions. Yet, they are not the causal source of anything. The so-called 'mental activities' are nothing but metaphysical fictions. Therefore, it cannot be a scientific goal to try to study them, because it is clear that scientists can measure only physical activities. However, there are "scientists" looking for the source of mental activities that supposedly give rise to purposes, intentions, etc. besides movements. Nevertheless, scientists cannot say anything about mental activities, meaning that they cannot discover the neural basis of purposes, even when they can indeed discover the neural basis of movements.

DISCUSSION

To demonstrate that the use of metaphysical statements are not exclusive to "bad scientists" or to those with low renown and therefore weak influence, we decided to analyze the review *Current issues in directional motor control* written by Apostolos P. Georgopolous, which appeared on the journal *Trends in Neurosciences* on November of 1995. In this way, we are dealing with the work of an eminent scientist published in a very prestigious journal.

In the abstract of the review we are told that the advances in the study of the relationship between muscular movements and neuronal activity will be given. Such an objective would not be a problem if what Georgopolous wanted was to acertain the correlation between the two activities, or the influence of one activity on the other. We are led to expect experimental results regarding measurable processes. However, terms such as *cortical representation*, *mental rotation*, or *memory-scanning* appear in the same abstract, which indicate nothing but the insertion of mental items to explain physical processes. As we will see, the use of mental items to explain physical processes indicates the acceptance of some

metaphysical positions which were maintained yet seriously criticized during the 16th and 17th centuries. We are talking about the doctrine known as 'occult qualities of matter'. This doctrine maintains that matter is capable of thinking, perceiving, desiring, etc. It gave rise to diverse dualistic and materialistic positions, not to mention the ensuing large discussion about the possibility of reducing teleological to mechanical explanations.

The assumption of a metaphysical doctrine in the scientific work forces a researcher to interpret his or her data in the light of those principles assumed *a priori* by the doctrine. In this case, Georgopolous is assuming the doctrine of occult qualities, and so it, is natural for him to introduce mental processes into the observed activities of neurons and muscles. We will explore the problems originated by such a metaphysical position and will advance an alternative point of view.

In this article we want to show that the contradictions and nonsense (understanding by this term propositions that are neither true nor false) supported by Georgopolous are established by the *a priori* assumption of the cause-effect relationship as the only kind of acceptable explanation. The causal relationship he employs implies the teleological form of explanation which determines the experimental strategy aimed at finding the existence of a productive agent. Such an experimental strategy, however, creates either an infinite regression problem or an internal contradiction.

The first sentence of the review by Georgopolous states the *a priori* interpretation regarding the kind of relationship present between muscular and neuronal activities, taking for granted that the activity of a group of neurons regulates the muscular activity:

> Research in the role of brain structures in the control of motor output in behaving animals was focused initially (from around 1965 to 1980) on the control of the magnitude of force, usually within the framework of a single joint or a precision grip.

This sentence indicates that a part of the brain somehow controls movements, meaning that the muscular activity is subordinated to the brain. Such a common assertion does not seem to have any problems, nevertheless, what Georgopolous is assuming is that part of the brain is controlling muscular movements through mental activities. Remember that the objective was to describe the relationship between a given cerebral activity and certain kind of muscular movements. That objective in itself is unproblematic, but adding the capacity of control unavoidably compromises Georgopolous with some kind of mental activity of the brain.

Furthermore, Georgopolous declares *a priori* that there is a relationship of control between the muscular and neural activities. This assertion is nothing but beginning the research from the end, that is, from the conclusions. From the start the kind of explanations which will be admissible while interpreting the results are determided. This means that the relationship that should be demonstrated has become a definition and not a scientific hypothesis that could be validated or refuted. Nevertheless, his definition is ambiguous, because it is not clear what kind of relationship he supports. Three items seem to be involved: a) muscular activities, b) neural activities, and c) the mental activity of control. However, it is not possible to grasp if the author is maintaining that mental activities control neural activities and these determine muscular movements; or, if neural activities produce mental activities that control muscular movements.

The claim of Georgopolous about cerebral regulation over muscular movements is an open acceptance of the efficient cause, that is, productive agents, as a valid descriptive form. Of course, there are alternatives. One description without efficient (productive) interpretations would be to take animal behavior as the framework for describing both the brain's electric activity and muscular motor activity. Those activities are just being detailed descriptions of the same animal behavior. Notice the absence of the claim that one activity (the brain activity) controls the other (the muscular activity), or that one explanatory level (of

organs or tissues) is the productive cause of the other (of the whole animal behavior). In the alternative version both, the brain activity and the muscular activity are simply more and more detailed descriptions of the mechanisms related with the observation of the same phenomenon: the learned activity of the whole animal.

The idea that muscles are subordinated to another structure is reinforced by treating movement as a *motor output*, indicating that muscular movement cannot be natural or spontaneous, but should be induced or produced. Yet, except for the learning process (which by the way is forgotten in the explanation), nowhere in the review the structure or process that would induce, or stimulate the movement is mentioned. In other words, there is no definition of *input* for which the movement is an *output*. Moreover, it is important to notice that the input problem is different from the control problem. While the control of a system is exerted by a *structure* (the controller) that is always present for regulating the system's behavior, the input, by definition, is the one that triggers the output. Thus, it is quite easy to find instances where the input and the control are separated. For example, the river's flux can be controlled with a dam, but the dam itself does not stimulate, induce or produce the river flux; therefore, the controller cannot be treated as an input.

Because Georgopolous never states the input which induces of the motor output, the reader has three options: to exclude the idea of movement as an output; to guess the signal, structure or process responsible for the input; or to make some combination of the two. Obviously there are problem maintaining Georgopolous' thesis with any of these options.

Let us explore the consequences of the reader's choices. If the idea of muscular movement as an output is abandoned, then movements should be considered as spontaneous since they would not respond to any external signal. Clearly this position disqualifies the search for the role of any structure in the motor control because an autonomous process does not requires any external stimuli. Nevertheless, it is obvious that the kind of movement that Georgopolous is referring to cannot be considered as autonomous; hence, this is not a good choice.

An alternative position is to assign the capability of inducing movement to an extramuscular structure. Because there is no reference in the review to such an entity, the reader is again faced with two options: either the signal comes from outside the animal or from its inside. If the signal is supposed to be external, say the luminous signal used to train a monkey, then such movement would be more properly referred to as a conditioned reflex. Speaking of muscular movements as reflexes pictures a passive brain, although it might indeed be an important piece on the mechanism for muscular activity. The problem with the last assertion is that the brain would be something like a relay between the external input and the motor output which is not compatible with the variety of functions Georgopolous gives to the motor cortex as the "control of motor output", "muscle selection and coordination", "representation of a number of visuomotor variables", "directional moto-cortical commands", "directional coding", "representation of trajectories", and many other related expressions throughout his text.

The next alternative is to locate the input somewhere inside the animal. There is a problem with this, however. If the activity of the whole system (the behaving animal), is triggered by one component of the same system, say the motor cortex, we may ask "What initiates the activity of the triggering element?" In this way we pose the problem one step behind since the motor cortex is a system with a particular electrical activity as well; thus, we must find the structure that originates the activity of the cortex itself. Suppose we say that a particular group of neurons initiates the activity of the entire motor cortex. If this is the case, then such a group of neurons would have an activity; consequently, we would need to find the structure that triggers the activity of those individual neurons, and so on. Clearly, locating the origin of the stimuli *inside* the system implies the problem of an infinite regression since it is necessary to search for the sub-subsystem that triggers the activity of the subsystem that triggers the activity of the system, and so on *ad infinitum*.

Finally, a combination of the last two alternatives, meaning that the input is a combination of outer and inner signals will lead us to accept that the external output is nothing but the external world, that is somehow perceived by the brain which in turn generates a mental representation of it. This representation seems to be the internal input which in turn generates the motor output. Under this interpretation a mental cause is the source of a physical activity (the muscular movements). This seems to be the implicit metaphysical position of Georgopolous, and may be why he never specifies the nature of the input. If this is the case, the review is closer to metaphysical speculation than to physiological research, since by definition, mental inputs cannot be physically detected.

CONCLUSIONS

In this article, we have shown that speaking of movement as an output initiates an ill-fated discussion about the location of the input. Unfortunately, the problem does not stay solely on discursive ground because this particular theoretical framework biases experimental strategy as well. If the scientist assumes that a movement is an output, then he or she is obligated to experimentally search for two kinds of mechanisms: those which produce mental processes and those which produce physical movements. Georgopolous needs the mechanism which produces mental processes in order to justify the use of concepts like planning, control, representation, regulation, mental rotation, etc. Nevertheless, he does not specify the physical basis of those mechanisms, even when for him they seem to be responsible for the input and the control of the motor output. The reason for the last statement is very simple: neither mechanisms of mental processes nor mental activities exist. Georgopolous cannot explain either the source of mental processes nor the source of physical movements. What he does is, in fact, to describe the monkey's arm movement in terms of neural and muscular activities.

So far, we have exposed that the idea of control defines *a priori* the kind of relationship between the brain and the muscles, and that the idea of output also defines *a priori* the experimental strategy. Both problems were originated for the use of productive causal explanations. Georgopolous seems to forget that the phrase "...the role of brain structures in the control of motor output in behaving animals..." refers to whole animal's behavior. He does this because he is looking for the causal source of the animal's behavior inside of the animal. In mentioning the entire animal, the possible explanation should be restricted to a description of movements and activities. This could help us avoid metaphysical puzzles. It is possible to study a system in terms of its movements or possible movements at different levels of description (physical, chemical, electrical, etc.,), or to study those movements in context, that is, with respect of what those movements are apt to achieve in context. Notice that we have to make a selection, either we study movements in terms of their mechanisms, or we study movements in terms of their goals; but not both together. One study can enhance the understanding of the other, but they are at two completely different levels of understanding.