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Theoretical Review

Was Tinbergen an Aristotelian? Comparison of Tinbergen's Four Whys and Aristotle's Four Causes

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Abstract
Tinbergen's 'Four Why's' are currently considered as a standard framework in the behavioral sciences. It has been repeatedly pointed out that this concept is derived from Aristotle's Four Causes, although no extensive investigation has been performed so far. Here we compare these two concepts and show that, in general, they parallel very well. The main difference is that Aristotelian theory is static and does not include evolution. In summary, Aristotle's general and Tinbergen's more specific framework for the study of natural phenomena are still viable heuristic concepts.

Key words: *behavioral science, epistemology, philosophy of science, ethology*

Introduction

There are not many scientific papers which would be so refreshing to read half a century after having been published. Tinbergen's 1963 paper "On aims and methods of Ethology" belongs among such exceptions. It gives us clear insight into the discussions and hot issues debated in those days within the behavioral sciences, with some of the questions (e.g. innateness) being still a matter of controversy today. However, the main reason why the paper has become a classic is that it gives evolutionary students of behavior a basic framework for their agenda. Tinbergen proposes, in what has subsequently become known as Tinbergen's Four Whys, that to achieve a complex understanding of a particular phenomenon, we may ask different questions which are mutually non-transferable. Instead, they address different aspects of the subject under scrutiny. Although such systematization appears partly ex post, it has become a standard part of introductory courses and textbooks in behavioral sciences (e.g. Barrett, Dunbar, & Lycett, 2002; Ridley, 1995). We therefore believe it is of crucial importance to understand from what thoughts and inspirations this framework has arisen.

Tinbergen himself builds on the work of Julian Huxley, although he does not make specific reference to this. Huxley (1942, p. 40) speaks about three major aspects of

biological facts, namely : i) mechanistic-physiological, ii) adaptive-functional and iii) evolutionary or historical aspect. He also stresses that "They [i.e. the three aspects] represent three separate fields of discourse, which may overlap, but are of fundamentally different natures." Tinbergen thus applies Huxley's framework to the study of behavior and makes significant contribution to it by adding another dimension – individual development or ontogeny. Here our search for the sources of Tinbergen's inspiration might end. However, it has been repeatedly pointed out that Tinbergen's Four Whys are based on Aristotle's teaching of four causes (Barrett, Blumstein, Clutton-Brock, & Kappeler, 2013; Dunbar, 2009; Ridley, 1995). Further, several online encyclopedias (e.g. New World Encyclopedia, Wikipedia) propose a similar parallel. This is an intriguing idea but, as far as we are aware, neither Tinbergen nor Huxley mention Aristotle in their work. We can, however, safely assume that Huxley, who graduated from the prestigious Eton College, was taught Ancient Greek philosophy. Nevertheless, Huxley devoted a considerable part of his efforts to persuading both scholars and the general public that evolution has no purpose (although he does tend to see progress in evolution). The debates about teleology in evolution are clearly in opposition to thoughts arising from Aristotelian final cause, making Huxley profoundly anti-Aristotelian (Swetlitz, 1995). One may therefore ask, how is any parallelism between Aristotle and Huxley possible? Can we speak about direct inspiration or are we dealing with superficial resemblance?

Before we proceed to the discussion of these issues, we will briefly introduce both concepts. It should be noted, however, that we intentionally only present the main aspects of the concepts and therefore Aristotelian scholars may find some of our statements simplistic. However, we aimed to make the paper comprehensible for a reader not versed in ancient philosophy. (For a basic overview of Aristotle's biological thought, including reference to his works, see Balme, 1992; Gotthelf & Lennox, 1987; Pellegrin, 1986; Lennox, 2001; Gotthelf, 2012).

Tinbergen's Four Whys

As outlined above, Tinbergen proposed four different questions, which cover different aspects of a particular behavioral/psychological phenomenon. These include: i] mechanism, ii] function (or 'survival value' in Tinbergen's words), iii] phylogeny (or evolution), and iv] ontogeny.

First, the question about mechanism is actually a question about proximate mechanism. In other words, it deals with the immediate cause of the behavior. Second, the question about function asks about the ultimate mechanism. In other words, it asks which evolutionary processes (e.g. natural selection) have given rise to a given structure or behavior. If we are dealing with an adaptation, we might ask how it influences the reproductive success of the individual.

As a side note, Tinbergen, like many of his contemporaries, speaks about survival value. Although survival value is undoubtedly an indispensable condition for reproduction (i.e. when you are dead you cannot reproduce), one's survival value may be extremely high, but unless he/she reproduces the traits affecting survival will not spread in the population. Thirdly, the question about phylogeny asks about the history of the trait. Have individuals of the particular species inherited it from their ancestor, or is it a trait that represents an evolutionary novelty in the particular lineage? Thus, we ask here about the origin of the trait separately from its function. The significance of this

distinction has been repeatedly highlighted by Gould and others (Gould, 1991; Gould & Vrba, 1982) as the traits that have originally arisen in order to fulfill some function may come to perform another function (or may not have any function at all) in phylogenetically related species. Finally, we may ask what developmental processes have shaped a particular behavioral trait. This includes studies which test the flexibility of a particular behavior with regard to various environmental influences; whether different developmental periods are specifically sensitive to environmental influences, and so on. From what has been just said, it is clear that different academic fields tend to single out and mainly focus on one of these questions. For instance, neurophysiology tends to address mainly questions about mechanism. In contrast, phylogenetics tends to focus mainly on questions about the history of the species. Frequently, we may often find that scholars treat the various types of hypotheses as if they were in conflict with one another. However, as both Huxley and Tinbergen teach us, the answers to the individual questions are not mutually exclusive as they simply address different aspects of the phenomena.

Four Aristotelian Causes

Let us now turn to the four Aristotelian causes:

I. the efficient cause is the impulse responsible for the origination of a thing or a living being whose subsequent development is also determined by its action;
II. the final cause is the goal or the purpose (*telos* in Greek) for which a thing or a living being originated and at which it aims;
III. the formal cause is the form or shape of a thing or a living being, possessing all the necessary characteristics which may be grasped in a general definition;
IV. the material cause is the material "out of which" a thing or a living being is composed.

This is only a brief and rather textbook presentation of Aristotle's immensely influential conception of causality. To get a better idea of it, we have to touch upon the historical development of Aristotelianism. In fact, there have been several Aristotles active over the course of history of European thought and the account of Aristotelian thought by contemporary scholars in the field of ancient philosophy is much different from the traditional one taught at universities since the Middle Ages. The latter owes much to the systematization of Aristotle's thought as promoted by the Neoplatonists in Late Antiquity, who placed his key concepts within a global hierarchical framework of their metaphysical universe deduced gradually from the first principle of all. Aristotle's great medieval commentators, Averroes or Thomas Aquinas, owe much to this reinterpretation of his thought, but one could still find some traces of it in, for example, early 19th century natural theology, such as that represented by William Paley.

The other Aristotle is represented mainly by his biological writings. Unlike Aristotelian physics and astronomy, that was heavily criticized and had already been abandoned by the Renaissance scientists, Aristotle's biology continued to be studied and further elaborated in the early modern period. Thus Thomas Harvey comments largely upon his writings and repeats some of his observations (Lennox, 2006), Georges Cuvier affirms a similarity in their approach (Pellegrin, 1986, p. 10-12 and 159-161), and an elderly Charles Darwin enthusiastically greets a recently made translation of the *Parts of*

Animals with a famous quote (Gotthelf 2012, p. 345-369): "Linnaeus and Cuvier have been my two gods, though in very different ways, but they were mere school-boys to old Aristotle." The interest of the key modern naturalists in Aristotle's biological writings is obviously due to the sheer mass of observations collected in them, as well as their deep biological insights. These even manage to counterbalance some biological mistakes and misjudgments, some very famous and funny ones. Needless to say, a metaphysician and a theologian will read Aristotle very differently, each stressing different aspects of his rich and sometimes puzzling work. Unfortunately, although his biological treatises had been largely neglected by philosophers until a few decades ago, they have been rediscovered and reinterpreted in a fresh and fascinating way by David M. Balme and his unofficial school, namely Allan Gotthelf, James G. Lennox, and Pierre Pellegrin. We thus have to keep all the different facets of Aristotelianism in mind if we are to compare it with Tinbergen.

Comparison of the Concepts

I. The efficient cause / mechanism

As has already been said, Aristotelian efficient cause basically elicits an activity. The comparison of the Aristotle's efficient cause and Tinbergen's mechanism is simple. Here both concepts fit each other well as both conceptualize an immediate cause, which, to use terminology from classical ethology, releases a particular behavior. Perhaps it was the relatively straightforward similarity between these two causes that has led several authors to draw similarities between the two concepts as a whole.

II. The final cause / function (or survival value)

Aristotelian final cause is one of the most controversial issues of his philosophical and scientific legacy. It had already been criticized by the early modern scientists who regarded it as superfluous for any physical or cosmological explanation. However, in this case more than the others, one has to clearly distinguish between the position of the actual Aristotle (especially in his writings on biology) and the constructions of his later interpreters. Although it may perhaps seem surprising for those not versed in the history of ideas, Aristotle did not have the divine first principle that actively creates and orders the world. This concept has been attached to him only after the Neoplatonists integrated his philosophy into their global metaphysical system, and a similar synthesis was then promoted by the medieval theologians (see e.g. Gerson, 2005). Such an interpretation of Aristotle was already refuted by Gemistos Plethon in 1439, in Florence, on the basis of a detailed reading of Aristotle's writings (Woodhouse, 1986), and the verdict of the contemporary scholars is exactly the same: Aristotelian first principle, the so-called prime (unmoved) mover, is not the creator of our world-order, being entirely passive, he is simply, due to his perfection, the object of desire of the things inside our cosmos.

Nor does Aristotle use the argument of (intelligent) design, popular not only with the so-called natural theology of the time of young Darwin. It claims that the apparent purposeful and rational order of our world, including the privileged position of man in it, necessarily leads to the hypothesis of its good and intelligent creator. Such an argument appears for the first time in Xenophon (most notably in his *Memorabilia* I,4 and III,4) and Aristotle's teacher Plato, and possibly goes back as far as their common

master Socrates. In contrast, Aristotle dissociates teleology, which he claims to be observable in both the world and living beings, from the idea of god actively creating everything that exists. His teleology is thus not global, but local, and it is not imposed on the world, so to say, "from above", but emerges "from below". There is no global blueprint responsible for the purpose and rational order of the world, but each individual thing or living being strives after its own aims or goals. In the end, it is the individual nature (physis) that directs its development and necessitates certain purposeful features, for example bodily organs, that are present for various functions and purposes. The chief reason why Aristotle feels a need to introduce the final cause in order to explain biological phenomena is that because of their complex nature, these cannot be reduced to a simple combination of basic material substances, namely, the four elements. He thus tries to avoid a purely mechanistic explanation proposed by his predecessor, the atomist Democritus, who considers living beings to be a result of an encounter of basic elements through pure chance (Sedley, 2011; Balme, in Gotthelf and Lennox, 1987, 275-285; Gotthelf, 2012; modern interpreters, however, disagree on whether teleology in Aristotle is only limited to living beings, or whether it may also be extrapolated to inanimate objects).

We can thus see that Aristotle's teleology must be conceived of in a much weaker sense than it is often thought even today (e.g. by the Neo-Thomists), even though there are some passages where he talks about an hierarchy among living beings with, as may be expected, man on the top as the most perfect of them all. '(This is most notable in *Politics*, I,8 1256b15–22, which is, however, obviously not a biological treatise; see also *The Parts of Animals*, IV,10 686b3–21.)' This considerably narrows the gap that is often felt between Aristotle and Darwin, who may even be conceived of as a proponent of a new, reformulated, and yet weaker type of teleology. It may perhaps be so if we regard some features as having been acquired by an organism *in order* to increase its fitness. The mechanism underlying such teleology is naturally rather different – in Aristotle it is the activity of nature(s), whereas in Darwin (or in Tinbergen) it is natural selection. In other words, only individuals with bodily or behavioral characteristics which increase their chance of successful reproduction will be disproportionally represented in the following generation. However, they both try to find their way between the extremes of mechanism based on purely random processes and creationism appealing to a higher divine plan (Lennox, 1993; Gotthelf, 2012, 367-369).

III. The formal cause / phylogeny (or evolution)

Turning to a discussion of Aristotle's notions of form and matter, we must always bear in mind that in his natural philosophy (we do not consider Aristotle's thoughts on form and matter in logic, as it is outside the scope of this paper), there is nothing like pure abstract form detached from matter (and vice versa, there is no matter without form). According to Aristotle, we always deal with individual things and living beings, or their components, organs, tissues, and elements. Although they can always be broken down into a particular form and matter, it may be done only subsequently and in a rather theoretical perspective. According to Aristotle, through our intellectual capacity for abstract thinking, we are able to grasp general forms, equal to species and genera. We thus have to distinguish between individual forms subsisting in concrete things and living beings and general forms abstracted from them. Primary in nature are the former.

As for Aristotle's form, that defines a particular species, this, in comparison with post-Darwinian biology, is of course static, and not a product of evolution. Apart from this difference, however, it has the very same function as the term species in modern biology, which, although not unchangeable, is stable and determined over the long term.

Tinbergen's question about the evolution of a particular trait might appear distant from Aristotelian formal cause. As pointed out previously, Aristotelian conceptualization is non-evolutionary. Undoubtedly, both concepts differ in this respect. Tinbergen's question about evolution is frequently presented as a question focusing solely on the timing of a trait's origin. We find such a comprehension incomplete. In a more general perspective, it also involves questions about predecessors and why descendants resemble them. In terms of current science, we speak about inheritance of appearance or form, if you like. Furthermore, the characteristics of a particular species predetermine its appearance (and, for Tinbergen, also behavior). This resembles Aristotle's general form. In contrast, individual form, which is a result of individual history, would fall under the question about ontogeny (see below). When these facets of evolutionary investigation are taken into account, they are clearly paralleling Aristotle's questions about form.

IV. The material cause / ontogeny

Here we have to briefly adduce Aristotle's theory of generation of animals. In this case, Aristotle provides us with a detailed theory of development of living beings in his *On Generation of Animals*. According to him, the embryo is conceived due to a combination of male semen and female menstrual blood that are analogous to form and matter, respectively. They both are products (residues) of the metabolic process of "concoction" and the quality of semen and menstrual blood matter then depends on the degree of success of this process. The semen thus acquires a varied capability to form a new living being and it enters the menstrual blood that may have varied potentiality of being formed by semen. The same form transmitted in semen may therefore be realized more or less perfectly in different environments, namely, different matter provided by the female (Balme, 1990, 1992).

The notion of material cause may also be extended to different "parts" of the body of living beings, with their respective characteristics that determine and limit their function. Furthermore, the qualities of a particular matter, out of which an animal is composed, are also connected with its habitat, most notably with whether it lives in the water, air, or on earth. Finally, animals change territories according to season and vary according to location and climate – this, too, is due, so to speak, to material conditions in which they live (Aristotle, *History of Animals*, bk. VII[VIII])

According to Tinbergen, the question of ontogeny addresses timing, i.e. at what age does a behavior first appear. More importantly, it also asks how previous experience has shaped the current behavior or whether learning processes have been involved at all. This is similar to Aristotle's note that an individual is shaped by various environments or experiences. However, Tinbergen's question of ontogeny cannot simply be equated with Aristotle's material cause. The former conception is apparently narrower as it focuses solely on individual experience. In contrast, Aristotle's material cause also points to characteristics and constraints given by a specific matter. Nevertheless, the current systematization of Tinbergen's Whys would also involve processes like developmental

constraints and canalization of learning processes. This broadens the original Tinbergen's concept, moving it even closer to the Aristotelian conception.

Discussion

In this paper we have aimed to point out the shared facets, as well as the differences, between the Four Aristotelian Causes and Four Types of Questions formulated by Tinbergen. Before we proceed to the main conclusions of our comparison, we would like to elucidate why we find it worthwhile to bother with a theory formulated over two millennia ago. In our view, the main heuristic value of both biological theories is that researchers may ask fundamental questions about the "nature" of living beings which, however, address mutually irreducible aspects of their "nature". Although, in theory, we may separate them for the sake of the inquiry, in living beings these aspects are always interconnected (such as Aristotelian form and matter or Tinbergen's phylogeny and ontogeny), and in some specific cases it is not possible to make a clear-cut distinction between them. The significance of these distinctions can be found in instances when scholars forget about or are unaware of them. For example, in the 1990s, the evolutionary behavioral sciences were characterized by fierce, though often unfruitful, debates between the schools of evolutionary psychology and human behavioral ecology. Only subsequently has it been acknowledged that these schools of thought may not be as incompatible as it seemed, but, rather, that one mainly focuses on proximate mechanisms (evolutionary psychology) and the other on ultimate causes.

To compare the two theories, the most fundamental difference clearly lies in the absence of evolution in Aristotelian thought. The structure of the Aristotelian world is given in its basic principles, and is static. This includes living beings and in such a framework it is difficult, for instance, to imagine an origin or an extinction of species. In contrast, Tinbergen's theory relies directly on evolutionary principles and unique historical characters of the evolutionary process are at the heart of his thinking. Taken at face value, this striking difference may suggest that the two theories have very little in common and their comparison is a waste of time. However, our analysis shows that the main parallels work surprisingly well. This was startling for both of us, as we were rather skeptical when we started to think about this paper. Our initial skepticism must be understood in the light of the fundamental differences between scientific knowledge available to Aristotle and to Tinbergen and the worldviews held. However, there are also characteristics which they apparently shared, most notably an extremely well-developed observational sense together with a broad knowledge of living beings. (This perhaps also shows the limits of some postmodern proposals that a theory cannot be understood without a metatheory behind it.)

Interestingly, in both theories, the material cause / ontogeny stands somewhat apart. This is perhaps due to the focus on individuation of a particular organism which is otherwise described by the three other, more general, aspects. Thus in Aristotle, it is sometimes difficult to distinguish between formal, efficient, and final cause and, similarly, it may not also be entirely incidental that Huxley, who aimed to describe general processes, originally came with three aspects and only subsequently Tinbergen added the fourth one – ontogeny.

To sum up, despite all the paradigm shifts and broadening of our knowledge of the natural world over the centuries, Aristotle's general framework for the study of natural phenomena is still a viable heuristic concept. From a historical perspective, we think of Aristotle as the one who, for the first time, marked out the field naturalists still play on. Only many centuries later did Darwin introduce the new rules according to which naturalists still play today. Scientists and scholars usually do not call into question whether it is crucial to rely on Darwin's work. Surely, they need to know the rules of the game. On the other hand, few of them are interested in Aristotle's biological writings. It seems an irony that they know the rules well but somehow overlook the importance of the ground upon which the game is played. Behavioral scientists are indeed lucky to have Tinbergen who so clearly demarcated their field again.

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