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# Psychology and Evolutionary Biology

## *Causal Analysis, Evidence, and Nomothetic Laws*

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### SUMMARY

Since James, some psychologists have referred to evolutionary theory as one of the sources of explaining behavior (James, 1890). However, the status of such references is not always clear. In the recent work of many authors,<sup>1</sup> it is not always clear (1) what kind of causal analyses are appropriate *in psychology* beyond those psychologists already use; (2) how psychological explanations fit in the general scheme of explanations in the life sciences, especially in biological explanatory schemes; and (3) what this implies for the evaluation of available evidence. This chapter is about these questions. I discuss five types of explanations involved in psychological explanations using an evolutionary perspective, and I discuss how these types of analysis relate to types of propositions and types of evidence.

### FIVE TYPES OF CAUSAL ANALYSIS

Niko Tinbergen suggested that explaining the actions of an individual member of a species can, and should, refer to four types of causal analyses (Tinbergen, 1963). Drawing on Tinbergen (1963) and Wouters (1999), I revise these types of analyses for psychology and claim that any psychological explanation that explicitly accounts for the evolutionary origins of behavior and experience is committed to five types of analysis. Present developments within “evolutionary psychology” only attend to one or two of them; however, I suggest that all five should be considered.

#### (1) Ontogeny

The first type of analysis refers to the ontogeny of behavior: how did this particular pattern of behavior develop in this particular individual? This is a familiar question for—especially—developmental psychology. It asks how the present individual came to behave this way and how *this* organism came to “set” the parameters of its capacities for this behavior in this way, given innate capacities and dispositions or capacities acquired earlier. It suggests that, whether it is innate, learned, or acquired in interaction between genetic and environmental factor, the characteristic development in the specific individual influences the way the behavior pattern will express itself.

For instance, Rakic (1991) has shown that although the visual system is to a large degree “prewired” to function in a certain way, there is enough plasticity in several

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<sup>1</sup> E.g., Buss, 1994; Bloom, 1999; Byrne, 1995; Cosmides et al., 1995; Cziko, 1995; Gigerenzer & Hug, 1992; Griffin, 1976; Jerison, 1976; Macphail, 1993; Pinker, 1994; Rozin & Schull, 1988, among others.

of the visual pathways in the brain to result in differences in visual and action competence. Eye dominance<sup>2</sup> might be explained by this ontogenetic factor resulting in individual variations. Certain inputs in the early stages of development, leading to cell death, axonal competition and modification of synapses in the cortex are crucial for the development of areas in the cortex and consequently for, e.g., the perception of objects, object-directed action, and physical knowledge (Rakic, 1995; Spelke, Vishton, & Von Hofsten, 1995). Thus, it is quite clear and accepted in psychology that ontogenetic factors are part of the analyses needed to explain why a certain organism acts and experiences in a certain way. As Linschoten (1956) already suggested, this influences depth perception.

## (2) Phylogeny

More attention has been given to Tinbergen's (1963) second type of analysis: the analysis of the phylogenetic origins of behavior. How did the behavior pattern concerned evolve in this particular population (species)? Evidently, the brain has evolved into the most complex system known. Via what evolutionary route did the human brain arrive at the present architecture, and therefore at the present behavioral and experiential patterns? Which species, extinct or still in existence, link human beings with the origins of life? Is our brains' structure due to either "their" or "our own" design?

Thus, phylogenetic questions include "why is there eye dominance?" and "how did the human species arrived at eye dominance?"; ontogenetic questions include "why is individual  $x$ 's left eye dominant?" and "why is individual  $y$ 's right eye dominant?" If one looks at mental capacities such as reasoning, calculating, logical inference, spatial orientation etc., more complicated answers can be expected.

Obviously, any phylogenetic explanation refers to natural selection. However, this need not imply that every behavior pattern has been selected for as it is. For behavior, it seems as obvious that environmental factors play an important role in the shaping of (a) the individual behavior as expressed at time  $t$  at location  $l$  and (b) the invariant elements in the behavior as a type—the pattern of behavior—to produce a certain result. Nevertheless, there always are phylogenetic constraints. One approach looks at the selection of diverse functions as the main source. For instance, Cosmides and Tooby (1995) suggested that all special functions are the product of selection for these functions as such. This *structure follows function approach*, however, turns out to be problematic (Fodor, 2000; Lewontin, 1998; Looren de Jong & Van der Steen, 1998). Another approach looks at the evolution of the brain as the major source. For instance, Jerison suggested that increasing encephalization leads to greater behavioral complexity. Brain parts increase in volume in coordinated and predictable ways (growth of one organ correlates with growth of another), but there are different slopes of increase for different brain components (Jerison, 1973).

More recently, Finlay, Darlington and Nicastro (2001) suggested that, although there are correlations between different enlarging brain components, the correlations

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<sup>2</sup> Eye dominance is the preference for one eye to dominate in visual orientation; most cortical receptive cells can be better driven by one eye than the other.

are not as large as can be expected. In their model, brain size is the result of the body's growth *and* lengthening of the period before the "birthday" of the neurons of specific structures. Their model

is entirely consistent with a number of important theoretical frameworks of current developmental biology. First it underlines the relevance of ontogenetic processes to any deeper understanding of how organisms evolve; natural selection does not do its work on some equipotent substrate, but on a complex mechanism with a history of previous change that makes some adaptations more "workable" than others. [...] Another way of thinking about historical contingencies on evolutionary change is to acknowledge that not only physical and behavioral traits are under selection, but also the processes that produce the traits. Developmental mechanisms that are both robust and flexible are often in the best position to "solve" adaptation problems, with the consequence that evolution tends to conserve those mechanisms. (Finlay et al., p. 276)

Remember that before a neuron becomes a neuron in a brain tissue, perinatal development consists of the division and constant duplication of cells. These precursor cells only later become neurons when they no longer divide. The longer this "birthday" (becoming a neuron) is delayed, the more precursor cells are destined to be neurons, resulting in a larger brain structure. Larger brain structures thus specializing at a later, postnatal date, and under stronger environmental specifications, are better equipped to do what these structures do: solve problems. Their model also proposes that the larger the structure—the isocortex is the largest structure in terms of number of neurons—the more functions it can fulfill, in other words, the more specific needs of an organism that can be imposed on the generic nervous structure. In yet other words, the more it resembles Gould's famous spandrels—byproducts of structural constraints that later happen to be available for some new functional requirement (Gould, 1977; Gould & Lewontin, 1994).

Thus, "*structure leads to function*". Much phylogenetic redundancy is present at birth and the adaptation problems *for the individual* fill in the ontogenetic details we happen to be competent in. However, although Finlay et al. (2001) at first sight seem to favor the idea that the brain's solution to adaptation problems is "massively parallel processing", one cannot avoid the conclusion that the redundancy to choose from still is very much constrained when compared to the number of neurons present. Phylogenetically present structure provides for ontogenetic plasticity that in turn provides the individual organism with sufficient flexibility for fulfilling necessary functions.

### (3) Function

Tinbergen's third type of analysis concerns the function of the behavior in question: what adaptive function did this behavior pattern have for the species at the time of its emergence in its present form? There are many uncertainties here: adaptation problems for generations of homo sapiens as far back as 100,000 years ago are not

easy to specify. This question seems to invite the 'just so stories' that true positivists want to dismiss as unscientific.

In a sense, the answers become even more complicated and distrusted once it is accepted that either the adaptation problems 100,000 years ago are different from the adaptation problems today, *and* human beings deal with present day problems as well as the old ones with the "old" specialized mental and behavioral tools. Moreover, the adaptation problems of 100,000 years ago are different from today's, but human beings deal with them using general mental and behavioral problem solving tools. Finally, the mental and behavioral problem solving tools available now have evolved so fast (either culturally or biologically) that most or all of them are appropriate for today's problems.

The third option, Lamarck's theory, is no longer a candidate. The discussion focuses on the first and second options: either we deal with present day problems by using earlier day solutions, or we deal with earlier day problems as well as present day problems with general problem solving tools. Depending on the most rational answer, a good theory is needed to explain either what the old functions solved in the old adaptive problems *and* what they can still solve in the new adaptive problems or what the old and new adaptive problems have in common such that the general mental and behavioral tools can solve them. In other words, we need an analysis of adaptation problems and the functions that go with them. This need not be a precise phenomenological description of earlier situations (100,000 years ago), but a sufficiently *abstract* characterization of adaptation problems for our species and their predecessors. It is hard to think of any way to do that without having plausible answers for Tinbergen's other questions. For instance, suppose—as is suggested by Finlay et al. (2001)—that human beings, in order to keep the overall metabolic rate constant, exchanged reduction of intestinal length for enlargement of the energy consuming brain. This structural change created new adaptive problems that the new brain structures solved very well: find more delicate food, cooperate to get the better food, and find ways to prepare food for consumption with the more delicate digestive system. Whether these are spandrels is not so important: they *did* solve some of the problems that came into existence with the increasing sophistication of the digestive system. The question is whether they could solve problems we now (still) have. Is the food finding function perhaps also available for the book finding function in the library, finding sites on the Internet, or gathering food in supermarkets? What have these problems in common? Can we describe them in a way that plausibly suggests the problem features that natural selection has worked on?

One other matter concerns the different notions of function that prevail in biology and psychology. For present purposes, it is sufficient to distinguish between *design explanations* (answering the question of the survival value of the property in question) and *property explanations* (answering the question of why the property in question performs the task in question)<sup>3</sup>. A function in this sense answers the question: What was the behavior pattern / action / organ / module / invariant input analysis / trait selected for at the moment of its coming into existence used for such that the fitness of the organism concerned has not decreased?

<sup>3</sup> See also (Wouters, 1999). Wouters text is more specific than reproduced here; however the present distinctions will do for my purpose.

A certain function can be obsolete. However, if it did not decrease the fitness of the species it still, latently, has that function, although it is no longer in use. Also, it can become useful for other functions than those for which it was originally selected, but again, as long as it is not to the detriment of the survival of that species, the organ or trait will have to be accepted as a proper element in the explanation of resulting behavior or functioning in general.

Finally, it should be noted in this context that an organ could have a function for an internal, anatomical, and physiological environment. Thus, organs like the hippocampus are functional for certain higher order functions, including remembrance of things past and storing stories that gave it context.

#### (4) Proximate Causation

Tinbergen's fourth type of analysis refers to the proximate factors that cause the behavior in question. Which proximate ecological and social cues trigger the behavior concerned? This refers to the necessary and sufficient environmental or mental conditions directly leading to the behavior. Obviously, however, the mechanisms translating input to output are mechanisms acquired during evolution. In other words, if a certain disposition to behave in a certain way has been acquired during evolution, what exactly are the triggers for it to actually be expressed? Thus, the answer to the question about the (physiological or mental) mechanisms underlying the relation between cause and effect belongs to the present analysis as well.

This fourth question is related to the other questions, but the others are related to each other as well. Answering the phylogenetic and function questions implies answering how an individual organism acquired the internal "organs" or mechanisms to properly react to the cues that indicate what is "now" a proper way to react. Answering the ontogenetic question implies answering the question how, during its own life history, the individual organism tuned its organs to the actual input patterns present and the output dispositions needed.

Actually, here the question might be translated as: What input modules and output modules produce properly adapted behavior on what features of the complete distal stimuli?

#### (5) Structure

An amended, fifth type of analysis will be proposed and introduced briefly. This concerns the question of the structure of the behavior concerned? Strongly related to the question of the input cues that cause the behavior concerned, it is useful to know what structure behavior must have in order to be an appropriate action in the situations of concern for the specific organism. In other words, what are the output elements that must necessarily be present in the behavior concerned for it to count as an adequate action in answer to the problem it is supposed to solve? The latter, amended type of analysis seems necessary because the behavior of mammals,

humans, and other primates in particular, often is very complicated. Language, for instance, is a multi-faceted category of behavior. Proper structural analysis suggests that language consists of several different aspects (some call it modules) that all behave relatively autonomously in order to make it possible for language users to communicate, represent, and coordinate actions. Knowing the way language is structured leads to different insights in the four types of analysis, as suggested by Tinbergen. Every module is sensitive to a particular domain of inputs, is disposed to a particular range of outputs; and must have its activities coordinated with the activities of other language modules.

Language in particular demonstrates the need to have a thorough characterization of these components and their specific kinds of inputs, outputs and structures of interactions. Co-adaptation in evolution results in the specific components, the reason for these components, and the composition in which they operate. Their present function depends on their ontogeny. The cues that activate them and the actions they lead to depend on the interaction between evolution of the species, development of the individual, external cues and externalizable action elements.

### THE EVOLUTIONARY APPROACH IN PSYCHOLOGY

The discussion of evolutionary approaches to behavior and experiences and the evolution of behavior, experience, and mind, etc. inevitably relates to the discussion of acceptable evidence for or against these claims. First, there is theory ladenness in the sense of the observation theory used to observe. Second, there is a form of theory relatedness (as I prefer to call it) of evidence, in particular (but not exclusively) of data, i.e., What is the evidence evidence *for* or *against*? What theoretical function could or should empirical material fulfill? The question is not so much whether, but *how* empirical data relate to other kinds of evidence. As explained elsewhere (Van Hezewijk, 1995), an observation (or series of observations) logically is a circumscribed existential statement.<sup>4</sup> A circumscribed existential statement is falsifiable and verifiable. Such a statement can have the falsification function for a universal statement,<sup>5</sup> i.e., a proper theory (to be precise, for a theoretical, that is falsifiable statement). However, it can have a verifying function for a metaphysical, that is non-falsifiable statement, that is—logically speaking—a proper existential statement<sup>6</sup>. It can have no falsifying or verifying function for a heuristic statement, that is—logically speaking—an “all-and-some-statement”<sup>7</sup>.

The latter kind of statements has an important heuristic role in explanations. Nevertheless, not every one of these metaphysical statements *in isolation* is therefore acceptable. Other, falsifiable statements imply metaphysical statements like this and—I am making a long argument short—this implication relation supports *locally*

<sup>4</sup> E.g., “There now is here a bonobo killing a chimpanzee,” to make up an absurd one.

<sup>5</sup> E.g., “All bonobos live peacefully with chimpanzees.”

<sup>6</sup> E.g., “There are bonobos.”

<sup>7</sup> E.g., “For every behavior there is a cause”, or—as Tinbergen suggested, “For every behavior there are four kinds of explanation”. Logically these statements are neither falsifiable (due to the “there is”-part) nor verifiable (due to the “for every”-part). Nonetheless they play an important role in science as heuristic statements waiting to be specified.



their functional role in scientific theories and towards empirical data. In other words, as long as they are connected to empirical statements  $p_i$  they are scientifically acceptable. Notwithstanding their metaphysical nature, the more empirical statements that imply them, the stronger their rational acceptability *in the theoretical network concerned*.

Universal, existential, and all-and-some statements together form a theory, the latter two making up the theoretical core. Thus, theoretical networks are networks of statements referring both backward and forward. The empirical (falsifiable) statements imply "backward" because a perfectly falsifiable, universal statement at least implies the existence of the objects, events, and mechanisms mentioned in it. In isolation, these are unfalsifiable existential statements. The networks consist of falsifiable *and* verifiable (circumscribes existential statements); falsifiable, (universal) statements; verifiable (existential) statements; and unfalsifiable *and* unverifiable (all-and-some) statements. The latter in particular are the core business of explaining in biology and psychology.

Thus, the value of evidence should be evaluated with regard to other evidence available. Every theory or hypothesis has to be testable and has to be tested as severely as possible. However, if due to technical or historical reasons, the evidence available does not attain the number of observations ritually demanded in psychological experiments, this does not imply that the hypothesis concerned is untrue. It only implies that the hypothesis has not yet been tested. The statement *as such* is thereby not supported by the "local" empirical data available, but this does not mean that it cannot gain support from its theoretical relations—the relations with other statements and their relation to empirical evidence.

Thus, the question is not whether biological or evolutionary claims should be tested in isolation in and for psychological use; it is whether or not psychological explanations gain more strength and become more testable by embedding psychological explanations in the network of metaphysical and theoretical statements. The claim here is that psychological explanations profit from embeddedness in a biological network.

### SPECIFICATION

Due to the logical nature of some of the necessary propositions in psychological explanations, psychological theories *cannot* be judged as systems of nomothetic laws (as physics is supposed to be). As Kuipers has demonstrated,

...intentional and functional explanation(s) ... (are) special cases of a general pattern of explanation, of which a certain type of causal explanation, viz. the one which identifies one of the causal factors as 'the cause', is another special case. The general pattern concerns the specification of a certain qualification (intentional, functional, having a specific cause). (Kuipers & Mackor, 1995, p. 33)



According to Kuipers, functional explanations are acceptable as explanations once it is (sometimes even trivially) shown that (a) the functional behavior (trait) causally produces the result supposed to be sufficient (e.g., fanning of the stickleback after fertilization produces more oxygen in the environment of the eggs), (b) the result presumed to be necessary leads to another result or train of results presumed to be sufficient for the survival of the species, (c) the functional behavior (or trait) has been favorably selected among alternatives (even if these alternatives were only a fraction less favorable for survival in, at least, the original 'selection niche'), and (d) the trait is functional in the present environment. Kuipers suggests that even when the original selection niche differs from the present one, or when the present function differs from the original one, a case can still be made for functional explanations as explanations in need of specification.

Thus, functional explanations can be seen as (sometimes large) networks of interdependent statements. Although taken in isolation not every one of them may be falsifiable, they nevertheless relate to each other in terms of mutual support by implication, "backward implication" included; that is, implication of statement P1 by P2. They also lead to new predictions, even if a number of the explaining elements need specification at a later date. They are supported by other unspecified functional hypothesis and relate to them via non-empirical statements.

### **AN EXAMPLE: LANGUAGE**

Not surprisingly, language is a good example of the necessity to analyze the structure of the behavior to be explained by psychologists. First, language is very complicated. It involves phonetic (including intonation and stress), morphological, syntactical, semantic, and discursive, as well as, perhaps, narrative capacities. The way these competences interact with each other, and with the performance of the speaker, as well as of the listener, is still the subject of intensive and extensive debate. Even within, e.g., the field of syntactical research, there is much debate about how languages are structured syntactically and why. It is impossible to summarize the findings here. However, the general idea one can extract from linguistics is that the answer to the question of the structure and evolution of language must be reformulated into two levels of questions. One level concerns the structure and evolution of phonetic, morphological, syntactical, semantic, discursive, and narration capacities and competences; the second concerns how the evolution of one influenced the other and/or is the result of the evolution of quite different behavior patterns and anatomical structures. For instance, it has been suggested already that the hippocampus, which is involved in the spatial organization of food storage in rodents may have evolved into narrative capacities of humans. This immediately suggests another question: what does the hippocampus do in other primates? (Aggleton & Brown, 1999; cf. especially the comment by Treves, 1999).

Artran (1998) offers another example. Artran investigated the cognitive universals and cultural particulars in folk-biological taxonomies. As diverse cultures as North-American (student) populations and Lowland Maya have strong resemblances, only varying slightly depending on the degree of contact with the taxa to be expected among them.

In yet another field of neurolinguistics, it gradually has become clear that cortical impairments in Broca's area—an area that anatomically speaking is a stable location with specific neurological functioning and physiological properties in human brains—are associated with subtle deficits in *syntactical* functioning, resulting in chance performance in identifying thematic roles in pictures representing the situations that sentences refer to. Aphasics have problems with grammatical transformations such as "The boy was pushed by the girl", whereas a sentence like "The boy was interested in the girl" did not result in such problems (Grodzinsky, 2000). The explanation for these impairments involves subtle syntactical analyses, neurological evidence and hypotheses, and a theoretical account of the cross-language differences in grammatical structure (in order to explain how a brain disorder in Broca's area for a native speaker of one language may result in a different syntactical dysfunction than the same brain disorder has for a native speaker of another language; Grodzinsky, 1990, 2000).

### CONCLUSION

My present concern is the importance of analyzing both the structure of the way varying populations represent their surrounding world and the structure (and degree of "invariance") of the approach they use. The structure of the adaptation problem and "solution" is relevant for finding answers to Tinbergen's four questions concerning the explanation of behavior patterns in ethology and psychology. The structure of the taxonomies demonstrates the variances and invariances in the cognitive functions of taxonomies, the phylogenetic and ontogenetic "solutions" to finding oneself in one's ecological niche, and the environment's role as causal trigger for finding the balance between variance and invariance for individuals as well as species.

In psychology's evolutionary approach five kinds of explanation are relevant to explain individual behavior. This involves more than showing a certain kind of behavior to be innate or related to variation and selection. In that light, I discussed the role of evidence for certain theoretical and metaphysical claims.

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