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Wired for Anticipation: An Adaptive Trait Challenging Philosophical Justification?

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1. Inductive Learning and Radical Skepticism

"Radical skepticism about the external implies", according to Graham (2007:19), "that no belief about the external is even *prima facie* justified." His demanding program of an exhaustive theoretical reply to skepticism focuses on skepticism about the external. But, as he notes, radical skepticism "also extends to beliefs about the future, the past, and the unobserved." Thus, if we correctly understand, it extends to both, radical constructivist epistemology (a) and Humean skepticism (b). Nola (2005: 258), in support of (a): "Radical constructivists take skepticism about the external world seriously as part of their position." Concerning (b) we refer to Douven's (2009: 25) admission that his attempt to a formal a posteriori resolution of "external world skepticism /.../ relies on the anti-Humean assumption that we can learn from experience". Given that this assumption is really anti-Humean – but see below the quotation from Hume – this would indicate that Cartesian and Humean skepticism cannot ~~not~~ be discussed completely independent from each other. To make things even more complicated, we cannot even take for granted that Hume's conception of "induction is skeptical at all" (Stanford Encyclopedia of Philosophy 2010: 1).

A discussion of these questions goes beyond the scope of this paper. Our program is, in contrast to Graham's, not at all exhaustive but – a well known correlation – as simple as radical: In Section 2 we refer to (neuro)biological studies suggesting cerebral "top-down" or "expectancy-driven" processing and the view of anticipation as a ubiquitous adaptive trait in living systems – not only in organisms having a central nervous system, such as *Homo* or the favored model organism *Drosophila,* but also in microorganisms having no brain at all.

In Section 3 we shall compare top-down models of learning and Bayesian machinery with conceptions of induction in radical constructivist epistemology and in Hume. It can be shown that top-down information processing and Bayesian machinery is – in contrast to Hume's conception of learning as "custom or habit" – well compatible with cases of single-instance inference (cf. Griffiths and Tenenbaum 2007). Hume knew that "even brute beasts" learn and "improve by experience" (Hume 1993: 25). But he was fixated on a data-driven conception of learning and could of course not know the meanwhile growing evidence for a view of anticipation as a ubiquitous adaptive trait. These arguments amount to a rather provocative question in the conclusions (Section 4): If (i) anticipation is a~~n~~ ubiquitous adaptive trait in biology, if (ii) there is no cogent argument for a preferential treatment of our "conscious" and "reasoned" forecasts, and if (iii) a logical justification is neither necessary nor possible in adaptive traits such as anticipation in microorganisms and in our adaptive immune system – why should it, then, be necessary and possible in our "conscious" inductive inferences?

2. Wired for Anticipation?

This title is inspired by Dickson's (2008) article "Wired for sex:/.../": *Drosophila* males estimate their respective chances primarily on the basis of female "pheromone signals predictive of mating success" (p.905). But the pheromone profiles that allow discriminating between receptive and unreceptive females can vary with time and place. Thus, "an optimal strategy for each location" requires learning from trial and error. At least some circuit elements of the flies' wiring system "must remain plastic in order to record this experience. In this case, evolution has written into the genome the instruction for solving the classification problem, not the solution itself." (p.907) This description of neuronal programs being, to some degree, open for "learning to predict mating success", also applies to the brains of other species, and apart from courtship and sexual behavior, to other domains such as eating behavior. Speaking more generally, we are not only wired for sex, but, above all, wired for anticipation.

The above example implies that inductive learning does not depend on "universal laws", but is, in contrast, induced by variation among different locations, with some local reliability or "local redundancy" as a sufficient condition. A largely overlooked side effect in Pawlow's experiments, mentioned in Pickenhain (1959: 28), moreover shows that the differences between locations can in turn become the object of the animals' classifications: The dog not only learns to classify a certain "neutral" stimulus as predictive of feeding, but also learns very soon – as a restricting condition, or as some higher-order redundancy – that these redundant stimulus-feeding successions are context-specific, i.e., restricted to a specific labor setting. (Due to lack of space, we cannot discuss a further kind of "higher order conditioning" described in Pickenhain, p.36f)

What might be the neurophysiological basis for anticipatory information processing and behavior? Buzsáki (2006) emphasizes that the brain, due to its ability to produce spontaneous activity, "does not simply process information but also *generates* information. /.../ 'Representation' of external reality is therefore a continual adjustment of the brain's self-generated patterns by outside influences, a process called 'experience' by psychologists." Ringach (2009: 439) similarly argues that "ongoing cortical activity represents a continuous top-down prediction/ expectation signal that interacts with incoming input to generate an updated representation of the world". Such continuous interactions between expectation and input may also explain the effects of learning by doing: Practice of whatever kind enhances the efficiency (speed and/or accuracy) of anticipatory analysis in specific domains such as reading (Järvilehto et al. 2009) as well as in rather general respects such as the allocation of visual attention (Collins and Barnes 2009).

But learning and anticipatory behavior are much older than brains and nervous systems in general. Should we consider anticipation a general trait of living systems? Maturana (1970) characterizes organisms as conservative but inductive/prognostic systems. Tagkopoulus et al. (2008: 1313) describe microbial networks forming "internal representations that allow prediction of environmental change", and the work of Mitchell et al. (2009: 220) "indicates that environmental anticipation is an adaptive trait that was repeatedly selected for during evolution and thus may be ubiquitous in biology." A growing body of literature (e.g. Allada et al. 2009) indicates that circadian clocks are universal in organisms and play a crucial role in the anticipatory control of behavioral and physiological processes.

One might suspect a "just metaphorical" wording in some of the above quotations using the terms *learning*, *anticipation* and *prediction*. Two papers that may dispel such concerns: Stewart (1993:196) emphasizes that it "is not just loose heuristic talk" when he assumes the immune system to be "cognitive" in the sense of his thorough definition of that term. More recently, Ginsburg and Jablonka (2009) elaborate a rather restrictive explication of *learning;* neither memory (p.633) nor anticipation (p.643) is a sufficient condition. Nevertheless they insist that this explication applies to learning in the immune system and to some responses of unicellular organisms.

3. Top-down Processing, "Subjective" Information, and our Sensitivity to Coincidences

Anticipation plays a multiple role in experience: It can be considered a precondition for efficient "learning" (in the broadest sense) and its enhancement an essential aim and criterion of success in the learning process. Cognitive progress, in this sense, is done by a continuous projection of more or less fitting hypotheses onto the process under consideration ("use of redundancy") and continuous modifications induced by discrepancies between the expected and the observed – to the effect that the predictability of events and the efficiency of the analysis increase (Fenk 1986: 212). This description of learning connects with some of the above descriptions of the underlying neuronal activity but was mainly inspired by philosophical analyses of the growth of empirical knowledge (e.g. Popper's "Logik der Forschung") and thus "anticipates" Waldmann's (1997:98) conclusion that learning, like the development of scientific theories, requires a flexible coordination of prior knowledge and empirical input.

In his analysis of Hempel-Oppenheim explanations, Feyerabend arrives at the view that it is generally impossible to maintain a formal theory of explanation; theory assessment should, instead, concentrate upon the formal character of theories and their "predictive success" (Feyerabend, 1962: 92).

Just as predictive power of theories and of tests reflects their validity, the increase of a subject's predictive performance in Shannon's guessing-game technique reflects the increment of learning and knowledge achieved by this subject (Fenk 1986): Predictive success can be used as measure of prior knowledge and its increase as measure of the growth of knowledge. Despite of varying terminology, the thread and aim of most of the relevant methodology is to determine the contribution of the current input (input in the broadest sense, including sensory and statistical data) by relating it to prior knowledge (knowledge in the broadest sense, including assumptions and subjective probabilities):

Hierarchical Bayesian models represent a very advanced such method allowing "flexible inductive biases for lower levels" of a (hierarchically organized?) body of knowledge, "whereas the Bayesian Occam's razor ensures the proper balance of constraint and flexibility as knowledge grows." (Tenenbaum et al. 2011: 1284)

Accordingly, methods using the apparatus of information theory tend to a relational concept of *information* (information as "subjective" information), meaning that the degree to which an event or a message is "informative" – from relatively new to extremely surprising – depends on the relevant prior knowledge. Information is a "relative quantity", says Dretske (1999: 80), and "it reveals the extent to which /.../ the information one receives is a function of what one already knows" (p. 81f).

Von Foerster (1972: 14), known as constructivist, also repeatedly stresses "that information is a relative concept", but adds: "The environment contains no information. The environment is as it is." Certainly true that it is as it is; but is this all we can say about it? Von Foerster avoids localizing information and redundancy in the cognitive subject's environment. But can we really conceive living systems or nervous systems that produce redundancy through interactions with a non-redundant environment and that function as prognostic systems in such a non-redundant world? The assumptions of radical constructivists about the external are as "parsimonious" as those of behaviorists about the internal; but both positions complicate the description as compared with a view of cognitive subjects as parts or subsystems of an overall redundant world. These subjects not only seek to optimize internal consistency/redundancy and to avoid or eliminate non-"viable" concepts; they positively learn about their environment. Since the "transinformation" – in turn a special case of redundancy – yielded between the internal and the external is symmetric, redundancy has to be ascribed to the external world as well. Internal representations need not be understood as "iconic", but as constructed following rules that are in turn empirically accessible.

Contemporary developments in the understanding of *learning* in cognitive psychology and neurobiology also allude to a further complex of epistemological questions: Hume's problem of induction (i) that prompted him to reduce induction to "custom or habit" (ii) which seems to be incompatible with cases of learning from only one instance (iii).

Popper (2007: 55) assents to Hume's explanation "that induction cannot be logically justified." (So, if this point makes Hume a skeptic, it makes Popper a skeptic, too.) But he rebuts Hume's "explanation of induction in terms of custom or habit" (p.56) – other than e.g. Suppes (2009: 151) who takes Hume's habits as "the basis of the theory of rational choice". We are, however, perfectly in line with Popper in this respect and for the same reason: "even a single striking observation" may, even in young animals and babies, be sufficient to create an expectation; one of the facts that Hume attempted to "explain away" (p.58) in his *Treatise*. An inconsistency in his *Enquiry* concerning the use of the "heat and flame"-example was shown elsewhere (Fenk 2010: 85).

The problem of "single-instance inferences" (for a more detailed discussion from a different perspective see Millican 2009) seems to be no problem for the Bayesian machinery (Griffiths and Tenenbaum 2007) that may be considered a special case of hypothesis testing models: When rats or even worms (cf. Zhang et al. 2005) show aversion and avoidance reactions after only one "suspicious coincidence" between "testing" some new food and getting a severe malaise, they obviously follow a more intelligent strategy than would be learning by custom and habit that something is poisonous.

4. Conclusions

(I) Predictive success is the touchstone in the evolution of knowledge systems.

(II) Yes, Hume may be right to the point that a logical justification of induction and prediction is not possible.

(III) Yes, Feyerabend is also right, a formal foundation of explanation may not be possible either.

(IV) Hume and Feyerabend are right just because the generalizations we project to the past and the future are (at best) based on observations "so far". They are, or may turn out to be, only statistical laws. And, which is not the same: Low level redundancy – "low" in a hierarchy of regularities of increasing generality – may easily change when contexts change.

(V) Thus, any decision within and beyond science is always a decision under uncertainty; growth of knowledge is reduction of uncertainty.

(VI) Our intelligence can understand and describe many things as intelligent/rational without always asking for a logical or otherwise philosophical justification. Take inductive learning in our immune system as an example.

(VII) Recalling points (II) to (V) we cannot see any reasonable argument for a preferential treatment of our "conscious" and "systematic" inductive inferences within and beyond science.

(VIII) Our final conclusion: A logical justification of induction and prediction is as impossible and unnecessary as a logical justification of anticipation in microorganisms, in our adaptive immune system or any other adaptive trait. It is as obsolete as an attempt to justify metabolism. Or, with more reservation, and "anticipating" some objections: If a logical justification is neither possible nor necessary in adaptive traits such as anticipation in microorganisms, why should it, then, be possible and necessary in our "conscious" inductive inferences?

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