

implication of this constraint is that the Solomonoff prior can be defined in terms of semi-computability or approximation from below, rather than strong or full computability.³⁹² To this extent, none of these features will be employed in the critical assessment of Solomonoff induction here. The argument will instead be centred on Solomonoff's interpretation of Occam's razor as compressibility bias, and its reliance on the notion of effectiveness.

It has been formally proved by Solomonoff that the aforementioned method of prediction is reliable in the sense that it leads to the truth. Essentially, Solomonoff induction is based on the definition of a type of predictor with a preference for simplicity, along with a proof that a predictor of this type is reliable in that it is guaranteed to converge on the truth. Accordingly, Solomonoff induction is a formal argument that justifies Occam's razor. In Solomonoff's theory, simplicity is characterized in terms of the weighted sum of program lengths, which depends on the choice of the monotone universal Turing machine. The choice of the machine which determines the length of the program or description corresponds to the argument from parsimony, while the length of the program itself corresponds to the argument from elegance.

However, a closer examination of Solomonoff's Carnap-influenced formal theory of induction reveals that this objective notion of simplicity is circular.³⁹³ The argument, as advanced by Solomonoff and further

392 A function is lower semi-computable or semi-computable from below if a universal machine can calculate increasingly closer lower approximations to its values without saying how close ($\lim_{K \rightarrow \infty}$). Or more succinctly, a function is semi-computable if it can be approximated from below or from above—in Solomonoff's case from below—by a computable function. Semi-computability can therefore be defined as the minimal level of calculability. Consequently, the notion of effectiveness in Solomonoff induction also corresponds not to full computability, but to lower semi-computability.

393 Solomonoff has explicitly referred to Carnap's claim that predictive induction is the most powerful and general form of induction as well as to his theory of inductive logic as the degree of confirmation, see Solomonoff, 'A Formal Theory of Inductive Inference parts 1 and 2'.

detailed by Vitányi and Hutter, can be briefly formulated as follows:³⁹⁴ Given two classes of predictors **Q** and **R** which respectively specify the class of algorithmic probability predictors via all universal monotone Turing machines and the class of effective mixture predictors via all effective priors which embody inductive assumptions:

- (1) Predictors in class **Q** have distinctive *simplicity qua compressibility bias*. Or equally, predictors in the class **R** operate under the inductive assumption of *effectiveness* in the context of sequential prediction.
- (2) Predictors in **Q** are reliable in every case. Or, predictors in **R** are consistent.
- (3) Therefore, predictors with a simplicity qua compressibility bias are reliable in essentially every case. Or, predictors operating under the inductive assumption of effectiveness are consistent.

However, by making explicit the property of consistency in the second step of the argument (i.e., the consistency property of Bayesian predictors as applied to the class of effective predictors),³⁹⁵ it can be shown that the argument essentially runs as follows:

394 See R. Solomonoff, 'Complexity-based Induction Systems: Comparisons and Convergence Theorems', *IEEE Transactions on Information Theory* 24:4 (July 1978), 422–32; and for the elaboration of Solomonoff's system in connection with Occam's razor and artificial intelligence, see Li and Vitányi, *An Introduction to Kolmogorov Complexity and Its Applications*; and M. Hutter, *Universal Artificial Intelligence: Sequential Decisions Based On Algorithmic Probability* (Dordrecht: Springer, 2004).

395 Bayesian consistency means that posterior distribution concentrates on the true model—that is, for every measurable set of hypotheses, the posterior distribution goes to 1 if it contains truth and 0 if it does not: Thus a prior p_0 on the parameter space Θ is consistent at $\theta \in \Theta$ if according to the chance hypothesis θ , the chance of a sequence of outcomes arising that together with p_0 would generate a sequence (p_1, p_2, \dots) of posteriors that did not concentrate in the neighbourhood of θ is zero. A consistent prior is 'essentially guaranteed to lead to the truth, in the sense that

- (1) Predictors in \mathbf{R} operate under the assumption of effectiveness.
- (2) Predictors in \mathbf{R} are reliable under the assumption of effectiveness.

In other words, a vicious circularity in the definition of simplicity qua compressibility bias emerges: predictors operating under the assumption of effectiveness are reliable under the assumption of effectiveness. The meaningful application of the formal notion of simplicity-as-compressibility to infinite data streams is ultimately predicated on the inductive assumption of effectiveness. But this assumption only offers a weak notion of simplicity, in so far as any inductive assumption can be taken as a specification of simplicity—which then requires a new inductive argument to specify which assumption of effectiveness is preferable or which notion of simplicity is more strongly objective. Adding such an argument would again require further inductive arguments to establish the ideal effectiveness as the simplicity stipulation. Without these additional arguments, the notion of simplicity ends up being viciously circular, and its connection to reliability cannot be established. But with the addition of an inductive argument that specifies effectiveness, a potentially infinite series of arguments will be required. Thus, ironically, the formal definition of simplicity requires a program that can no longer be identified as simple (elegant or parsimonious) in any sense. Moreover, pace Vitányi and Hutter, there is nothing in the definition of Solomonoff universal induction nor in the definition of any inductive-predictive method that warrants our interpreting effectiveness as a metaphysical constraint on the world rather than as an epistemic constraint (i.e., What is calculable?).

An inductivist may contend that Solomonoff induction finally provides us with a reliable and universal standard to discriminate green-type hypotheses from grue-type hypotheses. This universal standard is the formal definition

no matter which chance hypothesis is true, any nonpathological stream of data generated by that hypothesis would lead an agent with that prior to pile up more and more credence on smaller and smaller neighborhoods of the true hypothesis'. G. Belot, 'Bayesian Orgulity', *Philosophy of Science* 80:4 (2013), 490.

of Occam's razor, or compressibility bias. Green-type hypotheses are more simple hypotheses as formally defined (i.e., they can compress the available data better). But this contention fails to be cogent on two accounts. Firstly, Solomonoff induction is clearly an effective interpretation of induction by instance confirmation. But as noted earlier, the essence of Goodman's new riddle is not about observed instances. Goodman argues that observed instances or the available data by themselves (i.e., without the application of projectable predicates to such instances) can result in incompatible hypotheses. The core of Goodman's problem is how to differentiate projectable from nonprojectable predicates which are not supported by their instances. Therefore, the inductivist contention misunderstands the scope of Goodman's problem. As for the second point, since the formal account of simplicity leads to an infinite regress, the inductivist has no choice other than to resort to a metaphysical account of simplicity. Then the question shifts: What exactly warrants a metaphysical conception of simplicity? Surely, it cannot be the principle of simplicity itself.

Foregoing the metaphysical conceptions of simplicity and effectiveness would require us to abandon the more ambitious claims regarding the sufficiency of inductive-predictive methods, the possibility of a universal learning machine, and the inductive nature of general intelligence, in favour of far more modest pragmatic-epistemic claims—which may indeed be significant in the context of our own methods of inquiry and only in conjunction with other epistemic modalities.

This is the predicament of simplicity-qua-compressibility as an objective epistemic notion: its criteria are underdetermined if not wholly indeterminate, and its definition is circular. In idealizing or overgeneralizing the notion of simplicity in terms of compressibility, and by identifying general intelligence with compression, the inductivist robs himself of exactly the semantic-conceptual resources that might serve not only to determine the criteria for the application of the principle of simplicity, but also to define general intelligence in terms not of compression but of the selective application of compression. Once again, the inductivist proponent of general intelligence finds himself confronted with old and new predicaments, albeit this time within the context of the formal-computational models of induction.

Ultimately, the pessimism weighing against the possibility of artificial general intelligence in philosophy of mind and the over-optimism of proponents of the inductivist models of general intelligence, in a sense originate from their choice of model of rationality. They choose either a thick concept of rationality that does not admit of the artificial realization of mind, or a notion of rationality so thin that not only is artificial general intelligence inevitable, but it inevitably takes the shape of an omnipotent omniscient inductive superintelligence. The popularity of these factions is not so much a matter of theoretical sophistication or technological achievement as the result of the dominance of such impoverished concepts of rationality. In their pessimism and over-optimism, they are both beholden to paradigms of justification derived from a narrow conception of rationality and mind. To truly begin to examine the prospects of the artificial realization of general intelligence, one ought to start from the position of systematic scepticism with regard to any paradigm of rationality built on a method of theoretical inquiry claiming to be a sufficient replacement for every other method (e.g., over-confident—as in contrast to modest—Bayesian or statistical methods) and to any inflationary model of mind that collapses the qualitative distinction between different faculties and the requirements for their realization.

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Index of Names

A

Althusser, Louis 490
Aristotle 381, 412
Armstrong, David 529
Awodey, Steve 334

B

Baars, Bernard 146n
Badiou, Alain 485n
Baianu, Ion 170
Bakker, Scott 152n
Bar-Hillel, Yehoshua 540
Bedau, Mark 96
Bennett, Charles 106
Berg, Adam 212
Berthoz, Alain 179
Boltzmann, Ludwig 208–219, 242, 244
Brandom, Robert 54, 68, 94, 139, 342, 464n,
487
sociality in 342, 376
Brassier, Ray 9, 304n, 432n, 475n, 493n, 497n
Bryan, George H. 217n
Buechner, Jeff 532, 540
Burbury, Samuel 217n

C

Carnap, Rudolf 267, 334, 335, 382n, 393,
395–396, 517, 520, 522
Cartan, Elie 426
Carus, André 334, 393, 395
Catren, Gabriel 113n
Changeux, Jean-Pierre 139
Châtelet, Gilles 288
Chomsky, Noam 323–324
semantic hierarchy 68, 323, 328
Clark, Andy 164, 171
Cohen, Hermann 398, 406n, 422
Crutchfield, James 313n

D

Davidson, Donald 478n
Deacon, Terrence 312
Dehaene, Stanislas 139, 147n
Deleuze, Gilles 408
De Morgan, Augustus 52n
Desjardins, Rosemary 481–482
Diogenes Laertius 405
Dutilh Novaes, Catarina 68–69, 387

E

Ehresmann, Andrée 165
Emtsev, Mikhail Tikhonovich 251n
Epicurus 381
Euclid 412, 413, 478

F

Findlay, J.N. 11–12n, 268n, 274, 497n
Foucalt, Michel 61n, 472n

G

Gentzen, Gerhard 348n
Ginzburg, Jonathan 139
Girard, Jean-Yves 253n, 365–373
Gödel, Kurt 527, 531, 532
Goodman, Nelson 424–425, 527–531
Grünbaum, Adolf 221, 226, 239–240, 542n
Guattari, Félix 408

H

Habermas, Jürgen 5, 343
Harper, Robert 289
Hegel, Georg Wilhelm Friedrich 1, 7–9, 18–20,
30n, 33n, 35n, 42, 66, 73, 115, 120, 125,
128, 234, 238
and individualism 56
and the given 48
geist in 19–27
Greater Logic 47, 78
Phenomenology of Spirit 22
reason in 8
Science of Logic 22
'transcendental turn' in 49