

Cybernetic Epistemology

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Abstract: Mainstream analytic epistemology conceives knowledge as representation: as true justified (un-Gettiered) belief. Such representation is conceived as independent of practice, its justification to consist in experience, and experience as mere observation. Such notion of experience is too narrow to take the epistemic value of experimentation into account. But science is emphatically experimental. On the other hand, John Dewey defined *experience* as *organism–environment interaction*. Such interaction is bidirectional and hence experimental by nature. It involves *feedback*. Cybernetics studies feedback systems. Hence, *cybernetic epistemology* is a consequence of Dewey’s definition. Cybernetic epistemology maintains that *knowledge is practice*, that is, an (approximately and relatively) invariant pattern of potential organism–environment interaction, rather than something independent of practice. In this article, I will make a case for cybernetic epistemology. It seems to dispense with the representational notion of knowledge and to provide an original justification for process ontology.

Keywords: *categories, Charles S. Peirce, cybernetics, Eino Kaila, epistemology, experience, invariance, John Dewey, meaning, pragmatism*

Introduction

There is a strange paradox in mainstream analytic epistemology. Virtually every analytic philosopher grants that the scientific method—the *experimental* method—is the best way to acquire empirical knowledge. Still, in a semi-authoritative anthology of analytic epistemology, edited by Sosa, Kim, Fantl, and McGrath (2008), *not a single author* discusses scientific practice in general and experimentation in particular.¹ They restrict the concept of experience to observation—or even worse, stimulus—*without argument*. Hence, scientific practice in general, and devising experimental setups in particular, are ignored without justification.

The unjustified omission of practice makes it seem that mainstream analytic epistemology still adheres to the traditional “spectator theory of knowledge” which John Dewey (1859–1952), a classical pragmatist, refuted in *The Quest for Certainty* (1929b, esp. pp. 23, 196, 204, 211, 213, 245, 291). It implies a physiologically passive notion of acquisition of knowledge: nature could be known without acting in it at all.² Thus, experimentation would not be needed.

The spectator theory of knowledge stems from Plato’s classical definition of knowledge, if not earlier.³ He examined the notion that *knowledge* be *justified true belief* but did not accept it himself (Plat. *Meno*, 97d–98a; *Theaet.*). As such, the classical definition says nothing about practice.⁴ Descartes made the issue with experiment even more difficult by introducing the subject–object dichotomy. Therefore, in the wake of modern philosophy, *belief* has often been

¹ This claim needs a qualification. I believe that the virtue epistemology of Ernest Sosa, John Greco, and others can accommodate competently conducted experimentation as an epistemic virtue. In the anthology, however, neither mentions experimentation at all. I also believe that epistemic virtues could be renamed simply as *skills* incorporated in *practices*. That may require revision in much of virtue epistemology. It is not sufficient to demonstrate the reliability of observation by citing neuroscience, cognitive science, and psychology. What the agent *does* with their observations is at least equally, if not more, important. I believe that sometimes even defective observations can be used successfully with appropriate skill (virtue); and sometimes even the most acute observations can lead to a miserable failure without appropriate skill (virtue).

² Kant (1956 [1781/7]) does grant the activity of the mind in the acquisition of knowledge, but he does not mention the activity of the body.

³ Pythagoras and Parmenides are possible precedents. See Diogenes Laërtius (1905, pp. 338–359, 384–385) and Diels and Kranz (1960, 14A, 14B, 28A, 28B).

⁴ I will suggest in Section ‘Criticism’ that an operational analysis of the terms of the classical definition of knowledge might involve a reference to practice.

subsumed under “subjectivity.”⁵ That makes the criterion of the attributability of *knowledge* to a person problematic: in order to make such attribution intelligibly, its grounds must be public and preferably “objective”; but the very subsumption of *belief* under “subjectivity” makes it emphatically private.⁶ Hence, in this sense, it remains a mystery how we can have knowledge about knowledge!

However, the traditional definition goes largely unquestioned in mainstream analytic epistemology. Even Edmund Gettier’s (1963) counterexamples have not led to the abandonment of the classical definition, only to attempts at its refinement.

Dewey repeats in several instances that modern scientific practice has blown up the spectator theory, but it lingers on in philosophy. In fact, science discovers phenomena by making experiments. Observations are indeed important, but not just any observations whatsoever, but specifically certain particular observations that result from running experiments. And in order to run an experiment, scientists must *act*. Usually they also need instruments—at least for measurement if not for express manipulation. Thus all epistemically relevant observations are *constructs*:⁷ their epistemic value (or their lack of epistemic value) issues at least partly from the actions of scientists.⁸

Dewey does not restrict experiment to science: on the contrary, he considers *all experience* experimental (1916a, pp. 163–178, 237, 317–322). Common sense involves the experimental method; in fact, we make experiments and test our prior beliefs all the time; we live and learn. In particular, the way an infant learns to navigate their way through nature and society is experimental (Dewey, 1933 [1910]; 1916a; 1922); here Dewey anticipates Jean Piaget’s (1952 [1936]) notion of “little scientists.” Hence, science is continuous with common sense rather than something distinct from, let alone opposed to, common sense (Dewey, 1929b, pp. 79–80, 84–85, 124, 199, 220, 240–242, 271, 295; 1938, ch. IV).

⁵ I reject the subject–object dichotomy, because my methodological concepts—*experience*, *practice*, and *situation*—cut across it, as I will explain below. I have thus decided to write “subjective” and “objective” within scare quotes to indicate non-commitment to such concepts.

⁶ See Bennett and Hacker (2003, ch. 4) and Lindholm (2021b, pp. 4–5, 4n17).

⁷ Dewey’s constructivism is manifest, for instance, in *Essays in Experimental Logic* (1916b, pp. 35–45) and *Experience and Nature* (1929a [1925], p. 428). In the latter, Dewey claims that we understand a phenomenon if we are able to regulate its occurrence—to construct it at will. For roughly identical notions, see Marx (MEW 3, p. 7), Engels (MEW 21, pp. 276–277), Kuusinen (1959, pp. 98–99, 111), Hintikka (1969, pp. 19–34) and Hacking (2010 [1983], pp. 22–24).

⁸ This notion is a consequence of experiential holism, which I will explain in subsection ‘Experiential holism’ below.

Charles S. Peirce (1839–1914), the founder of pragmatism, also believed in such continuity (CP 5.438–452, 5.494; EP 2, 346–354, 419–420).

Thus Dewey rejects the split between everyday experience and science. Experimental practice keeps science within the *lifeworld*⁹ and its objects *ready-to-hand*¹⁰ (cf. Ihde, 1974; 2012 [1977]; 1979; 1990; 1991; 1993a; b; 1998; 2009; Rouse, 1987; 1996; 2002; 2015). Dewey also rejects the split between practice and theory. Even theorizing can be understood as a peculiar practice among other practices rather than something distinct from, let alone opposed to, practice (Rouse, 1996, p. 127; cf. Dewey, 1916a, p. 169; 1922, pp. 69, 77; 1929a [1925], p. 358).

Even if nature could be known without acting in it, we are not immaterial Cartesian souls: the bodies of scientists are within nature and, at least potentially, affect the object of knowledge.¹¹ That might compromise the possibility of knowledge: in order to make an observation, an agent (or at least a measurement device) must be present; the presence of an agent (or of a measurement device) might alter the object; that might alter the observation; and that might alter the ensuing knowledge. Therefore, in order to secure the reliability of observation, the possible effect of the agent (or of a measurement device) upon the object must be determined and compensated or removed. Again, the compensation or removal of the effect of the agent (or of a measurement device) requires *action*. Hence, in a word, the presence of an agent (or of a measurement device) is already an *experiment*: the object to be observed may have been unwittingly manipulated prior to the very act of observation. The epistemic problem is to *control* that experiment so that it yields determinate and reliable results about the object, not about what the agent (or the measurement device) has accidentally produced.

That suggests a bidirectional notion of experience. According to Dewey, an agent is necessarily part of nature, and hence nature and the agent necessarily affect each other. Thus he defined *experience* simply as *organism–environment interaction*¹² (Dewey, 1916a, pp. 163–78; 1916b, pp. 136n1, 270–278, 388; 1929a [1925],

⁹ For the notion of *Lebenswelt*, see Husserl (1976a [1936]; 1976b [1939]).

¹⁰ For the notions of *Zuhandenheit* and *Vorhandenheit*, see Heidegger (1977a [1927], §§15–16).

¹¹ I will justify that claim in subsection ‘The effect of the observer upon the object’ below.

¹² This is an operational definition. I will explain the notion in subsection ‘Operational definitions’ below. Peirce may already have had a bidirectional notion of experience (CP 1.324, 1.336). See also James (1909, pp. 48–49, 103, 108–109, 126–128), according to whom an object experienced and the experiencing of it are two names for one indivisible phenomenon: both the knower and the known are different parts of the same phenomenon. Thus the concepts of *experience* and *phenomenon* cut across the division between the “mental” and the “material.” See also fn 41.

pp. 3a, 246–247, 279–280, 283, 314, 344–346; 1929b, pp. 172–173, 234; 1980 [1934], pp. 22, 53, 56, 132, 246, 251; 1938, chs. I–V; 1941, pp. 183–184). By definition, Dewey’s notion of experience cuts across the subject–object dichotomy. On the other hand, the spectator theory involves a unidirectional notion of experience: nature affects the observer, but not *vice versa*.¹³

Bidirectional interaction means *feedback*. Now, *cybernetics*¹⁴ is the science of feedback systems. Wiener (1948) defines *cybernetics* as “control and communication in the animal and the machine.” Wiener’s cybernetics is a field of applied mathematics. In control engineering, a field of technics that borders on and is based on applied mathematics, the standard way to implement self-regulating control in a machine is feedback. In biology, there are several feedback mechanisms that maintain homeostasis in organisms and ecological systems. However, Wiener’s definition is too narrow by his own principles: the laws of control and communication apply to *entire systems* which may or may not include animals or machines.¹⁵ Hence, an epistemology that adopts the bidirectional notion of experience is a *cybernetic epistemology*. Its unit of analysis is not an object or its properties, but the *interaction* between an agent and an object. For this reason, in order to accommodate experiment, epistemology must be cybernetic.

The agent being part of the interaction, the knowledge based on the interaction is necessarily restricted to a point of view, rendering it perspectival. For a biological organism, a God’s Eye point of view, an Archimedean point in epistemology, is simply impossible. We cannot escape our environment. Marx and Engels (MEW 3, 20–21, 20n, 21n) and Heidegger (1977a [1927], §§12–13) have made roughly similar points.

The restriction of knowledge to a point of view threatens the objectivity of knowledge. Such restriction makes knowledge contingent and relative, while the criterion of objectivity is (arguably) universality. I will suggest a way to defuse this threat below. Before that, I must derive a couple of implications.

¹³ The unidirectional notion of experience seems to be a necessary consequence of the Greek notion of *knowledge*. For the Greeks, knowledge (ἐπιστήμη) is absolutely invariant. The Greeks thought that that requires that the object of knowledge be absolutely invariant too; the alleged “knowledge about a changing object” would amount to changing knowledge, which would be either a *contradictio in adjecto* or mere opinion (δόξα). Therefore, in order to know an object, it must be kept intact. Therefore experiment would, by definition, compromise the very possibility of knowledge at the outset. (See Kaila, 1939, pp. 56–57, 73; cf. Dewey, 1929b; Lindholm, 2021b, p. 7.)

¹⁴ From κυβερνάω: “I steer,” “I navigate,” “I govern:” and from κυβερνητική: “governance.”

¹⁵ For instance, the climate of the earth is a cybernetic system independently of whether there are animals or machines.

If the previous analysis is correct, then the very notion of *knowledge* must be revised. If the acquisition of knowledge is impossible without experiment, then knowledge cannot possibly consist in representations (for instance, justified true (un-Gettiered) beliefs) that are independent of practice. On the contrary, I will argue in this article that knowledge *is* practice—namely, an (approximately and relatively) invariant pattern of potential organism–environment interaction which involves doing and undergoing its results.¹⁶ It may or may not involve representation; but as such, representations are incapable of constituting knowledge alone if abstracted from practice (cf. Dewey, 1916a, p. 169).

One could object that practice is “subjective.” Then, the argument might go, the “objectivity” of knowledge is compromised. I will reply that the concept of practice cuts across the very subject–object dichotomy like Dewey’s notion of experience. Practice may or may not involve “subjective” traits, but in the main it is public, observable, and causal, and hence qualifies as “objective.”¹⁷

If knowledge is practice, the problem of objectivity, that the restriction to a point of view ensues, evaporates. Instead of the accuracy of representation, the criterion of knowledge is simply *success or failure*, which can always be determined “objectively”—even from a restricted point of view that cybernetic epistemology imposes upon itself: it takes place within the domain of possible experience as defined above.

In this article, I will make a case for cybernetic epistemology. It extends and elaborates on Lindholm (2021a). Karen Barad (1996) and Joseph Rouse (2002, ch. 8) have attained similar results; I will show how these results can be attained by different means, thus increasing the plausibility of their conclusions.

My method is ultimately based on Peirce’s *pragmatic maxim*. Its import is *radical empiricism*: all meaning is *a posteriori*. The reason for such method is that cybernetic epistemology must be *reflexive* in order to be justified: it must apply to itself. Unless the selected method is internal criticism, it would be self-undermining to begin from an Archimedean point and then conclude that an Archimedean point is impossible. Therefore I must begin *as if* cybernetic epistemology *were* sound—restrict the treatment to what can be empirically

¹⁶ The classical pragmatists refer to such patterns with the technical term *habit*. I believe that Joseph Rouse’s (1987, chs. 4 & 7; 1996, chs. 5–9; 2002, chs. 5–9) notion of *practice* can be considered synonymous. I will discuss the nature of habit and practice in subsection ‘Habit and practice’ below. I will justify my main thesis that knowledge is practice in Section ‘Knowledge as practice’ below.

¹⁷ I will continue this line of argument in subsection ‘Habit and practice.’

determined—and then conclude that this approach was the sole possibility and hence justified all along.

In Section ‘Meaning,’ I will outline the theory of meaning that the pragmatic maxim implies. Its purpose is to yield *operational definitions*: definitions that make sense strictly within the domain of possible experience—that is, without reference to supra-empirical entities like propositions in their traditional sense.¹⁸ Such qualification is necessary to make sure that my method does not exceed the restriction to a point of view that cybernetic epistemology imposes upon itself.

In the third section, ‘Experience,’ I will apply the pragmatic maxim to the notion of experience in order to define it operationally. That will yield an account of how experience is present to experience itself. The result is that *experience is organism–environment interaction*, just like Dewey defined. Based on Dewey’s account, I will show how experience is holistic. I will continue to explain, how the very possibility of experience changes its object at least potentially. I will also show how Peirce’s categories¹⁹—firstness, secondness and thirdness—can be derived empirically. That will facilitate an empirical analysis of Eino Kaila’s notion of *invariance*. I will argue that an invariance is a universal and therefore falls under thirdness.

In Section ‘Knowledge as practice,’ I will explain how the notion of invariance can be applied to redefine knowledge as practice. First I will apply the pragmatic maxim to the notion of knowledge in order to define it operationally. As with experience, that will yield an empirical account of knowledge. The result is that *knowledge is an (approximately and relatively) invariant pattern of potential organism–environment interaction*. In other words, *knowledge is practice*, which is the fundamental thesis of cybernetic epistemology I am putting forward. That, in turn, suggests an original defense of process ontology.

¹⁸ Analytic philosophers have traditionally understood propositions as *abstract entities* that are accessible to reason but not to experience. There are different ways to define propositions: some define them as unstructured entities, some as structured entities; some reduce them to another ontological class, some understand them as a *sui generis* class. I will not discuss the traditional theories of propositions here at further length. Stjernfelt (2014) has insightfully examined Peirce’s semiotic theory of propositions that provides an alternative.

¹⁹ In Western philosophy, *categories* have been traditionally understood as the *highest genera of being*. In Aristotle’s *Catg.*, categories exist in nature, though he abstracts them from the structure of language. In Kant (1956 [1781/7]), however, categories exist only in the understanding. He argues that they are necessary conditions of the possibility of experience. Hence they are also necessary conditions of the possibility of empirical knowledge. In Peirce too, categories seem to exist in the mind; but for him, mind is part of nature.

In the fifth section, I will point out some weak points in my argumentation. The sixth section will conclude with some remarks about opportunities for future research.

Meaning

In this section, I will explain the methodological import of the concept of *meaning* and show why it must be understood pragmatically.

The pragmatic maxim

Peirce published an important pragmatist doctrine—the *pragmatic maxim*—in his 1878 paper ‘How to make our ideas clear.’ It involves a simple theory of meaning:

Consider what effects, which might conceivably have practical bearings, we conceive the object of our conception to have. Then, our conception of these effects is the whole of our conception of the object. (CP 5.402; EP 1, 132)

Peirce elaborates:

what a thing means is simply what habits it involves. [...] Thus, we come down to what is tangible and practical, as the root of every real distinction of thought, no matter how subtile [*sic*] it may be; and there is no distinction of meaning so fine as to consist in anything but a possible difference in practice. (CP 5.400; EP 1, 131.)

Peirce’s original formulation seems to have problems with *conditionals* and *counterfactuals*. Thus, he added later that he means *potential* practice: in order for a sign (e.g., conception) to have meaning, it suffices that it be *potentially interpretable* in practice (CP 2.92, 2.275, 5.18, 5.196, 5.425–427, 5.438, 5.453, 5.457; EP 2, 134–135, 145, 234–235, 340–341, 346, 354, 356). Short (2007, p. 173) calls this “the subjunctive version of pragmatism:” the meaning of a proposition is how it *would* influence conduct—that is, our habits—*were* it believed and *had* we some practical purpose to which it was germane.

In a word, Peirce defines the *meaning* of a thing as the *potential practical effects* of that thing; and *potential practical effects* as *habits*.²⁰ One can readily see from this formulation that the pragmatic maxim is not restricted to language (cf. Peirce EP 2, 221); in principle, *anything* (possibly a speech act) that has potential practical effects can be meaningful. A concept is meaningless if nothing practical follows from it. In order to be meaningful, a conceptual difference must make a practical difference. The discoveries of second-generation cognitive science seem to support the pragmatist theory of meaning (Lakoff & Johnson, 1999).

The pragmatic maxim, if sound, makes the determination of meanings an *empirical—experimental—matter* (cf. Peirce CP 5.465; EP 2, 400–401). In order to determine what a thing (possibly a speech act) means, one must study how different organisms respond to it. That dispenses with the *a priori* method in philosophy of language.

At any rate, the purpose of the maxim is to dispel all senseless metaphysics²¹ which theoretical concepts and distinctions may yield, especially in rationalist philosophy like Descartes's and Hegel's. It can also be understood as a restatement of Kant's (1956 [1781/7]) claim that concepts only apply to experience. The difference between Kant and the classical pragmatists is the concept of "experience": for the former, experience seems to be "subjective"; for the latter, both "subjective" and "objective" at once, as I have explained above.

There is a standard objection to the pragmatic maxim which has been made by Horkheimer (2004 [1947], p. 33) and others. The conception of the object is the conception of its practical bearings; then, the conception of the practical bearings is the practical bearings of these practical bearings, and so on, *ad infinitum*. That seems problematic: if such *progressus* of conceptions arises, we have to wait indefinitely long until we can determine the meaning of a thing. That is a serious problem and deserves a careful solution.

I have provided a defense, based on Peirce's semiotics, in Lindholm (forthcoming; 2023). I bite the bullet and accept Horkheimer's objection. Semiosis, or the

²⁰ Classical pragmatists use the term *habit* in a technical sense. I will explain that in subsection 'Habit and practice.'

²¹ Here I emphasize the word *senseless* in order to make room for metaphysics that *does* make sense because its concepts arise from practice. The classical pragmatists believed that such metaphysics is possible.

process of interpreting signs²² (e.g., conceptions), is indeed infinite—but only potentially. It tends to termination. The terminus of semiosis is the establishment of habit.²³ Interpretation comes to its end when all possibilities for habitual encounters with the object²⁴ of the sign have been exhausted. But because pragmatism involves *fallibilism*,²⁵ there remains room for criticism: we have no criterion to determine whether all possibilities for habitual encounters with the object have indeed been exhausted; and the object can change. Hence, we have to keep updating our beliefs indefinitely. Thus, Horkheimer is correct, but his claim turns from an objection into a description of semiosis.

²² For the sake of simplicity, I speak about “signs,” though in Peirce’s semiotics, a distinction must be made between *sign-relation* and *sign-vehicle*. Peirce himself refers equivocally to both sign-relations and sign-vehicles as “signs,” but usually it can be seen which he means from the context. When I speak about “signs,” I mean *sign-vehicles*. I will try to keep semiotics to the minimum in this article. A reader interested in Peirce’s intricate conceptual apparatus may consult the second volume of *The Essential Peirce* (Peirce EP 2) and the correspondence between Peirce and Victoria Welby (Peirce & Welby SS).

²³ As we interpret the object of a concept, we also interact with it directly. (Peirce understood direct acquaintance with objects as instances of firstness and secondness; see subsection ‘Categories’ below.) Continued direct interaction forms a habit. Thereby we discover inductively what opportunities for action the object affords (Peirce CP 2.643; EP 1, 198–199). Thus Gibson (1979) speaks about “affordances.” Direct interaction with the object always remains possible, but as the habit emerges, the interaction gradually acquires mediated characteristics (cf. Dewey, 1922, p. 32). (Peirce understood mediated acquaintance with objects as instances of thirdness; see subsection ‘Categories’ below.) The inductive discovery of the object also develops the sign. The development of the sign is called *semiosis*.

²⁴ Again, I speak about “object” for the sake of simplicity, though in Peirce’s semiotics, a distinction must be made between the *dynamical object* of the sign and the *immediate object* of the sign. The latter denotes an object as represented by a sign: how that object appears at a given stage of inquiry. The former denotes the real object independently of how the sign represents it: how it appears at the conclusion of the inquiry, defined as the point where everything about the object is known, and no further increase in knowledge is possible. When I speak about the “object,” I mean the *dynamical object*. Again, for a more detailed account, the reader may consult the second volume of *The Essential Peirce* (Peirce EP 2) and the correspondence between Peirce and Victoria Welby (Peirce & Welby SS).

²⁵ *Fallibilism* is the doctrine that “anything, including mathematics and logic, can be questioned, if positive reasons to do so arise.” For Peirce’s fallibilism, see his ‘Questions concerning certain faculties claimed for man’ (CP 5.213–263; EP 1, 11–27), ‘Some consequences of four incapacities’ (CP 5.264–317; EP 1, 28–55), ‘The fixation of belief’ (CP 5.358–387; EP 1, 109–123), and ‘How to make our ideas clear’ (CP 5.388–410; EP 1, 124–141). For Dewey’s fallibilism, see Dewey (1916b; 1929b; 1938). Peirce allowed doubts about mathematics and logic in his (CP 5.577, 5.582, 6.595; EP 2, 44, 47). Peirce also denied that positive certainty be accessible (EP 2, 26), forswore demonstrative proofs in his philosophy (CP 1.7), and even defined *proof* as the mere removal of particular doubts rather than the establishment of an irrevocable truth (CP 3.432). Inquiry is condemned to go on and postpone final judgment about truth indefinitely (Short, 2007, p. 331).

Habit and practice

The *meaning* of a thing having been defined as the *potential practical effects* of that thing, and *potential practical effects* having been defined as *habits*, one needs an account of the concept of *habit*.

Dewey (1916a, pp. 54–58; 1922, pp. 14ff) defined *habit* as a “form of executive skill, of efficiency in doing; an ability to use conditions as means to ends-in-view;”²⁶ and “an active control of the environment through control of the organs of action.”²⁷ Habits involve certain properties of nature at our disposal. They involve the cooperation of organism and environment. I suggest a shorter definition: an (*approximately and relatively*) *invariant pattern of potential organism–environment interaction*.²⁸ The organism and the environment exchange causal signals (including observations and actions) in space and time, and recurring patterns in such exchange are *habits*.

This definition is independent of whether the organism has a mind in general and a consciousness in particular: it allows the formation of habits without cognition. That allows continuity between inanimate and animate nature—a consequence of Darwin’s theory of evolution. Peirce was aware of the necessity of such continuity and sometimes talked about the habit-formation of plants and even rivers (CP 5.492; EP 2, 418).

Dewey (1922, pp. 25–26) distinguished between *active* and *passive means*. He defined *habits* as *active means* and *bodily organs and instruments* as *passive means*. Outside actual use, a passive means is just a thing. It is a means only potentially. Being habitually used actualizes its status as a means.

I have suggested that Dewey’s notion of *habit* and Rouse’s (1987, chs. 4 & 7; 1996, chs. 5–9; 2002, chs. 5–9) notion of *practice* are roughly identical (Lindholm,

²⁶ Cybernetic epistemology involves a feedback that adjusts the behavior of an organism to the environment so that given ends are achieved. The notion of *end-in-view* suggests a higher-order feedback that regulates the ends themselves. Dewey (1916a, pp. 121–123, 127–129, 205–206) distinguishes between *categorical ends* and *ends-in-view*. On the one hand, a *categorical end*, being categorical, is independent of, and hence external to, any practice. It leaves no room for deliberation and criticism. Hence it is both epistemically and morally unjustified. Positing a *categorical end* runs the risk of dogmatism. On the other, an *end-in-view* is internal to a practice. *Ends-in-view* are flexible, revisable and adaptable to conditions. They are constantly re-evaluated if something unexpected happens during the course of action. In certain conditions, they can be even discarded and replaced.

²⁷ Again, this definition is operational. I will explain that notion in subsection ‘Operational definitions’ below.

²⁸ I will discuss the notion of *invariance* in subsection ‘The concept of invariance’ below.

2021b, p. 7). Thus I believe that they can be used interchangeably, but Rouse's "practice" might capture better what Dewey tried to express by "habit."

Somebody might object that habits (practices) are "subjective." I reply that habit (practice) cannot be understood in abstraction from its concrete setting, including possible instruments. For instance, take chopping wood. If we consider only whatever is "subjective" in chopping wood, we are left with the behavior of the agent (at most). But if the practice of chopping wood is "subjective," then it could be understood as chopping wood without an ax and without wood! Consider a person performing the bodily movements of chopping wood without proper equipment and material. That could be understood, perhaps, as performance art; as mimicry or as parody; but such sense is derivative: in order to recognize the behavior in question, one must already be acquainted with actual chopping of wood. Habit (practice) is therefore both "subjective" and "objective" at once: it cuts across the subject–object dichotomy.

Neither organism nor environment can determine a practice alone: without the cooperation of environment, the activity of the organism will probably fail; and without the cooperation of the organism, the activity of the environment will produce the desired results only by accident.

Operational definitions

The application of the pragmatic maxim to concepts yields *operational definitions*. For instance, Dewey's definitions of *experience* as *organism–environment interaction* and of *habit* as *ability to use conditions as means to ends-in-view* are operational.

The point of an operational definition is to make concepts completely understandable in empirical terms. It contrasts with a *nominal* definition. On the one hand, a nominal definition explains a word with other words. The domain of nominal definitions is aloof: staying within its confines, it is impossible to determine what is being talked about. On the other hand, an operational definition determines the empirical, public criteria of the intelligible use of a concept.

The traditional definition of *definition* is a *phrase that states the necessary and sufficient conditions of the thing in question*—a notion which ultimately stems from Aristotle (*Top.*, 101b35–102a5). On the other hand, an operational definition states *what can be done with the thing, to the thing, or in response to the thing in question*. That is not necessarily a *refutation* of the traditional notion but its *operational explication*.

Bennett and Hacker (2003) have argued that the criterion of the intelligible attribution of psychological predicates is *behavior*, including speech acts.²⁹ I believe that this thesis can be derived from the pragmatic maxim. The operational definition of a psychological predicate determines the empirical criteria of its intelligible attribution. In order to intelligibly attribute a psychological predicate to a person, that person must give public evidence for being in a certain psychological state; and such evidence consists in behavior, including speech acts. A psychological predicate can be *true* of an attributee without behavioral evidence,³⁰ but it cannot be *meaningful*. Nobody could understand what such attribution *means* in the absence of evidence. (Cf. Lindholm, 2021b, pp. 4–5, 4n17)

Peirce himself made two operational definitions of psychological predicates. He defined *belief* operationally as *habit* and *doubt* as *privation of habit* (CP 5.367, 5.417; EP 1, 112, 114; EP 2, 336–337). I will apply these definitions to describe the *belief–doubt model of inquiry*.³¹

Dewey (1938, pp. 66–67) defined *situation* operationally as a *contextual whole within nature within which experience, as defined above, takes place*. I will apply this definition to describe *experiential holism*.³²

Dewey (1933 [1910], pp. 20, 136–137; 1929a [1925], pp. 166, 174) defined *object* operationally as a *meaningful thing*; that is, a thing that happens to mean something else for a potential interpreter; that is, a thing which an interpreter knows to have potential practical effects. I will apply this definition to describe *experiential holism*.³³

²⁹ Strictly speaking, this position does not equal behaviorism. As far as I know, behaviorism would *reduce* the meaning of psychological predicates to behavior.

³⁰ For instance, Putnam (1963) presented the thought experiment of super-Spartans who do feel pain but possess such self-discipline as to never manifest it. Then pain could be true of them even when they do not show it.

³¹ See subsection ‘Experience as experimentation’ below.

³² See subsection ‘Experiential holism’ below.

³³ See subsection ‘Experiential holism’ below.

The genesis of meaning

Dewey (1929b, pp. 81–84) provides an account of how meaning emerges from experiment.³⁴ First, a known change (possibly nothing) is introduced. Then something else (possibly nothing) changes as a result. This change is measured. Then these changes are correlated. The operations are repeated in varied conditions. If the correlation persists in different circumstances, an experimental practice can arise, whereby these changes become signs of each other: the presence of one is a (fallible) sign of the presence of the other. This applies to objects and words alike (Dewey, 1916a, pp. 14–19).

The emergence of meaning consists in the reconceptualization of the discovered cause–effect relations as means–ends relations. Once a causal relation has been learned, by directly manipulating the occurrence of the cause, one acquires the capacity of indirectly manipulating the occurrence of the effect. According to Dewey, that is the purpose of all intelligent activities. If meaning emerges from them, they acquire the status of *art*. (Dewey, 1929a [1925], pp. 136, 177, 180–183, 369–370; cf. Lindholm, 2021b, p. 7)

This discussion suggests one way in which the pragmatic maxim is inadequate. I have explained that Dewey seems to have held that the cause and the effect are (fallible) signs of each other. But the pragmatic maxim says that only the cause can be a sign of the effect, not *vice versa*. I see no reason why that should be the case. Therefore I conclude that meanings *can* include *both* possible practical effects *and* possible practical causes. In short, to be meaningful is to be potentially causally active. At any rate, Peirce was on the right track. His crucial insight was that causality is constitutive of meaning. (Lindholm, forthcoming)

Universal hermeneutics

I have said that *anything* can be meaningful in Peirce's sense: anything can have potential practical effects. Thus *anything can be interpreted*. That resurrects the medieval notion of the *book of nature* in a secular sense (Lindholm, forthcoming). Moreover, that calls for a *universal hermeneutics*, the general science of the interpretation of any kind of sign.

³⁴ Recall that Dewey considered all experience experimental. Hence, meaning can emerge in the described way also in an everyday context. In fact, the emergence of meaning in an everyday context must necessarily precede the emergence of meaning in a scientific context, because the express acquisition of knowledge is a highly specialized activity that makes sense only against a broad background of other activities (Dewey, 1916b, pp. 1–13; 1938, chs. I–V).

Neo-Kantians are correct in that all knowledge is interpreted. But they are wrong if they insist that interpretation be always linguistic. I submit that there are *non-linguistic meanings* fit for *non-linguistic interpretation*. The terms might look like oxymora to somebody trained in twentieth-century philosophy with its obsession about language (cf. Ihde, 1998, p. 116). But I submit that there are at least three kinds of non-linguistic meanings: aposematism, perceptual and motor functions of cognition (Lakoff & Johnson, 1999), and cause–effect relations, conceived as means–end relations³⁵ (cf. Lindholm, forthcoming). According to Määttänen (2009; 2015), non-linguistic meanings are more basic than linguistic meanings. Language could not function without an already existing stock of non-linguistic meanings that connect speech acts to practice—not least of all because an agent must make use of perceptual and motor meanings in order to produce speech acts in the first place.

Joseph Rouse has introduced *practical hermeneutics*, which he distinguishes from theoretical hermeneutics. Both kinds of hermeneutics are universal: they are designed to interpret anything. Practical hermeneutics is based upon Rouse's original reading of Thomas Kuhn's epoch-making *The Structure of Scientific Revolutions* (Kuhn, 1996 [1962]), according to which science is practice and paradigms are shared practices. The point of departure in practical hermeneutics is Heidegger's analysis of being-there (*Dasein*) in his *Sein und Zeit* (Heidegger, 1977a [1927]), while theoretical hermeneutics sets out from Quine's philosophy of language. Rouse points out that the ideas of both kinds of universal hermeneutics can be found already in Dilthey (1956; 1957). Practical hermeneutics understands practices as meaningful on their own right and interpretation itself as a practice. Theoretical hermeneutics maintains that it can stay uncommitted to, and indifferent about, any particular interpretation, because each situation is in principle arbitrary to it. That makes it a species of spectator theory of knowledge; I understand it as a version of Cartesianism in which soul is simply replaced with language (Lindholm, forthcoming). On the other hand, practical hermeneutics shows that the world is already disposed towards certain possibilities and that they determine certain opportunities for action. The material setting in which we find ourselves is not up to deliberation, negotiation and choice.³⁶ Hence interpretation *matters* to us. That is an implicit refutation of theoretical hermeneutics. (Rouse, 1987, chs. 2–3)

³⁵ See subsection 'The genesis of meaning.'

³⁶ This statement is a rehashing of Heidegger's notion of *In-der-Welt-sein* (Heidegger, 1977a [1927], §§12–13).

Don Ihde has introduced *visualism*, which chiefly builds upon Rouse's work. Ihde follows Latour (1987, pp. 67–68) and understands scientific instruments as *inscription-producing devices*. A typical scientific instrument creates a visual output and records data upon it.³⁷ Ihde argues that science can do a hermeneutics of things by turning them into scientific objects. Scientific objects are accessed via the technological construction of images. The hermeneutics of science is of a special kind: not necessarily linguistic or even propositional but first and foremost *bodily* and *perceptual—visual* in particular. The scope of scientific imaging ranges from isomorphic to non-isomorphic depictions of scientific objects. The less it retains isomorphism with the object, the more hermeneutic activity is required to make sense of it. The interpretation of visualizations of data is a matter of *learning to see*—to figure out which patterns indicate something else and which do not. Such learning takes place dialectically with the development of the instruments of observation, recording, and visualization. (Ihde, 1998, chs. 11–14)

I have argued that Lindholm (2022; forthcoming) practical hermeneutics and visualism can be founded upon the pragmatist theory of meaning. Scientific practices and the instruments they involve are in causal contact with scientific objects. By the virtue of this contact, they generate meaning,³⁸ which is to be interpreted practically.

Experience

In this section, I will explain the epistemic import of Dewey's (and possibly Peirce's) definition of *experience*³⁹ and show why it has to be understood holistically and bidirectionally. That involves a brief explanation of how the very possibility of experience alters its object at least potentially. I will also derive Peirce's categories empirically and discuss their relation to Eino Kaila's notion of *invariance*.

³⁷ Not all scientific instruments are visual; consider, for instance, the stethoscope.

³⁸ See subsection 'The genesis of meaning.'

³⁹ See 'Introduction.'

Experiential holism

Experience, or organism–environment interaction, takes place within a *situation*, defined operationally.⁴⁰ According to Dewey (1916a, pp. 42, 56, 91–92, 232–234; 1938, pp. 66–70), situations must be understood *holistically*—as comprehensive wholes. That does not mean that the organism attends to each part of the whole simultaneously; it means that the organism does not necessarily attend to anything specifically but can potentially attend to anything within the field of experience.

A situation is not purely “objective” (if such concept is applicable at all in interpreting Dewey): it includes not only surrounding conditions but also the agent with their practical and conceptual skills, possibly including language.⁴¹ We are active creatures by nature: action is the rule and contemplation is the exception—namely, a highly specialized kind of action. An ongoing, purposive course of action maintains the unity and coherence of a situation. Once again, the concept of *situation* cuts across the subject–object dichotomy.

A situation can be analyzed into its parts, if need be. But that can only begin from the situation as an integral whole: that is needed to provide a purpose, meaning, and resources for such analysis and its possible results to be intelligible. Parts are not meaningful as such; they are just there. On the other hand, meaning presupposes a relation between a sign, an object, and an interpretant.⁴² Therefore, to understand a thing is to comprehend its relations to other things. Hence, the meaning of each part results from their being arranged in a certain way as a whole.

⁴⁰ See subsection ‘Operational definitions.’

⁴¹ Rouse (2002, ch. 8) also emphasizes that his concept of *phenomenon* includes conditions and the agent with their practical and linguistic competence. Hacking (2010 [1983], pp. 220–232) seems to be saying something similar. I believe that Dewey’s notion of *situation* and Rouse’s (and perhaps Hacking’s) notion of *phenomenon* are at least roughly synonymous. Peirce emphatically understood phenomena as *objective*, somewhat akin to “effect,” as in “the Hall effect” and “the Zeeman effect” (CP 5.425–427; EP 2, 339–341): reproducible patterns of events within nature under specific conditions. See also fn 12.

⁴² Once more, for an account of the triadic relation between a sign-vehicle, an object and an interpretant, and of the definition of *interpretant*, the reader may consult the second volume of *The Essential Peirce* (EP 2) and the correspondence between Peirce and Victoria Welby (Peirce & Welby SS).

Analysis itself is a possible, highly specialized course of action. In order to identify and determine a constituent, an unarticulated background⁴³ must be presupposed and taken for granted.⁴⁴ As such, a part of the whole is just a thing among other things that can be safely ignored unless there is reason to consider it and not something else instead. It does not stand out on the background of other things. In order to identify a part *qua* part, it must have meaning; that is, it must be identifiable as an *object*, defined operationally.⁴⁵ In order for a part to have meaning, that is, to qualify as an object, it must have *potential practical effects*: it must be a sign of something else that is relevant for the ongoing course of action. That presupposes prior practical acquaintance with the part: the agent must have learned to habitually associate the part with what it signifies. The agent must have done something to the part and undergone the results; it is necessary that what is observed results from the action of the agent; otherwise it cannot stand out of the background of other observable things.⁴⁶ Hence *the determinacy of an object presupposes practice*.⁴⁷

The whole *may* be ultimately reducible to its parts. That must be tested in each case anew. But even then, the parts cannot be *understood* without taking the whole into account. They are there, perhaps independently of our concepts; but no concept can be applied to them unless a context is provided.

Parts are the *result* of analysis. Therefore they cannot be the starting point. For somebody who encounters a certain kind of situation for the first time, the situation itself is epistemically basic. Continued involvement with it may result in the determination of its parts. The parts can be epistemically “basic” only in a derivative sense, namely, for an expert with sufficient prior knowledge about the given kind of situation.⁴⁸

⁴³ Here “background” does not refer exclusively to background *assumptions*. Rather, it refers to the *conditions* in which the course of action takes place. Dewey (1916b, pp. 1–13; 1938, chs. I–V) explains that the acquisition of knowledge is a highly specialized and derivative mode of action: in order to make sense, it presupposes a large background of non-epistemic practices.

⁴⁴ Dewey’s thesis has an affinity with Heidegger’s (1977b [1935/36]; 1984 [1935/36]) dialectic of earth (*die Erde*) and world (*die Welt*): on the one hand, determinate, meaningful entities can arise only against an indeterminate background; on the other, thereby the background becomes partially articulated.

⁴⁵ See subsection ‘Operational definitions.’

⁴⁶ Thus “im Anfang war die Tat,” as Goethe declares in his *Faust*. One qualification must be made: the attribution of a causal relation between what is done and what is observed to result is always eminently fallible.

⁴⁷ Rouse (2002, ch. 8) arrived at the same conclusion via a different route. See also Barad (1996).

⁴⁸ Here Dewey suspends judgment about what is *ontologically* basic.

The agent themselves is a part of the whole. What applies to the determination of the parts in general also applies to the determination of the agent. Hence the identity of the agent is not a presupposition but a *result* of their interaction with their surroundings. The agent discovers themselves reflexively from phenomena, to the production of which they have contributed by their actions. Thus, by determining what nature is, we also determine who *we* are (cf. Rouse 1987, pp. 181–185). Our situatedness avoids the problems associated with the Archimedean point, or the God’s Eye point of view. Kant (1956 [1781/7], B129–B169) may have been the first who had such notion. In his 1787 “Transcendental Deduction of the Categories,” “Schematism,” “Refutation of Idealism,” and “Analogies of Experience,” he argued that the necessary unity of apprehension must follow from concepts. That entails the objective validity of the categories. That, in turn, entails the existence of the transcendental ego.⁴⁹ Kant’s deduction is not impeccable, however; for instance, the transcendental ego must have an origin and a history of development, and Kant does not take the bodily actions of the ego into account. Ihde (2012 [1977], p. 11) points out that phenomenology has a similar, reflexive understanding of the “subject.” Rather than a presupposition, the subject is a *problem* for phenomenology.

Acquaintance with a given kind of situation allows habitual encounters with it. Habits enable us to posit *ends-in-view*⁵⁰ by creating expectations on the basis of the meanings of the encountered objects. Ends-in-view make purposive behavior possible. Purpose, like I said, is necessary for the unity and coherence of the experienced situation.

Most situations are non-epistemic: for instance, conversation, the use and enjoyment of certain goods, routine work, or games. Epistemic activity is highly specialized, and it presupposes a background of non-epistemic activities, from which it acquires its meaning. Contemplation is an extremely specialized activity, very rare, and possible only in extremely specific conditions. Hence, unlike in the spectator theory of knowledge, contemplation should not be considered the standard epistemic activity. (Dewey, 1916b, pp. 1–13; 1938, chs. I–V)

Problematic situations call for epistemic activity. They arise when habitual action fails.⁵¹ A problematic situation is indeterminate: we do not know its meaning. The encountered phenomena might be new to us; or they might signify many

⁴⁹ See also Guyer (2010, pp. 129–150) and Emundts (2010).

⁵⁰ See fn 26.

⁵¹ I will explain the epistemic function of the failure of habitual action in subsection ‘Experience as experimentation’ below.

different things, of which some may be even contradictory. Hence experience provides only *data*, to which we must learn to relate critically. Unlike what the classical empiricists taught, data present *problems to be solved*. So they prompt epistemic activity. We must study them in order to resolve the problematic situation. By definition, the problematic situation does not provide a solution by itself. But it may provide resources for us to construct a solution ourselves. By intelligently and creatively rearranging the resources that the situation affords, we can inquire what the data signify. That involves the generation of meaning by experiment.⁵² The purpose of inquiry is to determine a unique meaning for each datum; in order to achieve that, parts must be analyzed into further parts until parts with unique meanings are found. The uniqueness of the meanings of data enables us to select the data that can be used to construct a solution to the problematic situation and ignore the rest. Then the solution must be tested; that is one more experiment to be conducted. We may fail at any stage of inquiry. Therefore, inquiry always involves a risk. If a proposed solution succeeds, we can resume our prior activities. For such reasons, it is putting the cart before the horse to begin with parts, because the problem is how to determine the parts and their meaning in the first place. The parts cannot determine themselves; if they could, the problematic situation would not have arisen. (Dewey, 1929b; 1938)

Purpose acts as a filter. It enables us to select and attend to significant data (with regard to it) and ignore insignificant data (with regard to it). Without purpose, all data is equally significant or insignificant. We would have no rational basis to attend to something rather than everything else, or to ignore something rather than everything else. Then either our activity would be blind groping or we would be flooded by a massive amount of insignificant data. In the former case, success is accidental—though it can turn out to be serendipitous in future activities. Hence trial and error is not the opposite of method but the most basic method.⁵³ In the latter case, we simply could not cope with the situation.

As concerns trial and error, more developed methods are continuous with it because they are experimental. We cannot possibly know in advance how to deal with the subject matter; otherwise there would not be a problematic situation in the first place. Therefore we must experiment with method simultaneously as we

⁵² See subsection 'The genesis of meaning' above.

⁵³ Dewey (1916a, pp. 169–170) goes as far as to claim that *all* experience involves trial and error. The success of that method depends on circumstances and thus is generally ineffective. But eventually it will lead to rudimentary knowledge about causal relations. That will enable a higher-order control of conditions and thus refines the most basic method. That will lead to further discoveries. Then they can be used to refine the method even more, and so on.

experiment with subject matter. Because of the experimental nature of method, *a priori* rules cannot be laid down for inquiry: the subject matter of inquiry determines what method will turn out best. Methods cannot be determined once and for all; they develop as inquirers (not necessarily scientists) invent better ways of reaching their ends-in-view.⁵⁴ This process is radically unpredictable. Dewey (1916a, p. 194) defines *method* operationally as “the arrangement of subject matter which makes it most effective in use,” and *efficiency* as utilization of material with minimum waste of time and energy. For such reasons, method cannot be abstracted from its subject matter. In this sense, there is a “unity” of subject matter and method: subject matter cannot be distinguished from method except formally and nominally, because in the process of experience, what an individual does and what the environment does are united (Dewey, 1916a, p. 195). Method must be adapted to each subject matter separately. Generalizations are often possible, but whether a given generalization holds for a given case must be tried out first. Hence method does not signify an independent, ready-made procedure to be followed to the letter. Such rejection of the *a priori* methodology implies *methodological pluralism*.⁵⁵

What attracts our attention is not necessarily significant for maintaining the ongoing course of action. Bright colors or loud voices might capture our attention but do not necessarily signify anything relevant for the purpose at hand. In order to discard the irrelevant, a prior habit is needed.

The effect of the observer upon the object

In this subsection, I will explain why the very possibility of experience alters the object to be experienced at least potentially. I will cite some results of experimental physics. Somebody might object that my account is a platitude, at least for anybody moderately well versed in physics. I grant that; it *is* indeed a platitude, at least for such people. However, *some* account is needed for making a case for cybernetic epistemology because, to my knowledge, mainstream analytic epistemology has not provided one; and not all analytic philosophers know physics.

The experience of an object is possible only if an agent or a measurement device is present in its vicinity. According to physics, their mere presence already

⁵⁴ See fn 26.

⁵⁵ Dewey (1916a, pp. 193–197, 211) made these points specifically with regard to the method of *formal education*, but I believe that they can be generalized to *any* kind of learning, including science: Dewey himself argued that formal education is relatively superficial; *nature and society themselves educate us* informally and more deeply (1916a, pp. 4–7).

has effects upon the object: for instance, a gravitational effect (the agent or the measurement device and the object attract each other at any distance), a thermodynamic effect (the agent or the measurement device and the object exchange heat at any distance), and a quantum mechanical effect (the wave functions of the agent or the measurement device and the object might interact at any distance). The effect increases when distance decreases.

Even if experience is restricted to mere sensation, it presupposes causal signals from the environment. The production and propagation of these signals effects changes, however minute, in the environment. Vision implies light; hearing implies sound; touch implies friction; and smell and taste imply the emission of aromatic particles. When light or sound is produced by or reflected from a body, the heat of the body changes, and its shape and texture can change too. Exposure to light can function as a catalyst in certain chemical reactions. It can change the color of certain surfaces. It can also make certain materials more fragile. In the case of very loud sounds, the possibility of disfigurement seems obvious: for example, an earthquake or the blast wave of an explosion.

Thus Kuusinen (1959, pp. 92, 100) is correct in claiming that objects manifest their properties when they change. A completely inert object that does not emit causal signals cannot possibly be present to sense; and by the conservation laws of physics and Newton's laws of motion, the very emission of a causal signal necessarily changes the object that emits it.

If nothing else, then at least Heisenberg's *principle of indeterminacy* undermines the spectator theory of knowledge. If the very act of measurement necessarily introduces a change to the quantity to be measured, the object of knowledge cannot be independent of the agent. (Cf. Dewey, 1929b, pp. 201–203)

Cognitive science has increased our knowledge about observation. According to Noë (2004), observation involves action at least potentially because it presupposes and is learned by rehearsing certain sensorimotor skills. Thus Määttänen (2009; 2015) explains that the object of experience does not consist primarily in entities or facts but in *opportunities for action*, or the relation between observations and action. Gibson (1979) has called such opportunities “affordances.” Määttänen describes the pragmatist notion of experience thus:

Human beings are embodied creatures, which are in constant interaction with other elements in the world. The world is experienced as possibilities of action. The hidden causes of perception are not the object of knowledge. The

structure of experience and the proper object of knowledge can be expressed with the simple scheme: $S_1 \rightarrow O \rightarrow S_2$. The situation S_1 is problematic, and some operations O have to be performed in order to attain the situation S_2 . The latter situation is hidden at first, but not in principle. The object of knowledge is the relation between these situations, and this relation is mediated by controlled activity, certain operations. To know is to know what to do in the situations one encounters in the world. This object of knowledge is within our epistemic access, and there is no need to contrast it with something “more real” beyond the scope of our epistemic access. (Määttänen, 2015, p. ix)

Thus it seems that even observation must be relinquished from the spectator theory of knowledge: even if the agent or the measurement device appears to be doing nothing overtly, their interaction with the object to be experienced is already bidirectional at least potentially.

Experience as experimentation

In this subsection, I will explain the operationalized epistemology of experiment.

Recall Peirce’s operational definitions of *belief* and *doubt*.⁵⁶ They imply a *belief–doubt model of inquiry*. It is common to both everyday and scientific experience. It has four stages, and it can be iterated. (1) We begin with whatever beliefs (habits) we already have. We cannot possibly begin with universal doubt, as Descartes requires, because doubt requires positive grounds in order to be meaningful; it simply does not occur to us to doubt a large amount of prior cognition; and, according to Lakoff and Johnson (1999, p. 5), a significant amount of prior cognition is completely indubitable for us—not because it is certain, but because we are unable to doubt it for neurophysiological reasons. (Cf. Peirce CP 5.265, 5.376, 5.416; EP 1, 28–29, 115; EP 2, 336) Any belief (habit) is a means to an end (Dewey, 1916, pp. 54–58; 1922, pp. 14ff): it has been established to fulfill a purpose. It does not make sense to doubt our already established habits as long as they fulfill their purposes. Hence they are *prima facie* justified. (2) This justification is lost, if habitual action fails. That is a positive ground for doubt.⁵⁷ (3) Failure prompts an inquiry, the purpose of which is the establishment of a new belief (habit). (4) Inquiry terminates when a new belief (habit) has been formed (Peirce CP 5.374–376; EP 1, 114–115). Then we can repeat (1).

⁵⁶ See subsection ‘Operational definitions’ above.

⁵⁷ See fn 25.

The third stage can be subdivided. (a) The establishment of a new habit begins with introducing a new hypothesis that accommodates some possible reason for the failure that occasioned the inquiry. This stage is called *abduction*.⁵⁸ (b) The second stage consists in the application of the pragmatic maxim:⁵⁹ the inquirer derives the potential practical effects of the hypothesis. This stage is called *deduction*. (c) The last stage consists in the experimental testing of the hypothesis: the inquirer checks, whether the practical effects of the hypothesis obtain or not. This stage is called *induction*. (Peirce CP 2.619–464, 5.161–174, 6.469–473; EP 1, 186–199; EP 2, 212–218, 287–288, 440–442.) Induction consists in experimentation and fieldwork (e.g., Peirce CP 5.145, 5.168, 5.170, 5.197, 5.579–584, 7.206, 7.218; EP 2, 45–48, 96–97, 106, 205, 216, 225, 234–235, 288); and abductive research is experimental (Peirce CP 5.581; EP 2, 46). This subdivision can be iterated, too—until a hypothesis that resolves the problematic situation is found.

Dewey (1933 [1910], pp. 100–101) adds that the conclusion of an inference is not the conclusion of the inquiry. Logic is not self-sufficient; rather, it is part of experimentation. Inquiry concludes when the problematic situation is resolved. To do that, not only intellectual but also bodily effort must be expended to transform conditions. That a “solution” “exists” in theory is only a part of the solution; somebody must also *enact* it in practice.

This model dispenses with both epistemic foundations and ends. We need not begin with a self-justifying set of beliefs. To be sure, *it does not matter at all where we begin*. Justification arises not from being derivable from individual beliefs but from the *process* of self-correction. (Peirce CP 5.416; EP 2, 336) In a sense, *learning trumps believing*. Simultaneously, there need not be a final set of truths to converge to. Like biological evolution, learning is adaptation to circumstances, and they may change drastically. Even if something remained eternally the same, we do not possess the criterion of an incorrigible truth. Hence inquiry must continue indefinitely—even when it has accidentally stumbled upon a permanent truth. One could adapt Eduard Bernstein’s (1899, p. 169) political slogan “the movement is everything, and the final goal is nothing” to epistemology.

⁵⁸ Peirce sometimes uses the near-equivalent term *retroduction*.

⁵⁹ See subsection ‘The pragmatic maxim’ above.

Fallibilism and the belief–doubt model of inquiry together make Peirce an *epistemological infinitist*⁶⁰ like Klein (e.g., 1999; 2003a; b; 2004; 2005a; b; 2007) and a few others, though in a different sense than Klein believes himself (see his 1999, pp. 306, 320n32). Inquiry is condemned to go on and postpone final judgment about truth indefinitely (Short, 2007, p. 331). Because belief must *not* be fixed, anything can be called to question at any time, if an occasion arises. Because anything can have meaning and therefore be a sign, everything can be interpreted; and because every interpretation can be reinterpreted, there does not seem to be room for justification which could forever remain unchallenged. Hence *justification can go on indefinitely long*.

Categories

Peirce devised a system of three categories: *firstness*, *secondness*, and *thirdness*. He derived them by several means. I will cite his phenomenological derivation because everybody can do that for themselves, at least in principle, because each category is present in everyday experience. If phenomenology is the science that studies experience *qua* experience,⁶¹ by Dewey's definition, it studies *modes of organism–environment interaction*. As I have explained,⁶² such interaction cuts across the subject–object dichotomy. That defuses the possible objection that phenomenology be essentially “subjectivistic.”⁶³ Peirce argues that all three categories are real—that is, mind-independent—, for instance, in the 1903 *Harvard Lectures on Pragmatism* (CP 1.314–316, 5.14–81, 5.88–212, 5.77n; EP 2, 133–241).⁶⁴

The central insight in Peirce's phenomenological derivation is the application of Augustus de Morgan's (1806–1871) logic of relations to experience (Peirce CP 1.562; EP 2, 425–426). This allowed Peirce to define simple concepts which would have been inexplicable and unanalyzable in syllogistic logic without relations (cf. Peirce CP 5.177, 5.207; EP 2, 219, 221, 239). Such advances in logic dispensed with references to intuition, to which nineteenth-century neo-Kantians and neo-Hegelians resorted.

⁶⁰ *Epistemological infinitism* is the doctrine that *the justification of a belief consists in a potentially infinite number of stages*. Arguably, it is a version of Pyrrhonic skepticism. For an admirably consistent account on Pyrrhonism, see Sextus Empiricus (1933).

⁶¹ The very term *phenomenology* is derived from φαίνόμενον: “what appears” and λόγος: “field of study.”

⁶² See ‘Introduction’ and subsection ‘Habit and practice’ above.

⁶³ See also Ihde (2012 [1977], pp. 10–13).

⁶⁴ See also Peirce's ‘A guess at the riddle’ (CP 1.1–2, 1.354–368, 1.373–375, 1.379–383, 1.385–416; EP 1, 245–279), *the Monist* ‘Metaphysical series’ (CP 6.7–65, 6.102–163, 6.238–271, 6.287–317; EP 1, 285–371), and ‘Immortality in the light of synechism’ (CP 7.565–578; EP 2, 1–3).

The prosaic names of the categories refer to the arity of the relations that compose each category: what is expressible by a unary relation (monadic predicate), falls under firstness; by a binary relation (dyadic predicate), under secondness; and by a tertiary relation (triadic predicate), under thirdness.

Unary relations (monadic predicates) express “the Idea of that which is such as it is regardless of anything else.” In phenomenology, “qualities of feeling” fall under this description. (E.g., Peirce CP 5.66; EP 2, 160) Firstness is the category of chance.

Binary relations (dyadic predicates) express “the Idea of that which is such as it is as being Second to some First, regardless of anything else and in particular regardless of any law, although it may conform to a law.” In phenomenology, the co-occurrence of effort and resistance falls under this description. (Peirce CP 5.66; EP 2, 160) Secondness is the category of efficient causation.

Tertiary relations (triadic predicates) express “the Idea of that which is such as it is as being a Third, or Medium, between a Second and its First.” (Peirce CP 5.66; EP 2, 160) In phenomenology, the establishment of habit falls under this description. Thirdness is by far Peirce’s favorite category. It is the category not only of habit-taking but also of mind, reason, universals, law, continuity, mediation, signification and evolution. Thanks to thirdness, nature is knowable. A thing is known by subsuming it under a universal. Particulars can be known insofar as they manifest regularity.⁶⁵ Irregularities and idiosyncrasies can be real and can be directly experienced, but they remain unknowable.

De Waal (2001, p. 10) summarizes Peirce’s derivation of categories as follows. Anything that can be distinctly thought about involves some *thing* positively, thus involving firstness. But being distinctly what it is, it is different from everything else. This negation introduces secondness. But opposition implies a medium: opposites must be opposed *in some certain respect* (possibly everything) for their mutual opposition to make sense. Hence the opposites have something in common. That brings in thirdness: a shared medium. Therefore, in order to think about anything articulately, it seems that all three categories are necessarily present. However, de Waal does not cite where this derivation can be found in primary literature.

Peirce’s system of categories is holistic: each category makes sense only with

⁶⁵ I thank Kirsi Liikkanen for asking whether and how particulars can be known in pragmatist epistemology.

reference to the other two. Without chance variations (firstness), and without brute contact to mind-independent facts (secondness), the establishment of habits (thirdness) would be impossible: there would be no room for deviation from already established law, and there would be nothing to adapt to. *Per impossibile*, even if thirdness could be real independently of the two other categories, it would be completely arbitrary: there would be no *reason* why lawlike phenomena occur in a certain way and not others. Firstnesses and secondnesses provide direct access to the world. But they cannot be understood save by a higher-order thirdness. Ideas (thirdnesses) cannot be communicated unless incorporated in a physical medium (secondness) (Peirce EP 2, 326). Likewise, chance (firstness) cannot have effects without its being causally connected (secondness).

The categories do not reduce to each other. It is logically impossible to analyze a dyadic predicate into monads, and to analyze a triadic predicate into monads or dyads or their combinations.

On the other hand, Peirce (EP 2, 267) claimed—without proof—that all quaternary (fourthnesses, quartanenesses) and higher relations can be analyzed into triads. Peirce did, however, sketch a proof on the analogy of the forking of roads: one fork in a road connects three objects, and by adding more forks to a road, a relation between any number of objects can be constructed (CP 1.363, 1.371; EP 1, 251–252; EP 2, 364). Burch (1991) has suggested a rigorous proof.

If *nature* is defined in Kantian terms as the *object of experience*, then nature includes all three categories. Hence mind—thirdness—is not distinct from nature but, rather, part of it.⁶⁶

Kant (1956 [1781/7]) considered categories *a priori*, necessary, categorical, and infallible. Peirce, on the contrary, considered them *a posteriori*, contingent, hypothetical and fallible (Rosenthal, 1997; cf. Peirce CP 1.301).

Universals, sign-relations, habits and laws are analogous. A universal determines not only a class of actual particulars but also potential particulars. Potential particulars can differ in an uncountably infinite number of ways: all possible variations constitute a continuum.⁶⁷ Hence no enumeration of particulars can exhaust a universal—unlike what William Ockham believed (cf. Kenny, 2007 [2005], pp. 143–150). Likewise, a sign-relation determines actual and potential

⁶⁶ Thus Dewey (1916a, pp. 39, 54–58, 62, 263–264, 319, 323, 400) argued that reason cannot possibly be distinct from experience, because it operates upon habit—a species of Peirce's thirdness.

⁶⁷ This, among other things, makes thirdness the category of continuity.

interpretants;⁶⁸ a habit determines actual and potential actions; and a law determines actual and potential events.⁶⁹

Against Locke, Peirce derived mind from signs, not *vice versa* (see, e.g., Skagestad, 2004). By the previous analogy, Peirce called the ensemble of all thirdnesses *mind*. That makes him an objective idealist in an emphatically anti-Cartesian sense of “mind.” But Peirce was a naturalist by the same token. Secondness constitutes causal events; and thirdness, or “mind,” constitutes what makes them conform to laws. Thirdnesses can be present to experience. No extra- or supernatural entities are presupposed. Hence it is just to conclude that objective idealism is part, but not the whole, of Peirce’s impeccably naturalist cosmology.

The concept of invariance

I adopt Kaila’s (1939; 2014) thesis that *invariances* are the “objective of knowledge” and modify it for my purposes. He distinguished between *substantial* and *relational* invariances. The former were the objective of Aristotelianism; the latter, that of Galileanism.

The notion of substantial invariance tries to account for the permanence of a substrate (ὑποκείμενον) when the world appears to change. Aristotle argued that a substance is a union of matter (ὕλη) and form (μορφή). He postulated that it has an unobservable, immutable essence (οὐσία) which remains undisturbed when its observable accidents (συμβεβηκοί) change.⁷⁰ Modern science has rejected essentialism and the involved notion of substantial invariance.

The notion of relational invariance tries to capture the permanence of mathematical laws of nature: the world appears to be in constant movement, but all changes are governed by unobservable, immutable mathematical (formal) laws. In order to discover these laws, one must use the “resolutive,” or “analytic,” method: one must infer to the best explanation (Lipton, 2004 [1991]; Niiniluoto, 2018) and work backwards from effects to their causes. Some caution is needed: it seems implausible to deny reality from natural laws; but they are not the only reality, as one can see from Peirce’s categories.

I will revise both notions of invariance slightly. Invariances are universals almost by definition: staying the same when conditions change could qualify as a first

⁶⁸ See fn 42.

⁶⁹ Peirce’s understanding of the analogy between habit and law was comprehensive; sometimes he called laws “habitudes of nature” (e.g., Peirce CP 5.587; EP 2, 53; cf. Määttänen, 2015, p. 34).

⁷⁰ See Arist. *De Gen. et Corr.*; *Phys.*; *Met.*; *Catg.*

approximation of the definition of *universal*. Now, as I have explained, universals fall under thirdness.⁷¹ But I have also explained that thirdness can be present to experience.⁷² Hence invariances cannot be purely formal and abstract: they also incorporate something “material” and “concrete” in a broad sense of the terms, which might be better described as “content.” I will flesh out the “content” of relational invariances in the following section. My method relies on the intimate analogy between universals, laws and habits.⁷³ Moreover, thirdnesses can evolve and are adaptable to secondnesses. Hence, if invariances are thirdnesses, they are not absolute but approximate and relative at least potentially.

Knowledge as practice

In this section, I will derive an operational definition for *knowledge* in order to make the criterion of its attribution public, show how it is connected to Kaila’s notion of *invariance* and Wiener’s cybernetics and briefly show how the results suggest process ontology.

The criterion of the attribution of knowledge

I have argued that the criterion of the attribution of psychological predicates is *behavior*, including speech acts.⁷⁴ Here I will apply this result to the concept of knowledge.

If knowledge is justified true (un-Gettiered) belief, if belief is “subjective,” and if what is “subjective” is private, then it is impossible to attribute knowledge to a person—except perhaps if the person attributes knowledge to themselves; but even then nobody else could understand what they are talking about. The concept of knowledge would have no use whatsoever because it would be impossible to determine a public criterion for its attribution.

Hence, in order to attribute knowledge to a person, that person must behave in a certain way, including speech acts. That can be understood in two senses: in a strong sense and a weak one. In the strong sense, the attributee must

⁷¹ See subsection ‘Categories’ above.

⁷² See subsection ‘Categories’ above.

⁷³ Henning (1998) has understood the affinity between the concept of invariance and Peirce’s third category. He applies these concepts in the philosophy of education.

⁷⁴ See subsection ‘Operational definitions’ above, Bennett and Hacker (2003, ch. 4) and Lindholm (2021b, pp. 4–5, 4n17).

show how they skillfully handle the object of their alleged knowledge, possibly including a verbal description of what they do. Its empirically determinable criterion is *success or failure*. Thus knowing in the strong sense implies *continual experimentation with subject matter in varying conditions*. In the weak sense, an adequate description, as in a school exam, is sufficient, perhaps with a reference to a reliable source. The weak sense depends on the strong sense: one cannot make adequate descriptions without somebody skillfully handling its subject matter, because *the latter is the criterion of the former*. Hence *knowledge in the strong sense is practice*; and knowledge in the weak sense ultimately refers to such practice. Theory is ultimately derived from practice, not *vice versa*. (Cf. Lindholm, 2021b, pp. 4–5, 4n17; Dewey, 1916a, p. 169)

Peirce explicitly identified knowledge with habit—though, to my knowledge, only once and only as if in passing (CP 4.531). My argument seems to justify this claim.

Dewey argues that knowledge is a “kind of action” in his *The Quest for Certainty* (1929b, pp. 83–88, 102–103, 167, 193). I have argued that if actions come in kinds, then these kinds must be *habits (practices)* (Lindholm, 2021b, p. 7).

Dewey maintains that science is art and that art is practice in his *Experience and Nature* (1929a [1925], ch. IX). I have defended this claim in Lindholm (2021b). I will add here that if knowledge is practice (as I have been arguing), if science is the perfection of knowledge, and if art is the perfection of practice, then it seems to follow that science is art.

Dewey summarized that we know a phenomenon when we are able to produce, sustain, and terminate it at will (1929a [1925], p. 428).⁷⁵ Thus his account is a version of *maker's knowledge*—a notion that recurs in the history of philosophy (Hintikka, 1969, pp. 19–34).

⁷⁵ Cf. Marx (MEW 3, p. 7), Engels (MEW 21, pp. 276–277), Kuusinen (1959, pp. 98–99, 111) and Hacking (2010 [1983], pp. 22–24).

Practice in cybernetic terms

I suggest that the pragmatist notion of *habit* and Rouse's notion of *practice* can be defined with reference to rigorous cybernetic concepts. I will not explicitly use the mathematics of cybernetics here; I confine myself to briefly describing the philosophical import of cybernetic concepts.⁷⁶

I suggested a definition of *habit (practice)* as an (*approximately and relatively invariant pattern of potential organism–environment interaction*).⁷⁷ In cybernetic terms, that is already concrete and practical enough: patterns of the exchange of causal signals in space and time between an organism and its environment can be empirically studied with pattern recognition methods. The development of computer science and technology has already made them feasible in the past decades. To my knowledge, pattern recognition techniques are usually akin to *observation* or *measurement* in their traditional senses and hence operate within the paradigm of unidirectional experience. But I am not aware of any reason that would make it impossible to generalize these techniques to the bidirectional paradigm, that would make them akin to *experiment*, or that would enable an agent or a software to interact with an object and simultaneously to recognize patterns in this interaction of which they themselves are part.

By the previous considerations, it seems to me that *habit (practice)* can also be defined as a *stable state of organism–environment interaction*—that is, as a *dynamical equilibrium*. This definition is closer to the basic idea of cybernetics: control, or the autonomous guidance of a system to its desired state or trajectory. *Stability* simply means that deviations from the desired state or trajectory remain within certain acceptable bounds. *Autonomy* means that the system maintains its stability without relying on external input.⁷⁸

Now, the organism is *internal* to the cybernetic system: in the case of science, the scientists, their skills and their instruments are themselves part of the phenomenon they are studying (cf. Barad, 1996; Rouse, 2002, ch. 8). Hence *autonomy* does *not* mean that nothing needs to be done. On the contrary,

⁷⁶ A reader interested in the mathematics of cybernetics may consult, besides Wiener (1948), an introduction to analog control by Dorf and Bishop (2017), an introduction to digital control by Åström and Wittenmark (2013) an introduction to system identification by Johansson (1993), an introduction to dynamic optimization by Kirk (1970), an introduction to estimation and sensor fusion methods by Bar-Shalom, Li and Kirubarajan (2001), an introduction to advanced control methods by Glad and Ljung (2014), and introductions to adaptive control by Sastry and Bodson (1989), and Åström and Wittenmark (1995).

⁷⁷ See subsection 'Habit and practice' above.

⁷⁸ I thank Heikki Hyötyniemi for inspiring me to develop this notion.

often the stability of the system depends crucially on what the organism does. *Autonomy* does not mean the internal autonomy of the *object* but the external autonomy of the *system* constituted by the agent and their environment. *That* is a matter of *skill*—of *habit* (*practice*).⁷⁹

Process epistemology and process ontology

According to Peirce, *thirdnesses evolve* at least potentially. By the virtue of possible chance variations (firstness), law (thirdness) can readapt to changing conditions (secondness). Now, knowledge, as universal, or as an approximate and relative invariance, falls under thirdness. This suggests *moderate historicism*: knowledge is universal, but the understanding of universals can change historically according to the conditions to which they have been adapted. Peirce's *synechism*⁸⁰ forbids radical ruptures, but gradual, continuous change of universals is possible: present universals are spatially and temporally continuous with their prior instances.

William James (1842–1910), Peirce's colleague and friend and co-founder of pragmatism, even seems to have suggested the mutability of truth (1916 [1907], pp. 27, 222–226, 241, 246–249, 255–258; 1909, pp. 59, 68–69, 80, 96–97, 155–160, 158n1). This controversial position has received a lot of criticism, of which much may be based on misunderstanding; but some misunderstandings might result from James's prose itself due to its lack of rigor.

The moderate historicity of knowledge provides room for *process ontology*: because knowledge can change, we cannot be certain that the objects of knowledge themselves be invariant. That cannot be determined by an *a priori* metaphysical fiat. Hence we cannot be certain about object ontology. We cannot determine what *is*; we can only determine what *happens*. The skillful stabilization of organism–environment interaction allows things to appear as stationary states of interaction. These stationary states are what we usually call 'objects.' Thus, object ontology must be generalized in order to take the possible variation of objects into account: the proper "objects" of knowledge are not objects in their everyday sense (bounded, determinate things) but *events*: the sustained occurrence of a phenomenon within a time interval, the relevant length of which depends on context. In a geological scale, a mountain range is an event (Dewey, 1929a

⁷⁹ Recall that habit (practice) does not presuppose mind or consciousness; see subsection 'Habit and practice' above.

⁸⁰ *Synechism* (from συνεχής 'continuous') is the doctrine of continuity. For an account on synechism, see Peirce (e.g., CP 1.1–2, 1.354–368, 1.373–375, 1.379–416, 6.7–65, 6.102–163, 6.238–271, 6.287–317, 7.565–578; EP 1, 242–371; EP 2, 1–3).

[1925], pp. 70–71; 1929b, p. 128; 1938, pp. 222–223, 248–249); and in an astronomical scale, the Milky Way is an event. Peirce’s *evolutionary cosmology*⁸¹ suggests that even laws are events in a broad sense because they evolve at least potentially, though the time scale can be immense.⁸²

By such considerations, it seems to me that once one adopts Dewey’s bidirectional notion of *experience*, Peirce’s theory of categories and Bennett and Hacker’s claim that the criterion of the attribution of psychological predicates is behavior, the possibility of process ontology seems to follow deductively. I believe that process ontology can be derived from physics alone: the conservation laws and Newton’s laws of motion seem to imply that every “object” develops.

The classical pragmatists are not, of course, the only, or even the first, who have (implicitly or explicitly) discovered the processual nature of things. Siddhartha Gautama seems to have entertained a process ontology more than two millennia ago (Laumakis, 2008, pp. 13–14, chs. 6–7; Edelglass & Garfield, 2009). Heraclitus’s notoriously difficult aphorisms arguably involve a process philosophy (cf. Plat. *Crat.*, 401d, 402a, 439d; Diogenes Laërtius, 1905, pp. 376–382; Diels & Kranz, 1960, 22A, 22B). I believe that Aristotle’s physics and metaphysics (*De Gen. et Corr.*; *Phys.* & *Met.*), with their description of the generation and corruption of substances and their doctrine of the eternity of movement, can be arguably read as a process ontology, though he does posit immutable essences. Schelling’s (1803 [1797]; 1800) and Hegel’s (1970 [1807]; 1969a [1812–1813]; 1969b [1816]) absolute idealisms seem to be versions of process ontology. A. N. Whitehead (1978 [1929]) influentially developed process ontology on a scientific basis. Process ontology is also part of Marxism,⁸³ or at least Soviet Marxism (Kuusinen, 1959, pp. 24–25).

⁸¹ See Peirce (CP 1.1–2, 1.354–368, 1.373–375, 1.379–416, 6.7–65, 6.102–163, 6.238–271, 6.287–317; EP 1, 242–371).

⁸² Kilpinen (2009) has insightfully discussed the involvement of classical pragmatism in process ontology and its consequences in epistemology and philosophy of action.

⁸³ I have not (yet) found explicit process ontology in Marx and Engels’s works, but Marx’s *Grundrisse* (MEW 42) seems to implicitly involve one.

Criticism

I have used the term “interaction” many times. That deserves some criticism. *Intra-action* is a pivotal concept upon which Rouse’s (2002) argumentation turns. He has adopted the term from Karen Barad (1996). She has criticized the commonly used term “interaction” for presupposing that the relevant actants be definitely bounded systems independent of their interaction. She proposed the neologism in order to avoid such connotations and to express how the actants become definite only through their mutual dynamic relations. (Rouse, 2002, p. 147n9) Such notion seems to describe better what I have said.

I have overlooked certain differences between Peirce and Dewey. That is another possible target of criticism. For instance, they might understand the pivotal concept of *habit* differently.⁸⁴ To my knowledge, that does not threaten my argumentation, but I may be mistaken.

I have said that the classical definition of *knowledge—true justified belief* (Plat. *Meno*, 97d–98a; *Theaet.*)—seems inaccurate for experimentation: it says nothing about action and its results. But if an operational analysis is performed on the classical definition, that is, if the pragmatic maxim is applied to the concepts of “true,” “justified” and “belief,”⁸⁵ one might be able to derive the thesis that knowledge is practice also from the classical definition. I will leave this possibility for future research.

Conclusion

I began with the paradoxical observation that analytic epistemologists seem to consider experiment the best method of acquiring knowledge but simultaneously seem to ignore it. They tend to restrict experience to observation, which is a unidirectional notion. I have suggested one way to account for experiment in epistemology. I have cited Dewey’s thesis that all experience is experimental because it consists in bidirectional organism–environment interaction. Because of its bidirectionality, it involves a feedback, making experience a cybernetic process; hence the title ‘Cybernetic epistemology.’ That notion accommodates the disconcerting fact that the organism affects the object of experience at least

⁸⁴ Cf. West and Anderson (2016) and Dewey (1916a, pp. 54–58; 1922, pp. 14ff).

⁸⁵ I have cited Peirce’s definition that *belief is habit*; see subsection ‘Operational definitions’ above.

potentially, which might impair the possibility of acquiring knowledge about the object, even when the organism appears to be doing nothing overtly. Thus, *whatever we do constitutes an experiment*. All our beliefs are at test all the time. The epistemic problem is how to *control* such experiment so that it yields reliable knowledge rather than accidental artifacts. That is a matter of *skill*. Epistemology becomes technics.

But experiment is not only what we do in fact; I have also shown in detail why it is generally reliable—though by no means infallible. Thus, I have also justified the widespread trust in experiment. The reliability of experiment is based on *skill* of manipulating conditions and thereby solving problematic situations. I have conceptualized skill as *habit* or, alternatively, as *practice*. Habit (practice) arises from discovering cause–effect relations. We discover causal relations by *doing* things, *undergoing* the results, and *correlating* our actions and the results. Our own input is necessary for being able to attend to relevant observations: effort is always selective, and without effort and its results, any observation would be as uninteresting as any other. In the simplest case, experiment consists in brute trial and error. This method succeeds only accidentally; but once it does succeed, we gain knowledge; and by applying it, we will be able to devise a more refined method. Still, in the final analysis, even the finest experiment remains trial and error to some degree, because positive certainty about the success of a proposed solution to a problematic situation is beyond our ken. When trying to construct a solution, we are simultaneously trying to discover a *method* to construct the solution. We have to invent and create. Such business is radically unpredictable. Hence success cannot be guaranteed—least of all *a priori*. We know a phenomenon if we are able to produce, sustain, and terminate it at will; but we can always fail, at least potentially. We know a phenomenon *only insofar as* we are able to do that.

Cybernetic epistemology is designed to be applicable *in medias res*. Organism–environment interaction must be understood holistically. Ongoing course of purposive action maintains the unity and coherence of the situation. The comprehensive whole that constitutes the domain of experience is potentially analyzable into parts. The determination of the parts requires that they have meaning, that this meaning is relevant for the ongoing course of action, and that the agent has already learned the skill of analysis from prior encounters with the given kind of situation. Analysis is necessary for the construction of a solution to a problematic situation: its purpose is to resolve the whole into its parts until each part has a unique meaning; then the parts that have a meaning that contribute to

the construction of the solution can be selected and rearranged, others ignored. Moreover, the agent is part of the situation they are in. They discover themselves reflexively by acting in the situation and observing the results. Hence we do not have to presuppose an already determinate agent. This notion dispenses with the problems associated with the Archimedean point in epistemology.

I have also suggested a way to define epistemological concepts with mathematical rigor. Organism–environment interaction consists in the exchange of causal signals between the organism and its environment. Habits (practices), or (approximately and relatively) invariant patterns in such exchange, can be recognized computationally. Moreover, the concepts of cybernetics and control engineering become applicable, if habits (practices) are understood as dynamical equilibria—that the trajectories of the exchanged signals do not deviate too much from their regular pattern.

My argumentation suggests an original defense of process ontology. If knowledge is an invariance, if invariances fall under Peirce’s third category, and if thirdnesses can evolve, then we cannot be certain about there being numerically identical and independently determinate “objects.” We can only determine *events*. Thus process epistemology seems to imply at least the possibility of process ontology.

I consider my argumentation a version of virtue epistemology in a broad sense: I believe that the *skill* of an organism that stabilizes its interaction with its environment so that definite objects can emerge from it qualifies as an *epistemic virtue*.

There has occurred a practical turn in philosophy of science. This movement began in the 70s and 80s in the sociology of scientific knowledge (SSK) and science and technology studies (STS). Its *primus motor* has often been dissatisfaction with the theory-driven and theoretical physics-centered concept of science in mainstream analytic philosophy of science.⁸⁶ The remoteness of philosophy of science from what scientists actually do has been considered problematic. Mainstream analytic philosophy of science tends to presuppose a representationalist epistemology and philosophy of language,⁸⁷ with or without argument. On the other hand,

⁸⁶ I follow Rouse (1996; 2002, ch. 4) and define *mainstream analytic philosophy of science* as the union of scientific realism (e.g., Popper, Putnam, Boyd, Niiniluoto, Psillos), instrumentalism (e.g., van Fraassen, Stanford), historical rationalism (e.g., Lakatos, Laudan), and social constructivism (e.g., Barnes, Bloor, Collins, Fuller, Pinch). See also Lindholm (2021b, 1n1).

⁸⁷ According to Rouse (1996), *representationalist epistemology* maintains that knowledge denotes a coherent kind (for instance, justified true (un-Gettiered) belief) and that this kind be independent of scientific practice.

the practical turn philosophers and sociologists consider science as *practice*. They have provided a large number of case studies about how knowledge is produced in practice. To my knowledge, their method is largely empirical: they prefer to make as few theoretical commitments as possible. The defect of this method is the implicitness of its justification.⁸⁸ I believe that what I have said in this article adds at least some of the missing theoretical depth and makes the justification of the empirical method more explicit.

I have relied on classical pragmatism and emphasized practice, but classical pragmatism is not the only praxis philosophy that seems to be able to provide such theoretical basis for the empirical method. Besides pragmatism, Marxism and certain variants of phenomenology, including the early Heidegger (1977a [1927]), the later Husserl (1976a [1936]; 1976b [1939]) and Merleau-Ponty (1967 [1942]; 2002 [1945]), qualify as praxis philosophies. Arguably, already the mechanistic philosophy of the 17th and 18th centuries was “practical” in the sense that it banished purpose from nature and thus allowed humans to impose their own purposes on nature, and hence to improve the human condition technologically. It seems too late for mechanistic philosophy, but there seems to be an opportunity for fruitful discussion between Marxism, pragmatism, and phenomenology.

Even some analytic philosophers have adopted the praxis point of view. The later Wittgenstein (2009 [1953]; 1969) comes strikingly close to pragmatism. Gilbert Ryle (1951 [1949]) distinguished between *know-how* and *knowing that* (propositional knowledge) and argued that the former is more basic. Moreover, Michael Polanyi, who might not wish to be called an analytic philosopher, coined the term *tacit knowledge* (1962 [1958]; 1983 [1966]).

One possible field of further inquiry is to determine whether and how the theory of *cellular automata*, developed by John von Neumann and others, and

⁸⁸ The practical turn philosophers and sociologists include Ihde (1974; 2012 [1977]; 1979; 1983; 1990; 1991; 1993a; b; 1998; 2002; 2009), Latour and Woolgar (1986 [1979]), Knorr-Cetina (1981; 1999), Cartwright (1983; 1989; 1994), Hacking (1983), Heelan (1983), Pickering (1984; 1989; 1992; 1995), Ackermann (1985), Shapin and Schaffer (1985), Franklin (1987), Galison (1987; 1997), Latour (1987; 1988 [1984]; 2000), Rouse (1987; 1996; 2002; 2015), Radder (1988; 1996), Traweek (1988), Gooding, Pinch, and Schaffer (1989), Gooding (1990), Rheinberger (1992; 1994; 1997), Kohler (1994), Buchwald (1995), Vihalemm (2001; 2011; 2012; 2013; 2015), Baird (2004), Boon (2004; 2006; 2008; 2009; 2011a; b; 2012a; b; 2015a; b; 2017a; b), Chang (2004; 2012), Giere (2006), Boon and Knuutila (2009), Mets and Kuusk (2009), Ankeny, Chang, Boumans, and Boon (2011), Knuutila and Boon (2011), Lõhkivi and Vihalemm (2012), Mets (2012; 2013; 2019), Currie (2018) and Lindholm (2021a; b; 2022; forthcoming). According to Rouse (1987, ch. 2), Kuhn (1996 [1962]) should be included; Kuhn’s criticism of philosophy of science has inspired much of the practical turn.

the theory of *self-organizing systems*, developed by Ilya Prigogine and others, bears on cybernetic epistemology.

I have intimated that Peirce's semiotics could be applied to Rouse's practical hermeneutics and Ihde's visualism. That is an obvious opportunity for future inquiry.

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