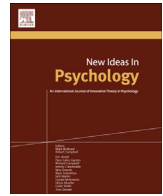Contents lists available at ScienceDirect

New Ideas in Psychology

journal homepage: www.elsevier.com/locate/newideapsych

How to operationalize a person

Mark H. Bickhard

Lehigh University, United States

A R T I C L E   I N F O

A B S T R A C T

The notion of operationally defining a person is absurd, but no more so than other uses of "operationalization". 'Persons' make that absurdity particularly clear because there is no sense in which persons can be directly observed, nor defined in terms of what might be observable, and thereby exposes the emptiness of the idea of operationalization more broadly.

On the other hand, persons can be modeled, and their ontology investigated, within frameworks that can address the processes and organizations that actually *constitute* persons.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

In the 19th century, physicists had to cope with how science could work with in-principle not-observable phenomena, such as electrical and magnetic fields. The rough answer is that they could investigate consequences that would follow if those postulated unobservable phenomena were real — they could test hypotheses that would follow from assuming the existence of the hypothesized phenomena, e.g., electrical and magnetic fields.

Psychology rejected the scientific investigation of unobservables for much of the first half of the 20th century — psychology was supposed to be the study only of (observable) behavior.[1] This stance unraveled with the advent of cognitive science (e.g., computer programs in the brain are not observable) but, nevertheless, under the spell of "operational definitionalism", psychology has still not developed a conception of science that can take unobservable

E-mail address: mark@bickhard.name.
URL: http://bickhard.ws/

[1] This is often thought to have been motivated by logical positivism, but it is arguably derived from Ernst Mach's positivism, more so than from logical positivism (Smith, 1986). The early logical positivists did try out a verifiability theory of meaning (Suppe, 1977), which is related to the Machian notion of meanings as data patterns, but also soon realized that there were serious problems with such empiricist attempts, including with the notion of operational definition (Hempel, 1965).

[2] Normative phenomena involve distinctions among which some are 'better' in some sense relative to others. If 'better' is determined by a (human) observer, then we have a *derivative* normativity — derivative from the human perspective — personal preferences, and so on. But some normative phenomena, arguably, are *intrinsically* normative: these might include issues of truth and falsity for representation, successful or unsuccessful for action, rational and irrational for reasoning, virtuous and non-virtuous for persons, and so on.

phenomena seriously in its models. Simply put, psychology — so I will argue — has no consensual way to take seriously the ontology(ies) of its own subject matter.

This point is most egregiously true for phenomena that do not directly fit into a causal, physical, factual world, such as normative phenomena.[2] Normative phenomena seem to be outside of the realm of science, even 'mystical' in some views. Among the most central of normative ontologies, of *psychological* ontologies, is that of *persons*, but the category of persons is widely ignored. Persons are the *loci* of acting, of perceiving, of knowing, of learning, of reasoning, of developing, of communicating, of meaning, of constituting social ontologies and processes, and so on — psychology is crippling itself by not recognizing the central ontology of its own subject matter. But persons are unobservable and normative — they cannot be operationalized. So, without a framework that makes sense of the roles of unobservables in science, persons will continue to be (generally) ignored.

Taking persons seriously, however, is quite possible: generate models of the ontologies of persons, and theoretically and empirically explore (the consequences of) those models. What could such a model look like? Here's one offered answer: human animals are complex agents, and agents with very complex possibilities. Among those possibilities is the developmental construction of special kinds of agents that can interact with and within, and thereby co-constitute, social realities. Socio-cultural-linguistic realities are a level of emergence beyond the level of animal agency, and so also is the developmental emergence of socio-cultural-linguistic agents — persons — that co-constitute those realities. Persons, then, are socio-cultural-linguistic kinds of agents that constructively and emergently develop from infancy through the life-span.

2. Operationalization

The notion of operational definition is a descendent of Ernst Mach's radical empiricism, in which he claimed that theoretical terms were just stand-ins for patterns of empirical data (Smith, 1986). The logical positivists adopted a similar strong empiricism in their verifiability theory of meaning — the meaning of a proposition is the means of empirically verifying that proposition (the data pattern) — and later, for terms, by Bridgeman, who introduced operational definitions. Such empiricist models of meaning were recognized to have failed many decades ago by philosophers of science (Suppe, 1977), but still dominate in psychology (Bickhard, 2011).[3]

The proposal for operational definitions fails as a general epistemology, but this is especially evident for phenomena that are unobservable. In the nineteenth century, physics confronted this problem with electric and magnetic fields. In the twentieth century, much of physics deals with realms of phenomena that are not observable, even in principle. For example, quark excitations in the chromodynamics field cannot even be isolated — singleton quarks cannot occur (Bickhard, 2001; Weinberg, 1996).[4]

Operational definitions make no sense, but that, of course, does not prevent physicists from developing and testing their theories: *consequences* of the theories are derived that can be tested and observed. Empirical data are crucial to such *testing*, but not as definitions of theoretical terms.

Psychology confronted similar problems with the demise of behaviorism: e.g., computer programs in the brain could not be "operationally defined" in terms of, for example, the reaction times used to test such computational models. But psychology has not learned the same lesson that physics did more than a century ago. Operational definitionalism has become an ideology of "science" for psychology and persists as such an ideology in spite of its basic incoherence.

Part of the reason why it can persist in the face of its failure is that the term has come to be used so loosely that an "operational definition" is no longer taken as "definitional" (most of the time). Instead, it has come to symbolize being careful and precise about methods of measurement, classification, and other methodological matters. Such precision is good practice, but it is not definitional. Nevertheless, operational definitions are still the primary means by which theoretical "definitions" are proposed; one still sees phrases such as "X is operationally defined in terms of such and such a test or procedure".

One serious consequence of such practice is that Psychology is backwards and naïve regarding how to work with genuine theory. Theory, and the metaphysical assumptions necessarily made in any theory, are off-limits within the empiricist framework that dominates, and even more so given the positivistic prejudice against metaphysics that psychology has inherited. To even ask questions in such realms is still regarded as a waste of time — and is derided as "arm-chair" philosophy. These positivistic background assumptions are not as strong as they were a few decades ago, but they have not disappeared, and, most importantly, there is no alternative framework for doing theoretical work that is on offer in most of contemporary Psychology.

3. Persons

If persons exist, and cannot be operationally defined, then what sort of existence is involved? The default assumption in Western thought is that anything that exists is either a substance or entity, or it is a property of a substance or entity (Campbell, 2015; Seibt, 2010).[5] But that default assumption has been progressively overturned in the history of science (Hull, 1974) and can be seriously misguiding when it is being presumed. If fire is a substance, for example, then phlogiston is the substance that is fire, and we would like to investigate its properties. But fire is not a substance, and investigating phlogiston was a direction of research whose basic metaphysical assumption was in error.

The case of phlogiston illustrates a general historical pattern: substance assumptions have been replaced by process models: phlogiston by combustion; heat by random kinetic energy; magnetic fluid by field processes; vital fluid by open self-organizing and self-reproducing systems; and so on. I have argued that this history is a manifestation of an underlying metaphysical point: there are no basic substances, entities, or particles. The world is constituted as process — quantum field processes, or something akin (Bickhard, 2009).

So, persons cannot be operationally defined (no more so than anything else), and it doesn't make sense to consider persons to be metaphysical substances or entities[6] (shades of Descartes). Could persons be some sort of process? I will outline such a model.

---

[3] A problem for a verificationist model that was recognized early in the history of logical positivism had to do with universally quantified sentences such as "all swans are white". In order to verify this, all past, present, and future swans would have to be examined, and that is not possible. With regard to terms, a problematic example would be "sugar is soluble". The intuitive meaning is something like: "If any piece of sugar were to be put into water, it would dissolve." But what if the sugar were never put into water? No satisfactory way to handle such counterfactual modalities was found. There were a number of revisions and patches to these models, both for propositions and for terms, but the underlying empiricism ultimately could not be made to work (Hempel, 1965; Suppe, 1977). Simply, meanings, whether of ordinary language or of scientific language, cannot be captured as patterns of data or observables.

[4] Quark excitations (plus gluon excitations) make up protons and neutrons. Single quarks cannot be isolated because attempting to pull such an excitation apart into isolation requires so much energy that new quarks (excitations) are created that form pairs or triplets of quarks — never singletons (Creutz, 1985; Riordan, 1992; Zee, 2003).

[5] Substances, entities, and their properties are commonly taken to be observable, at least in principle (though is "air" directly observable, or do we observe *consequences* of [flow of] air?). So such kinds of metaphysics lend themselves to an empiricism. But, for example, a computer program is something that can be *realized* in a computer, but it is not *observable* (though a print-out might be) — just as the numeral "3" is observable, but the *number* 3 is not. They are abstractions or relational phenomena.

[6] We use the word "entity" (or multiple equivalents) to refer to various 'things' in our world, and, in that sense, entities clearly exist — trees, rocks, candle flames, and so on. But the mistake is to take "entity" as a metaphysically basic category. A candle flame, for example, is an 'entity', but it is a very different kind of entity than a rock. A candle flame is a process of flow of oxygen, etc. into a self-maintaining region of high temperature containing wax volatiles from the wick, and the subsequent removal of combustion waste products. There is no substance base — even if molecules were taken to be basic entities, the flame is the *process of flow and change* among molecules: there is no set of molecules that constitutes the flame. (What if the candle is moved; is it still the same flame? The molecules involved have certainly changed.) A candle flame has multiple phase change boundaries — e.g., various colors in the flame — and *no* boundary at which it can be isolated (if isolated, the flame ceases to exist). A rock, in contrast, is not an open process, and has one phase change boundary (from solid to gas) at its surface. A rock also has a boundary at which it can be pushed (which happens to be co-extensive with the phase change boundary) and a(n also coextensive) boundary at which it can be isolated. The candle flame, in contrast, has no "pushable" boundary and no isolatable boundary. Nevertheless, the rock is also a process (thought not an open process): it is a process of quantum electromagnetic and chromodynamic fields that has a stability in a particular *organization* of process that constitutes the rock. That is, the rock *is* an organization of (not open) process, and the candle flame *is* an organization of (open) process (Bickhard, 2009; Campbell, 2015).

3.1. Process and emergence

Persons may be processes and not substances, but a recognition of process as the basic metaphysics does not suffice to model the ontology of persons. In particular, if persons are processes of some sort, then perhaps persons are merely epiphenomenal. Perhaps everything is just basic particle interactions and flows,[7] and nothing at any higher level of organization has any genuine causal power of its own.

If persons are to be genuine participants in the world, with consequences for how the world proceeds, then they must be *emergent* — there must be some "causal" consequences of persons beyond those of the basic particles that participate in those processes. But emergence is metaphysically problematic; if there is no emergence, then persons would seem to be at best not real actors on the world's stage — epiphenomenal. Can ontological emergence exist?

There are powerful arguments against emergence, but the strongest of them assume an underlying particle metaphysics (Bickhard, 2009, 2015; Campbell & Bickhard, 2011; Campbell, 2015). In such a metaphysics, process and configuration among basic particles may yield particular "causal" *regularities* of outcome, but, nevertheless, all causality is at the level of the particles. In brief, organization and configuration are *not* substances or entities, and so are not even *candidates* for having any causal power of their own, so long as we remain within a substance/particle framework (Bickhard, 2009, 2015; Campbell, 2015).

In a process metaphysics, however, processes are *intrinsically organized* — they do not merely *participate* in organization — and have whatever consequences they do in part due to those organizations.[8] In such a framework, organization cannot be delegitimized as a potential locus of causal power without eliminating causality from the world. Therefore, organization must be accepted as a possible locus of causal power, and (new) organization may yield resultant, perhaps emergent, causal power of its own. A process metaphysics, thus, is not only suggested by history, but it also yields the possibility of genuine metaphysical emergence.[9]

But is a process metaphysics correct? Process metaphysics may rescue emergence, but, if process metaphysics were all false or incoherent, then they would not help. Process metaphysics, however, are not false or incoherent; their status relative to particle metaphysics is the reverse.

First, a pure particle metaphysics cannot account for anything happening in the world: point particles have zero probability of ever hitting each other. Point particles have no way of attracting or repelling each other. The common idea of point particles that interact via *fields* already grants processes (fields are processes), and, therefore grants organization (of fields) as a potential locus of causal power.

Still further, according to our best physics, *there are no particles* (Aitchison, 1985; Cao, 1999; Clifton, 1996; Davies, 1984; Fraser, 2008; Halvorson & Clifton, 2002; Huggett, 2000; Hobson, 2013; Kuhlmann, Lyre, & Wayne, 2002; Sciama, 1991; Weinberg, 1977, 1995). What is left of the notion of a particle in quantum field theory is a quantization of interactions among oscillatory field processes. But this quantization is equivalent to the quantization (integer value) of the number of wavelengths in a guitar string, and there are no guitar sound particles (Bickhard, 2009; Zee, 2003).

Overall, then, it is a particle metaphysics that is false and incoherent.

3.2. Normative emergence

Metaphysical emergence, however, still does not suffice to provide a framework for modeling persons. Persons are constituted in multifarious ways by *normative* phenomena — e.g., action success and failure, rationality and irrationality, ethics and values, and so on. If these cannot be accounted for within an emergence model of persons, then the most basic characteristics of persons cannot be accounted for.

And there would seem to be special difficulties in accounting for any such normative emergence: Hume's "argument" in particular, that norms cannot be derived from facts, would seem to block any such account. I have argued, however, that Hume's claim involves a false presupposition, and is, therefore, unsound. I address the details of this argument against Hume elsewhere (Bickhard, 2009),[10] but, if it succeeds, then not only emergence, but potentially also normative emergence, is consistent with an underlying process metaphysics.[11]

3.3. Situation conventions

The metaphysical possibility of normative emergence provides the framework for modeling a kind of phenomena that is crucial for the emergence of persons: situation conventions.

One problem encountered in the evolution of agents is that of being able to indicate what actions and interactions are available in the moment, so that the agent can select among those indicated which to engage in. A frog, for example, may have a fly in one direction, another fly in another direction, and a worm straight ahead. The frog may select the worm to flick its tongue at because it is bigger.

The frog may also have an indication that, if it were to move left a bit, then another fly and two more worms would come into range. Such indications of interactive potentiality, then, can branch — several flies and worms — and can *conditionally iterate* — *if* the frog were to move, *then* further possibilities might become accessible.

In complex agents, such as human beings, such branching and iterating indications can form complex webs, indications of possibilities that may span the globe and extend for years. There may be, for example, among my web of anticipated possibilities, a region of trajectories that will bring me from some city in Europe to my home in the US.[12] Such webs of interactive indications constitute the agent's knowledge of the organization of interactive potentialities — it is called the organism's *situation knowledge*.[13]

Situation knowledge is always changing, with the passage of time, with activity on the part of the organism, and with other changes in the environment, perhaps by other agents. Situation knowledge, thus, must be continually maintained and updated. The process of such maintenance and updating is called *apperception* (Bickhard, 2009).

---

[7] Perhaps of quarks, gluons, and electrons.

[8] To a first approximation, 'organization' means organized in space and time, but space-time itself is a field, so the organizations are within and among multiple (quantum) fields.

[9] Note that most of our world did not exist 13 billion years ago, and it does now: it has to have emerged. So any theory or metaphysics that cannot account for such emergence — or, worse, makes such emergence impossible — is at least incomplete if not directly refuted.

[10] The basic claim is that Hume made assumptions about the nature of definition — e.g., definition of a normative term — that are not correct (Bickhard, 2009).

[11] See Bickhard (2009) for models of key normative emergent properties: those of normative function and normative (truth valued) representation.

[12] Or at least I *hope* that there is such a set of possible trajectories.

[13] Note that the indications involved in situation knowledge can be true or false: they have truth value, and, thus, constitute (emergent) representation. Complex situation knowledge constitutes an organism's representation of its interactive situation.

3.3.1. The problem of other agents

Consider now two or more complex agents in each other's presence.[14] Each attempts to apperceive the situation, including the interactive potentialities afforded by the other agent(s).[15] But each then requires an interactive characterization of the other, which, in turn, will depend on the other agent's characterization of the first agent, including that agent's characterization of the second, and so on. There is, then, a problem of potential regress involved in the interactive characterizations — characterizations with situation knowledges — of situations involving other complex agents: a regress of characterizations of characterizations. There is no solution to this problem unless some sort of fixed point of consistent characterizations among all participants is found or created — a relationship of interactive coherence among those participants.

Such a situation in which participants seek a characterization solution, but any solution requires coordinative coherence among those participants, constitutes a coordination problem in the sense of Schelling (1963), and, thus, a solution constitutes a convention in (roughly) the sense of Lewis (1969).[16]

Such a solution is called a *situation convention* — a convention about the interactive nature of the situation. Note that a situation convention is itself an *emergent* in the (coordinative) relationships among the respective situation knowledges of the participants.[17]

3.4. Language

Language is commonly understood to be constituted as re-encodings of mental contents into utterances (or written sentences). It proves to be impossible to integrate such a model with that of situation knowledge outlined above — situation knowledge as a web of interactive possibilities does not provide the (atomistic) common ground across persons for any socially common encoded meanings to be defined, or learned (Bickhard, 1980). In addition, such frameworks for understanding language involve their own inconsistencies and impossibilities (Bickhard, 1980, 2009).

An alternative that is consistent with the above model, and that avoids the fatal problems with standard encoding notions, is to understand that utterances are (human) interactions with the world, similar to (human) interactions with physical objects. The fundamental difference is that utterances are used to interact not with physical objects, but with situation conventions.

The apperception of smoke updates situation knowledge — it can yield anticipations of fire. The apperception of an utterance *also* updates situation knowledge: It alters the situation knowledge of the persons involved, and, if successful, does so in a way that generates a new, altered situation convention (Bickhard, 1980, 2009). So, for example, the calling of meeting to order changes a situation convention of (perhaps) multiple parallel local conversations into one of a formal meeting (perhaps even with Robert's Rules of Order), while an utterance of "I'm hungry" might shift a political discussion to one of where a good place to eat might be.[18]

One consequence of this is that the ontology of situation conventions, and, thus, of social ontology in general, is constituted in significant part (though not entirely) by potentialities for further language processes.[19]

3.5. And persons

Human beings are agents, but human infants are not agents that can co-constitutively participate in full social realities. Infants develop, and a major aspect of that development is the progressive construction of abilities to participate in more and more complex social realities, more and more complex situation conventions. This begins with, for example, simple turn-taking coordinations, comes to include language, and eventuates in abilities to participate in vast and complex institutional and interpersonal organizations and relationships.

That is, human infants develop as agents into an emergent *kind* of agent that can participate in, and thereby co-constitute, social realities of their family, society, and culture. Such development, then, is an emergence of a special kind of social agent — a *person*. Human infants, thus, are biological agents who have potentialities and tendencies to develop into socio-cultural persons. That openness to the developmental emergence of persons is a — perhaps the — central characteristic of the nature of what it is to be a human being (Berger & Luckmann, 1966). That *openness to developing* as a person is the initial social ontology of infants.[20]

The crucial point here is that it is quite possible to construct a model of the nature of persons. The overall model outlined may or may not be correct, but it is, arguably, metaphysically coherent, and it can be studied — it has testable consequences (Bickhard, 2013). The model, however, cannot be operationally defined: it can be tested via observable consequences, but it cannot be defined — 'person' cannot be defined — in terms of observables.[21]

4. Persons and psychology

It is quite possible, then, to study persons scientifically, but not via operational definitions. It requires, *like* physics, recognizing how to theorize and empirically investigate intrinsically unobservable phenomena — and, *unlike* physics, taking emergent normativities seriously.

Persons are at the center of what psychology studies; persons are the loci of psychological phenomena. Psychology needs to change its conceptions of science and the philosophy of science so that it can take that center into scientific account.

---

[14] Neither flies nor worms are sufficiently complex for this problem to emerge for frogs. And it is not clear that frogs are sufficiently complex for this problem to emerge even *among* frogs — though it is possible that some minimal version of it emerges for, for example, frog mating behaviors.

[15] The term "affordance" is used deliberately here. There are strong convergences of the intuitions behind Gibson's affordances and interactive indications, but also strong differences: e.g., Gibsonian affordances cannot form webs — cannot constitute complex situation knowledge.

[16] There are, however, some significant differences from Lewis's model (Bickhard, 2008, 2009).

[17] A situation convention is similar to, and partially derived from, the symbolic interactionist notion of a definition of a situation (Berger & Luckmann, 1966; McHugh, 1968). But the symbolic interactionist notion has at least two problems that I have attempted to remedy: 1) there is no model of the ontology of a definition of the situation, and 2) the term is used ambiguously between an individual level 'definition' (situation knowledge) and a social level (situation convention).

[18] How such a model can address, for example, phenomena of *productive* utterance construction is, of course, complex — productive utterance construction is intrinsically complex. See, e.g., Bickhard (1980, 2009).

[19] As we shall see, this means that the social ontology of persons is also in significant ways an ontology of languaging potentialities.

[20] Supported by various enabling scaffolds. The nature and purported innateness of such scaffolds are matters of investigation and dispute, but two such scaffolds seem to be infant attention to roughly facial forms, and to the prosody of 'infant directed' speech.

[21] No more than a computer program or the number 3. I should add, however, that, while a computer program illustrates a relational abstraction that is not itself observable, but nevertheless exists and is important in the world, I would not consider computer programs to be a good framework for modeling the ontology of minds or persons (Bickhard, 1996, 2009).

References

Aitchison, I. J. R. (1985). Nothing's Plenty: The vacuum in modern quantum field theory. *Contemporary Physics, 26*(4), 333–391.

Berger, P. L., & Luckmann, T. (1966). *The social construction of reality*. New York: Doubleday.

Bickhard, M. H. (1980). *Cognition, convention, and communication*. New York: Praeger Publishers.

Bickhard, M. H. (1996). Troubles with computationalism. In W. O'Donohue, & R. F. Kitchener (Eds.), *The philosophy of psychology* (pp. 173–183). London: Sage.

Bickhard, M. H. (2001). The tragedy of operationalism. *Theory and Psychology, 11*(1), 35–44.

Bickhard, M. H. (2008). Social ontology as convention. *Topoi, 27*(1–2), 139–149.

Bickhard, M. H. (2009). The interactivist model. *Synthese, 166*(3), 547–591.

Bickhard, M. H. (2011). Myths of Science: Misconceptions of science in contemporary psychology. In H. J. Stam (Ed.), *Theoretical psychology — Contemporary readings* (Vol. II, pp. 57–71). London: Sage, ISBN 978-1-84920-773-7. reprint of Bickhard, M. H. (1992). Myths of Science: Misconceptions of science in contemporary psychology. Theory and Psychology, Vol. 2 (3), 321–337.

Bickhard, M. H. (2013). The emergent ontology of persons. In J. Martin, & M. H. Bickhard (Eds.), *The psychology of personhood: Philosophical, historical, social-developmental, and narrative perspectives* (pp. 165–180). Cambridge: Cambridge University Press.

Bickhard, M. H. (2015). The metaphysics of emergence. *Kairos, 12*, 7–25.

Campbell, R. J. (2015). *The metaphysics of emergence*. New York: Palgrave Macmillan.

Campbell, R. J., & Bickhard, M. H. (2011). Physicalism, emergence and downward causation. *Axiomathes, 21*, 33–56.

Cao, T. Y. (1999). *Conceptual foundations of quantum field theory*. Cambridge: U. of Cambridge Press.

Clifton, R. (1996). *Perspectives on quantum reality*. Kluwer Academic.

Creutz, M. (1985). *Quarks, gluons and lattices*. Cambridge: Cambridge University Press.

Davies, P. C. W. (1984). Particles do not exist. In S. M. Christensen (Ed.), *Quantum theory of gravity* (pp. 66–77). Bristol, England: Adam Hilger.

Fraser, D. (2008). The fate of "particles" in quantum field theories with interactions. *Studies in History and Philosophy of Modern Physics, 39*, 841–859.

Halvorson, H., & Clifton, R. (2002). No place for particles in relativistic quantum theories? *Philosophy of Science, 69*(1), 1–28.

Hempel, C. G. (1965). *Aspects of scientific explanation*. New York: Free Press.

Hobson, A. (2013). There are no particles, there are only fields. *American Journal of Physics, 81*, 211. http://dx.doi.org/10.1119/1.4789885.

Huggett, N. (2000). Philosophical foundations of quantum field theory. *The British Journal for the Philosophy of Science, 51*(supplement), 617–637.

Hull, D. L. (1974). *Philosophy of biological science*. Englewood Cliffs: Prentice-Hall.

Kuhlmann, M., Lyre, H., & Wayne, A. (2002). *Ontological aspects of quantum field theory*. River Edge, NJ: World Scientific.

Lewis, D. K. (1969). *Convention*. Cambridge, MA: Harvard University Press.

McHugh, P. (1968). *Defining the situation*. New York: Bobbs-Merrill.

Riordan, M. (1992). The discovery of quarks. *Science, 256*(5061), 1287–1293.

Schelling, T. C. (1963). *The strategy of conflict*. New York: Oxford University Press.

Sciama, D. W. (1991). The physical significance of the vacuum state of a quantum field. In S. Saunders, & H. R. Brown (Eds.), *The philosophy of vacuum* (pp. 137–158). Oxford: Clarendon.

Seibt, J. (2010). Particulars. In R. Poli, & J. Seibt (Eds.), *Theory and applications of ontology: Philosophical perspectives* (pp. 23–57). New York: Springer.

Smith, L. D. (1986). *Behaviorism and logical positivism*. Stanford, CA: Stanford University Press.

Suppe, F. (1977). The search for philosophic understanding of scientific theories. In F. Suppe (Ed.), *The structure of scientific theories* (pp. 3–241). University of Illinois Press.

Weinberg, S. (1977). The search for unity, notes for a history of quantum field theory. *Daedalus, 106*(4), 17–35.

Weinberg, S. (1995). The quantum theory of fields. In *Foundations* (Vol. 1). Cambridge: Cambridge University Press.

Weinberg, S. (1996). The quantum theory of fields. In *Modern applications* (Vol. II) (Cambridge).

Zee, A. (2003). *Quantum field theory in a nutshell*. Princeton: Princeton University Press.