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Realisms and their Opponents: Philosophical Aspects

In everyday usage, ‘realism’ is often used as a name for a practically or epistemically low-ambition attitude, while ‘idealism’ is often taken to denote a high-ambition—if not utopian—attitude. In philosophical usage, mostly, it is the other way around: those who are called realists tend to claim more than their opponents—they are the philosophical optimists.

Within philosophy itself, ‘realism’ adopts a variety of interrelated and contested meanings. It is used as the name for doctrines about issues such as perceptual access to reality, the existence of universals, the goals and achievements of science, the nature of truth, the objectivity of morality, and many other things. Given this variety, no single shorthand definition of the term ‘realism’ can be provided.

One manifestation of this variety is that the opponents of realism about these issues are not called

uniformly by a single label (other than the rather uninformative ‘antirealism’): the labels used include idealism, phenomenism, instrumentalism, conventionalism, fictionalism, noncognitivism, constructivism, relativism, irrealism, and others. Sometimes such labels vary from one dispute or domain to another even when similar ideas are being expressed. Sometimes they are used to make claims that are specific to the domain at hand and distinct from other antirealist theses.

In what follows a brief tour will be taken along some of the representative philosophical highways and lanes, from ontology through semantics to epistemology. Along the way, realism will be confronted with some of its various opponents and internal conflicts. The philosophical landscape in the neighborhood of realism is nowadays much broader than it used to be: in a typical older encyclopedia, ‘realism’ was taken to name doctrines about universals or about perception, or both, to the exclusion of much of its present coverage, and many of the current opponents were missing from view altogether.

1. Ontology

As an ontological doctrine, realism is a claim about the existence of something. Versions of ontological realism differ from one another in regard to what this something is—the domain of existents (things that exist)—and what kind of claim is being made about items in this domain. If we take ontological realism to have the form of the statement ‘*X* exists,’ then in order to identify different versions of realism and its denial we need to examine the various ways in which its two components are interpreted. We need to consider the two questions: ‘what exists?’ and ‘what is existence?’

If we just claim that the world exists, without providing further specifications of the constituents and structure of the world, our realism will remain rather uninteresting. Philosophers of the nominalist persuasion add that particulars, and nothing but particulars in time and space, exist. The world consists of objects such as you and me and the particular copy of this encyclopedia that you are reading now. A radical nominalist will claim that only ‘bare’ or propertyless particulars exist, while properties do not. Whereas nominalists can be realists of sorts, they are opposed by those who have been called the realists in the debate over the existence of universals. In this debate, realists claim that universals—kinds, properties, relations—exist, that they are, or are among, the constituents of the world. Not only does this particular encyclopedia exist, but among the furniture of the world are books as a cultural kind, properties such as weight and colour, and the relation of being owned by someone. Such universals can be multiply instantiated in particular objects in space and time. Platonic realism takes universals to constitute reality: redness, ‘book-

ness' and ownership inhabit a separate realm of ideas, independent of the particulars that exemplify them. Aristotelean realism takes both universals and particulars to be real, and claims that universals only exist when exemplified in particulars. In the philosophy of mathematics, the view that numbers, real-valued functions, and sets exist as 'abstract entities' is called Platonism, while the opponents denying their existence are known as intuitionists, formalists, and logicians.

Common sense takes the world to be furnished with medium-sized material objects that are the possible objects of sense perception. Considering these objects to exist leads to realist doctrines about the ontology of perception. The opponents of realism in the theory of perception include the idealists (to whom it is 'ideas' that constitute the world) and phenomenologists (who try to construe the world out of 'sense data'). *Direct realism* says that perception is a direct awareness of material objects that exist in reality and that nothing else exists between perception and perceptible objects. Naïve realism, entertained by philosophers as a target of criticism, is a version of direct realism that takes sensible qualities to be the intrinsic properties of material objects and these objects to have all the properties they are perceived as having. *Indirect realism* states that perception is directly about mental representations (such as bodily sensations and after-images) and only indirectly about the external world and that both the direct and indirect objects of perception exist.

An encompassing commonsense realism takes objects in the commonsense domain, whether material or mental, to exist. Its list of existents includes my bathroom and my belief that it is vacant, as well as ducks and the desire to eat one. Anyone ontologically committed to folk psychology, holding the commonsense view that beliefs, desires, hopes, and fears exist, is a realist about the mental. Common sense also seems to suggest that there are moral facts about the world. To say that something is morally good or morally bad is to describe aspects of objective reality. Moral realists deny a sharp distinction between facts and values, holding that moral values are among the facts of commonsense experience. In contrast to these views, an eliminative materialist denies that mental and moral facts exist and takes only matter or physical objects to exist, thus counting as a realist about the material but not about the mental or the moral.

Scientific theories characteristically discuss unobservable entities such as quarks and electromagnetic fields. If we take these to exist, we hold the ontological position of *scientific realism*. The opponents of realism about the ontology of scientific theories are the phenomenologists and fictionalists. For them, unobservables do not exist—only observables do. Rather than being among the fully authorized inhabitants of the real world, the unobservables of science are nothing but fictions of imagination in the scientists' minds.

One may combine scientific realism with a commonsense realism that takes both scientific objects and the objects of folk physics, folk psychology, morality, and folk sociology to exist: the full set of existents includes plans and plaitiveness, plantations and plebeians, plants and planets, platelets and plastids. This is disputed by a radical scientific realism that holds that only scientific objects exist; thus, trees do not exist, but the atomic and cellular structures that constitute them do. A radical commonsense realist will deny existence to scientific objects while granting existence to commonsense objects: plants exist while plastids do not. One can also be more discriminate among the various classes of commonsense objects, granting or denying existence to material, mental, and moral facts in different permutations, for example, holding that only the material exists; or that the material and the mental exist; or that all three exist.

One's notion of scientific realism has to be qualified in relation to specific scientific disciplines. The standard formulations are in terms of unobservable entities that lie far beyond the commonsense domain, with physics serving as the paradigm science. But suppose one wants to be a scientific realist about the explanatory posits of a sociological theory that discusses community and custom, role and authority, motive and reciprocity? If one takes these commonsense items to exist, the scientific realism that ensues will not be strictly modeled after the realism about photons and neutrinos and other noncommonsense posits of physical theories.

One can also choose to be a realist about modality. Modal realists argue that science and common sense deal with possibilities and necessities as aspects of the world. In decision theory, the decision-maker is viewed as considering possible choices and possible outcomes with probability values. In experimental science, the experimentalist considers various possible designs and possible outcomes with estimated probabilities. A modal realist takes such possibilities as real. An actualist denies the existence of possibilities and only regards actual things in a realist fashion. Yet, among the actual existents (in contrast to merely possible), one may include dispositions, propensities, capacities, and causal powers: they are potentialities that, under certain conditions, manifest themselves.

Having thus listed some possible domains of existents, and having made a selection from among them, the realist might leave it there. Of some *X*, the realist about *X* just says that *X* exists. Yet, pressed by antirealist arguments, the realist may feel forced to take a few more steps. This is because antirealists can go along with the realist to accept that *X* exists, but just interpret the meaning of '*X* exists' differently. Thus the realist has to raise the further question of what is claimed about the existence of the existents, or what is meant by '*X* exists'.

This question has a number of variants. One is about whether one reads existence claims literally or

reductively. A phenomenalist may say that electrons and elm trees exist, and add that what she means to say is that certain constellations of sense data exist; claims about electrons and elm trees and other such entities can be reduced to claims about sensory experiences. A realist would say that electrons and elm trees exist, period—signaling that the claim is to be understood literally. An eliminative materialist may say that a given mental property exists, and then add that this is just another way of saying that a certain neurophysiological configuration exists. A mental realist would resist such a reduction. In general, when considering the existence of *X*, the issue is whether the statement '*X* exists' is to be taken literally or to be reduced to another claim: '*Y* exists.'

Once we have fixed a literal answer to the question of what is claimed about the existence of the existents, another version of the question can be raised. This concerns the possibility and actuality of existence. The weakest realist claim is that it is *possible* for *X* to exist: the claim that *X* exists is intelligible and coherent. One is a realist about *X* not by claiming that *X* actually exists, but by claiming that *X* is the sort of thing that might exist. This is consistent with having doubts about its actual existence or a later discovery that it does not exist after all.

Many realists make stronger claims than just possible existence. They include statements about *actual* existence in their definition of realism. There are different versions of this, depending on the quantifier that is used in relation to the sets of items that are claimed to exist. No realist would like to claim that *all* alleged universals, particulars, commonsense objects, and/or scientific objects exist (this would imply that unicorns and ether are as real as magnolia trees and DNA molecules). Many realists would say that *some* of them, or *most* of them, exist.

Another version of the question (of what is claimed about the existence of existents) arises as we recognize that such claims are customarily formulated in terms of independence. Such claims take on the form, '*X* exists independently of *Z*'. Two further questions arise from such a claim: 'what is *Z*?' and 'what is independence?'

The ordinary formulation is that something exists mind-independently or independently of the mental, with 'mind' and 'mental' designating facts about the human mind. The paradigm meaning of 'exists' is based on an image of physical reality that existed before there were any humans around. Physical particles and their systems, such as molecules and galaxies as well as natural laws, existed independently of human perception and thought, and now that humans are around, these things continue to so exist—and were human life to disappear, they would still exist. One issue is whether 'exists' in this paradigm meaning applies to anything at all. Another issue is whether it is appropriately general to be extended to cover all important cases of existence claims, including

those about things that have emerged along with or since the arrival of humankind into the world. But what is independence?

If we take it to mean logical independence, we may want to say that physical objects are logically mind-independent since statements about them do not imply the existence of any human minds. This will require reading '*X*' literally as denoting physical objects: otherwise it would be open to a nonrealist to argue that *X*'s existence is logically mind-dependent for the simple reason that '*X*' is just another name for a bundle of sense data or some such. But if '*X*' denotes a human mind or a mental property itself, we cannot say that its existence is logically independent of the mental, because it entails the existence of the mental.

We may also say that something exists in the sense that it is causally independent of the mental: the human mind does not causally produce or reproduce it. Were this to apply to physical objects, 'causal production' itself would have to be literally understood as denoting a real connection in the world rather than a function of our minds. Whether it applies to human minds themselves depends on whether we take the reproduction of the species of sentient creatures like us to be causally mind-dependent activity. But it certainly does not apply to the many things in the world that are causally mind-dependent, such as material artifacts and social institutions.

Other notions of independence may be more successful in taking care of logically or causally mind-dependent things. We may choose to say that *X* exists independently of its recognition or any evidence we may have for its existence, or that it exists independently of any particular inquiry addressing it, or that it exists independently of any particular linguistic or other representation of it. Such formulations may enable realism about mental matters as well as about artifacts and many social entities that are causally dependent on the mental. The question of whether a given mental property or social entity exists is an objective question in the sense that it is separate from the question of whether anybody has thoughts, beliefs, or representations about it, has inquired into it, or has evidence for it.

Many realists hold the view that the world has a definite structure independently of our conceptual accounts of it. One may think that the world consists of propertied and related objects, such as natural kinds that are linked with one another by causal relations, and that these causal relations have a specific character, such as involving causal powers, causal transmission, and natural necessity. A nominalist would object to this by arguing that the world itself has no intrinsic structure, even though it may exist as an unstructured collection of propertyless particulars. Whatever structure the world is taken to have, it is rather our conceptualizations that impose it upon the world. The world is conceptually constructed so as to grant it a structure, and the origins of that structure

are in our ideas and conversations. This gives us an idealist and constructivist view on this matter. Thinkers are capable of ‘worldmaking’ as Nelson Goodman’s ‘irrealism’ puts it, or of the ‘social construction of reality’ as the radical wing of social constructivism alleges. Insofar as our ideas are permitted to legitimately vary, this results in a form of ontological relativism as well: to each different communally-held or justified conceptualization corresponds a different structure of the world. Thomas Kuhn’s suggestion that after a scientific revolution from one paradigm to another, scientists ‘live in a different world,’ can be—contestably—read as implying this idea.

The social world poses a special challenge to the realist: the social world *is* constructed and *is* dependent on people’s ideas. There can be no communities and conventions, authorities and audiences without people acting on their ideas. Yet the realist wants to say they exist. These things may be taken to exist independently of, say, scientific theories about them, in the sense that the construction of a theory about a social entity is not a matter of constructing the entity.

2. *Semantics*

Ontological realism is about the existence of *X*. One may also raise questions about linguistic expressions ‘*X*’ and ‘*X* is such-and-such’ in relation to *X*. Indeed, ‘realism’ has become increasingly defined, especially by many antirealists, as a name for certain semantic views concerning such things as reference, meaning, and truth. It is characteristic of many antirealists to take semantic issues pertaining to language as primary, whereas realists often give priority to ontology and view semantic theses as derivative of, or motivated by, ontological positions.

The claim that scientific theories and the terms they include refer to real existents is part of the semantic thesis of scientific realism. Another part is the view that at least some of the major sentences contained in scientific theories can be used to make genuine statements about the real world, and as such, they may be true or may be false. More generally, semantic realism about some subject matter or domain maintains that statements about that domain are capable of being true or false—that they are capable of describing facts about the domain truly or falsely.

Some philosophers, such as Michael Dummett, have taken bivalence as a defining notion of realism: one is a realist about a statement or theory if one takes it to be either true or false. The ontological ramification of this is as follows: if there were gaps between these truth-values, this would indicate that the world itself is somehow indeterminate. If ‘*N* is bald’ is not clearly true or false but somewhere in between, then it would seem there is no determinate fact of the matter about *N*’s baldness. This may be taken to motivate antirealism. The realist should not reason along these

lines. If bivalence has a difficulty with statements like ‘*N* is bald,’ this may be nothing but an indication of the vagueness of the language of baldness, not a matter of some indeterminacy about *N*’s head. For a realist, the properties of language have no implications for the properties of reality in such cases.

Realist theses about possible reference and possible truth in scientific theories are often complemented with claims about actual properties of actual science. One such claim—made by Richard Boyd, Michael Devitt and others—is that the theoretical terms of most current (or the best of ‘mature’) scientific theories typically refer and that their lawlike statements are at least approximately true. Another related claim is the convergence thesis: as science develops, its theories get progressively closer to the truth. Both of these are empirical claims about actual science and should not be made part of the concept of scientific realism. Their truth is dependent on contingent matters such as the institutional structure and other resources of scientific research as these happen to be in any given society and time period. This is not to deny that a realist may need a concept of approximate truth, truth-likeness, or closeness to the truth in order to defend the possibility of truth acquisition in science. Nor is it to deny the obvious idea that the notion of convergence towards the truth may be used to give content to the notion of scientific progress.

As for the concept of truth itself, a realist will hold the view that truth transcends any conceivable evidence. In this sense, truth is characterized negatively as nonepistemic, as being independent of whether, and how, we may have epistemic access to it. This runs counter to neopragmatist suggestions to define truth as provability (as does Dummett) or ideal acceptability (as does Hilary Putnam). For a realist, truth is one thing, and it is quite another to prove it, discover it, confirm our belief in it, or find evidential warrants for our beliefs. Since there is no necessary connection between truth and these things, the realist thinks that evidence-transcendent truth is not necessarily attainable. This implies that even if the epistemic warrants for a statement or theory were as good as possible, or in some sense ideal, our theory might be mistaken.

‘Realism’ is also used in connection with—but is not defined by—a specific view of what truth is: the correspondence account of truth. This view allows for many alternative formulations. A generic formulation is to say that a sentence (or proposition, or utterance, or whatever the appropriate truth-bearer is taken to be) is true in virtue of its correspondence with certain facts about the world, the truth-makers. This can be linked with ontological matters. On the one hand, truth presupposes an ontology within which truth-makers find a place. On the other hand, there is the route from an account of truth to ontology, from claims of truth to claims of existence. If it is up to the truth-makers to make the truth-bearers true, and if the truth-makers are objective facts about the world, then

the truth-makers of a true truth-bearer must exist. Thus, if mathematical statements can be true, then there must be mathematical objects of which they are true. If moral statements can be true, then there must be objective moral facts that make them so. Some realists have severed the connection between realism and the correspondence account of truth: they want to endorse the former without endorsing the latter. Most of these realists hold a deflationary or minimalist account of truth.

Nonrealists can also choose from different options. An instrumentalist about scientific theories can insist that no truth-values can be ascribed to theories as they make no claims about the world. Theories are no more than instruments for organizing the data, predicting future events, or helping to manipulate the world. They are tools of management or tickets of inference, and it is in the nature of tools that one should not ascribe truth or falsehood to them. Tools are characterized as useful or useless, convenient or inconvenient, relevant or irrelevant, powerful or powerless, and so on—all these attributions being relative to the purpose to which a given theory is put. This is the traditional version of instrumentalism that has been inspired by the familiar feature of physical theories that they appear to postulate unobservable entities. In case one has empiricist suspicions about such unobservables, it is tempting to construe theories as neither referring to them nor making any claims about them, whether true or false.

Likewise, in case one is ontologically suspicious about intentional properties, there is still an option to use the intentional vocabulary of folk psychology instrumentally: even though there really are no intentional properties on top of the physical ones, folk psychology can be usefully employed for predictive purposes provided it is construed nonreferentially. Daniel Dennett's 'intentional stance' serves as an example. One may adopt this stance as a perspective from which to treat systems *as* intentional without asserting that they really *are* intentional. No truth claims are being made about a system *really* possessing beliefs and intentions, but the predictive benefits created or lost by treating any given system as intentional is an objective matter.

Another instrumentalist possibility is to view a theory as a false tool, rather than as a truth-valueless tool. This is in line with Hans Vaihinger's fictionalism: falsehood is a characteristic of scientific theories regarded as fictions. Even though Vaihinger did not discriminate between natural and social sciences in applying his fictionalism—Isaac Newton's gravity and Adam Smith's economic man served as his examples—this view may be able to accommodate a feature of many social scientific theories: they do not seem to postulate unobservables in the same sense in which one finds them in physical sciences. Many social theories, and especially economic theories, involve idealizations and simplifications about familiar com-

monsense objects: immensely informed consumers with transitive preferences over all options of choice, and international economies with two countries with identical production functions, two goods, two fully-employed and internationally-immobile factors of production. Since many such idealizations are wide of the mark, one may be tempted to construe theories involving them as false, but nevertheless useful, instruments.

A popular view among the opponents of moral realism is to claim that apparent statements about some domain are not really genuine statements at all, but that they are rather used to express emotions or commitments or to persuade audiences. Thus, one may argue that moral claims of the form, '*X* is morally good' are not statements of some objective moral facts capable of being true or false, but express the utterer's emotions or persuasive intentions. This nonrealist position is called a noncognitivist position in contrast to its realist opponent, the cognitivist view, which takes moral claims to be truth-valued. This is an example of a reductive, nonliteral account: a descriptive claim that '*X* is good' is not supposed to be taken literally, but rather to be reduced to recommendations or approvals.

Yet another nonrealist possibility is to retain the vocabulary of truth and refute the correspondence account. Truth can be viewed as essentially involving pragmatic features, such as instrumental efficiency, ideal consensus, or warranted assertability. Whatever works for this or that purpose and meets certain constraints is true. These views make truth dependent on things such as our interests and goals, our thoughts and recognitional capabilities, our linguistic and other social conventions. Realists tend to think of truth as independent of such things.

Radical relativism regards all truths as indexical: '*P* is true in culture or community *C* but not in *D*,' '*P* is true for me but not for her,' and so on. Some formulations of constructivist sociology of scientific knowledge result in relativism of this sort by equating truth with acceptability within a scientific community. Equating truth with *ideal* acceptability is supposed to avoid the pitfalls of such relativism: the ideal conditions are supposed to fix truth uniquely. Realists claim to avoid them by not equating truth with anything epistemic.

3. *Epistemology*

Many of the issues above can be turned into issues of belief, justification, and knowledge. Some formulations of scientific realism refer to epistemic attitudes: scientists accepting a theory believe it to be true; and it is the goal of science to pursue true theories. Both formulations are problematic. A scientist with ontologically and semantically realist convictions may, with no inconsistency, accept for some purposes a

theory not believed to be true or not yet so believed. And whether or not truth is actually pursued as a goal is not implied by the notion that scientific theories include sentences that are capable of being true or false—or that their posits are capable of existence. It is also questionable whether science is the sort of entity to which goals can be attributed. Whether truth is among the goals of a particular body of scientists, and whether science as a collective endeavor will actually deliver truths as an outcome, depends on the actual prevailing institutional organization of science. Claims about scientists' actual beliefs, goals, and achievements are empirical claims whose truth depends on various contingencies; they should not be included in one's core definition of 'realism'. Of course, to accommodate such ideas, one may stipulate complex labels such as 'axiological veristic scientific realism,' which says that scientists had better pursue true accounts of the world.

Forms of epistemological realism are best formulated in terms of 'knowability'—of believability and justifiability. Supposing the world, and these or those of its constituents exist, can we acquire knowledge about them? Realist theories of perception share the view that there is no veil of perception, that perception is able to provide us with (perhaps very complex and indirect) access to at least some parts of reality. More generally, an epistemological realist holds that the world is knowable; for example, the theoretical claims of science may be justifiably believed to be (approximately) true.

With respect to scientific theories and the entities and relations they postulate, one may hold the view that the ontological question of their existence is irrelevant. They may exist, and theories may be true or false about them, but what is crucial is that we *cannot know* that they exist, nor that claims about them are true or are false. Therefore all that matters for science—insofar as its goals and criteria of success are concerned—is empirical adequacy, that is, the truth of the claims science makes about observable phenomena. This empiricist combination of ontological realism and epistemological antirealism has a long tradition, including Auguste Comte's positivism and, presently, Bas van Fraassen's constructive empiricism. People like Ernst Mach have been closer to taking the more radical step from epistemological to ontological antirealism, from denying epistemic access to the unobservable posits of science to denying their existence.

Many contemporary versions of antirealism, including Putnam's 'internal realism,' hold that insofar as truth is concerned, the semantic and epistemological issues cannot be kept distinct: truth is epistemic. Truth consists in warranted assertability, or in ideal acceptability. This means that a theory that is epistemically ideal cannot be false. An epistemically ideal theory is a fully justified theory: it is a product of our very best efforts in the most favorable circumstances, one that is

perfectly supported by all available evidence and meets all relevant theoretical constraints. While the realist will distinguish between the notions of being true and passing for truth in any circumstances, the antirealist will not acknowledge a difference between truth and passing for truth in ideal circumstances. The antirealist view makes truth conditions identical to the conditions of the recognition of truth, thus there is no recognition-independent or evidence-transcendent truth to be sought. Truth becomes epistemic; semantics and epistemology become fused. This may be taken to have ontological import. If an ideal theory suggests that quarks exist, then the statement 'quarks exist' is true, and therefore quarks exist. In this picture, ontic matters are derivative from epistemic matters.

This antirealist view is often presented as providing protection against skepticism about truth acquisition: making truth attainable by definition is supposed to help avoid the misery of truth possibly escaping us in all circumstances. Semantic realism decouples truth and justification by viewing truth as evidence-transcendent and otherwise nonepistemic. This may be taken to create room for skepticism: since even epistemically ideal theories may be false, we may be doomed to be mistaken forever, even though most realists would say that, as a matter of fact, we are not. Indeed, epistemological realists believe that we are able to acquire justified true beliefs about the world, thus they deny skepticism. Whether one formulates scientific realism as suggesting that most (or some) current scientific theories are recognizably and justifiably (approximately) true, or as the implied weaker view that it is in the character of scientific theories that they can be recognized as being true or false, one thereby subscribes to epistemological realism. Yet, given that truth and justification have been conceptually decoupled, the realist has to face the difficult problem of showing how these two things are related empirically so as to ensure that our cognitive efforts are somehow conducive to truth-acquisition.

The antirealist who holds truth to be epistemic is not necessarily much better equipped against skepticism. While actual justification will not guarantee truth, ideal justification does, or so some antirealists suggest. The challenge is to give a detailed account of what ideal justification consists of, and to do this in purely epistemic terms without invoking a prior grasp of the notion of truth itself. This may be difficult or impossible. If we say that ideal justification takes place in circumstances where all sources of error have been removed, and take this to mean circumstances where there are no obstacles to the attainment of truth, we will have failed to meet the challenge.

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Reasoning with Mental Models

Reasoning is the mental process of drawing a conclusion from a set of premises. The premises may be statements, perceptions, beliefs, or items of general knowledge. The conclusion may be a statement or a thought that guides action. Reasoning is a central component of human intelligence, and without it, there would be no laws, civilization, or science (see *Scientific Reasoning and Discovery, Cognitive Psychology of*). Laws would have no application because individuals would be unable to make the following sort of inference:

Pat has a license or else Pat is disqualified from driving;

Pat does not have a license;

∴ Pat is disqualified from driving.

This inference is a valid deduction, that is, its conclusion must be true given that its premises are true. Logic is the science of valid deductions, but not a theory of how people reason. Such theories are the province of psychology, and psychologists have proposed a variety of theories (see *Logic and Cognition, Psychology of*). Human beings can reason about topics for which they have no general knowledge, and theories of this ability fall into two main categories.

Some theorists postulate that reasoners rely unconsciously on formal rules of inference akin to those of a logical calculus (see *Natural Concepts, Psychology of*). The preceding inference depends on a rule of the form: A or else B, not A, therefore B. Other theorists propose that reasoners rely instead on their grasp of meaning and of principles akin to those for the semantics of a logical calculus. These theories rely on mental models, which are internal representations mirroring the structure of the external world. This article describes their role in reasoning and evidence corroborating it.

1. Mental Models

The idea that humans construct models of the external world goes back to the Scottish psychologist, Craik (see also *Mental Models, Psychology of*). He wrote:

If the organism carries a 'small-scale model' of external reality and of its own possible actions within its head, it is able to try out various alternatives, conclude which is the best of them, react to future situations before they arise, utilize the knowledge of past events in dealing with the present and the future, and in every way to react in a much fuller, safer, and more competent manner to the emergencies which face it (Craik 1943, Chap. 5).

Another antecedent is Wittgenstein's (1922) thesis that propositions represent reality in a similar way to pictures. What the modern theory of mental models adds to these programmatic proposals are three main assumptions:

(a) Each model represents a possibility. Thus, the assertion: either Pat has a license or else Pat is disqualified from driving calls for two models to represent the two possibilities (shown here in simplified form on separate horizontal lines):

License

Disqualified

where 'License' denotes a model of the possibility in which Pat has a license, and 'Disqualified' denotes a model of the possibility in which Pat is disqualified from driving.

(b) Models have a rich internal structure (not shown in the preceding diagram). Like an architect's plan, the parts of a model correspond to the parts of what it represents, and so the structure of a model corresponds to the structure of the world (Wittgenstein 1922, Propositions 2.13–2.17). Visual images are based on models, though many models are not visualizable (see *Imagery versus Propositional Reasoning*).

(c) The principle of truth: models normally represent what is true according to the premises, but not what is false. Hence, the preceding models of the disjunction represent only the possibilities that are true. Likewise, for true possibilities, models represent clauses in premises only when they are true in the possibility. For instance, the first model in the set above represents the possibility that Pat has a license,