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# AN EPISTEMOLOGICAL BASE FOR THE PROBLEM SOLVING MODEL OF CREATIVITY

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## 1. Introduction

Creativity is important for gaining knowledge, yet its role has been generally ignored in standard, twentieth century epistemological views. The focus has been on methods for producing truths, especially a greater number of truths than falsehoods. Practically, this means generating many little truths most of which are insignificant. Few proponents of standard epistemological views take the significance of the truth generated as part of their accounts. Yet, a creative person may produce a great number of falsehoods on the way to a powerful new insight. In the philosophy of science, creativity is recognized for its role in generating hypotheses to test, but this "context of discovery" in which creativity is displayed is thought to be beyond the scope of philosophy. Thus, neither twentieth century analytic epistemology nor twentieth century philosophy of science has the resources to ground the structured development of creative insight. A new approach is needed. My project is to show how scientific understanding can be reached through the exercise of well-chosen intellectual virtues. On this approach, creativity is central. Creativity results *from* intellectual virtues and results *in* scientific understanding.

## 2. Grounding the Problem Solving Model

Psychologists interested in creativity have developed models, the most promising of which seems to be the Problem Solving Model. Its strength comes in its broadness of scope. Other models are narrower in focus,

taking into account only cognitive aspects, or personality correlates, or the role of social interaction.[1] These other models can be seen as parts of the larger, more inclusive Problem Solving Model, for it encompasses cognitive traits and processes, attitudinal and motivational traits, and educational and social contexts. On the Problem Solving Model, these factors combine to result in the creative and novel production of insights. This model is particularly powerful in science where formal education produces a relatively stable social context, and problems are well articulated.

The Problem Solving Model is powerful. It is partly descriptive and partly normative, stating not only what creative problem solving is like, but also skills one should have to find creative solutions to problems. This is how it should be, given that the Problem Solving Model stems from an empirical discipline. It is the role of philosophy to ground such models. In so doing, a philosophical account would justify the claim that creativity leads to knowledge. Yet, philosophy, and philosophy of science in particular, has failed to do so, given the traditional assumption that the "context of discovery" is beyond its scope.[2]

To justify the claim that creativity is important for gaining knowledge in a more central way than merely producing testable hypotheses, the Problem Solving Model must be embedded in a broader epistemological framework. Yet, this framework must not be limited in the same way as standard accounts that seek the necessary and sufficient conditions for true, justified beliefs. The account I will develop focuses on the intellectual virtues that are needed for the generation of creative scientific insight. This approach does not address the question of how rational researchers should proceed when confronted with problems for which there is no standard procedure. This is a virtue-centered account in which the development of epistemic character is required. There will be no algorithm and no formal rules. Rather, this approach addresses the

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[1] Brown, 1989; Martindale, 1989; Sternberg, 1988.

[2] Some may wish to argue that Kuhn, or those who have "naturalized" the philosophy of science have included the context of discovery in their accounts. In so doing, they ground models of creativity. To make this case requires discussing whether Kuhn's view is at bottom relativistic and whether naturalized philosophy of science is still philosophy. In this article, I wish to investigate a third approach, one that I hope will move past these old problems. See: Kuhn, 1996; and Fine, 1984.

question of how rational researchers should *be* if they are to be successful when confronted with novel problems. It is a matter of the epistemic virtues, or the habits of mind, which rational researchers should seek to develop as part of their characters.

I will, however, make some assumptions. First, I will assume the Problem Solving Model of creativity, but not argue for it or develop it. Second, I will assume that a creative scientist has a background of domain specific knowledge sufficient to recognize and formulate a problem so that a range of solutions can be proposed. Further, this background is sufficient for evaluating and testing the proposed solutions. These are all skills needed for problem solving. In addition to these two assumptions, I will bracket the background of social and developmental factors that are needed for creativity. There are interesting issues in these neighborhoods, but my concern today is epistemological rather than social or psychological.

My question is, given a social, developmental, and informational background, how do we become creative problem solvers in a way that can lead to knowledge. Note, the question is not just: how do we generate hypotheses? Rather, it is: how do we generate *justified* hypotheses? How does a scientist generate theoretical understanding that meets epistemic criteria?

## 3. The Nature of Epistemic Virtues

Traditionally, virtues are character traits over which we have some degree of control. They can be developed and are distinct from natural abilities and skills.[3] Unlike virtues, natural abilities are neither praised nor blamed. We may be held responsible for developing our natural abilities, but not for having them in the first place. Skills are also unlike virtues in that I could choose to withhold using a skill, and still be said to have it. If I am a surgeon and fail to perform surgery when called for, I may be a cad, but I still have surgical skills. I cannot, on the other hand, fail to exercise a virtue when called for, and still be said to have that virtue. If I fail to be brave in general when courage is called for,

[3] Not all would agree. See: Greco, 1993; Kvanvig, 1992; and Sosa, 1985.

then I lack that virtue.[4]

Epistemic virtues fit this general characterization. A virtue is not a transitory disposition; rather it requires character stability and is developed through attention and habit. It includes a constant readiness to act in a virtuous manner when the situation calls for it. Epistemic virtues are somewhat narrower, and are usually characterized as cognitive dispositions exercised in the formation of beliefs.[5] As we will see below, there is also a motivational aspect to epistemic virtue. It is an excellence of intellectual character, part of which is cognitive and part of which is motivational, that is needed to reach creative scientific understanding. This account will parallel to some degree Aristotle's exhortation to develop an excellence of character.

We should be aware of the consequences of shifting to a virtue-centered approach. In traditional philosophy of science, necessary and sufficient conditions for an adequate theory are stated in the abstract, separated from any discussion of any individual's particular ability to gain knowledge, ability to generate hypotheses, or propensities for carefully considering evidence. On another well-established paradigm in the philosophy of science, the context of individual scientists is taken as the starting point. On this approach, the idiosyncrasies of individual scientists are essential, but they are seen as resulting from the socio-historical context. In contrast, this new approach is "agent-centered." The focus is on the skills and traits of the individual scientist attempting to gain knowledge. In addition, the epistemological force comes from the scientist's deliberately developed intellectual habits rather than from the accepted disciplinary matrix in which the scientist works. The next step is to see just what epistemic virtues a scientist should develop that will result in creativity and eventually, scientific understanding.

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[4] The distinctions among natural abilities, skills, and virtues are not as clean as I have I have made them appear. The stoics, for example, view the virtues as skills for living well. The rough characterizations given here are enough to focus our attention on virtues as consciously developed character traits that guides one's behavior.

[5] This is Guy Axtell's formulation. See: Axtell, 1997, 1996.

## 4. The Epistemic Virtues

Epistemologists developing virtue-centered approaches have produced varied but overlapping lists of intellectual virtues. James Montmarquet's list is one of the most general, and hence most easily applied to other contexts. He considers four epistemic virtues (Montmarquet 1993). First is "epistemic conscientiousness," which he describes as a desire for finding truths and avoiding errors. Second is "impartiality." Someone who is impartial is willing to exchange ideas and learn from others without a bias toward one's own ideas. It includes a "lively sense of one's own fallibility". (1993, p. 23) Third is "intellectual sobriety." The sober-minded inquirer is cautious to the right degree. Such a person avoids intellectual fads and does not let the excitement of new and unfamiliar ideas overshadow the desire for truth. Fourth is "intellectual courage," which is a willingness to conceive and examine alternatives to popularly held beliefs. It includes a willingness to persevere in the face of opposition.[6]

This account is important, but cannot be adopted wholesale. Montmarquet's list is too traditional when epistemic conscientiousness is understood in terms of finding truths and avoiding error. As noted, this conservatism is not conducive to creativity. What Montmarquet highlights, however, is that part of epistemic conscientiousness is motivational. Creativity research on attitudes, motivation and personality traits can be narrowed and recast to help define epistemic conscientiousness. Creative people tend to be intrinsically motivated, display high perseverance, and have a drive to produce.[7] The drive to produce and the ability to persevere are aspects of intellectual courage. But production and perseverance are directed. The goal is scientific understanding. Thus, the recasting of epistemic conscientiousness reveals that it is epistemic and motivational.

Other virtues on Montmarquet's list appear as attitudinal traits in the creativity research. The trait of a willingness to take risks is an aspect of intellectual courage, but it also includes a willingness to consider many

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[6] Montmarquet's account is far more complex that I have represented him here. Nonetheless, the very brief gloss I have given is sufficient for the present context.

[7] Martindale, 1989; Woodman & Schoenfeldt, 1989

falsehoods on the way to a creative scientific insight. Scientists' tolerance of uncertainty and ambiguity in their work requires intellectual sobriety and a lively sense of one's own fallibility. Further, intellectual sobriety tempers intellectual courage. Perseverance and the drive to produce do not require the production of hypotheses that meet epistemic criteria. Sobriety is needed so that not just any hypothesis will do. It is the sober-minded scientist that evaluates the epistemic worth of an hypothesis. The virtues are epistemic; yet, as we have seen, the personality traits of creative individuals are directly related.

Aristotle's list of "prized intellectual traits" overlaps to some extent with Montmarquet's list of epistemic virtues. Traditional epistemology left behind Aristotle's concern for practical wisdom, which in part is an account of how wisdom is gained by the right exercise of the right intellectual virtues. The central epistemic virtues Aristotle considers are ingenuity (which includes intellectual creativity), perceptual sensitivity, acuity of inference, a sound sense of relevance, and an active ability to determine the relative importance of heterogeneous and sometimes incommensurable ends.[8] These are important additions, for exercising epistemic virtues enables the inquirer to focus attention and define what is salient. These are skills needed to gain context-dependent, goal-driven understanding.

Intellectual creativity was one of Aristotle's prized character traits. But an account is needed of just what virtues result in intellectual creativity. Some researchers interested in creativity have focused on skills and traits such as having a good imagination, being flexible, and being able to make unusual associations.[9] These traits, along with Aristotle's and Montmarquet's (recast) intellectual virtues are the basis for the following short list of virtues for scientific creativity. The virtues I list here are not all and only the virtues that could be singled out as valuable. They are, however, some of the central virtues.

Intellectual virtues that result in the creative generation of scientific understanding include:

1. The ability to focus at the right level and define what is salient.
2. The ability to evaluate the degree of "trouble" an anomaly is for a

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[8] Politics i 1260a17, iii 1277a25; Nicomachean Ethics 1095a

[9] Dowd, 1989; Sternberg, 1988.

theory or hypothesis. This includes sensitivity to "noise" versus an anomaly faced by a theory or hypothesis. Aristotelian virtues that contribute to this virtue are perceptual sensitivity and a sound sense of relevance.

3. Having a synoptic grasp of disparate domains. This results from three other skills or virtues: having backgrounds of domain specific knowledge, focusing at the right level, and making unusual associations. Included in a synoptic grasp is the ability to abstract the presuppositions that are particular to a domain and the presuppositions that the domains share. Thus, Aristotle's "acuity of inference" is important here as well as in the following virtue.
4. Being able to represent alternative points of view, both perceptually and theoretically. This is the flexible, imaginative ability that is frequently cited as a creative trait. One proof of the ability to represent alternative points of view is the ability to reason hypothetically about the outcomes of possible alternatives. Another is the ability to transfer solution schemas to new contexts.
5. Being motivated by epistemic conscientiousness. This includes drive and courage, tempered by intellectual sobriety, in an effort to reach scientific understanding.
6. The ability to exercise the right epistemic virtue at the right time. Aristotle would consider this as part of practical wisdom.

These virtues are highly interactive. For example, being able to represent alternative points of view requires hypothetically adopting an alternative set of presuppositions. But that requires knowing currently held presuppositions and their degree of fundamentality. Developing and using the virtues is not a linear process. Frequent re-evaluation is needed both of the hypotheses generated and of the process of their generation. Both of these steps require the recursive use of the intellectual virtues.

Virtues can be listed separately for discussion, but none actually act in isolation. For none of the virtues can it be said that one should act on them in an unqualified manner. Epistemic virtue arises only when these traits are clustered and balanced in someone who desires scientific understanding. An epistemically virtuous person is someone with a well-constructed character that acts appropriately to gain understanding. An unqualified exhortation, "Be intellectually courageous!" is foolhardy advice. To gain understanding, one must be intellectually courageous *when one should*. Yet knowing when one should requires a balancing of

courage against other appropriate epistemic virtues.

On Aristotle's and Montmarquet's accounts, the intellectual virtues are all of the same order. Yet, a sound sense of relevance seems to require inferential acuity and perceptual sensitivity. The ability to determine the relative importance of heterogeneous and sometimes incommensurable ends seems to require impartiality and intellectual sobriety. The resolution of this difficulty will be to see some virtues as first order and some as second order. This is anticipated in the short list of virtues above. Having a synoptic grasp of disparate domains, for example, is a second order virtue, with other related skills as first order. Clearly, the ability to exercise the right epistemic virtue at the right time is a second order virtue. Second order virtues are not the guiding goals, yet they result from the first order traits. Furthermore, they result in creative discoveries on which scientific understanding is built.

## 5. Creativity and Understanding

Creative hypotheses are not the result of trial and error. They are the results of applying epistemic virtues that have been consciously and conscientiously developed. I have been speaking in terms of the results of creativity as having epistemic worth. Yet, it cannot be that all instances of creativity are justified. If this were a consequence, the whole enterprise would be defeated, for many falsehoods may be generated on the way to a discovery. It is important to distinguish between the hypothesis or theory that is justified and the scientist who has epistemic virtues.[10] Having intellectual virtues results in epistemic character. Virtuous epistemic character results in beliefs that are well supported by standard scientific methodology.

This link between creativity and knowledge is what needs to be justified. How is scientific understanding realized by a scientist who has developed intellectual virtues? How do the virtues work together to produce understanding? A clue can be taken from Gail Fine who sees

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[10] There is considerable discussion on the epistemic virtues of theories rather than scientists. Such virtues include explanatory power, simplicity, and empirical adequacy. This is a separate and unrelated issue. For discussion see: van Fraassen, 1980; Churchland, 1985.

Plato as equating understanding with knowledge:

> On the account [of Plato] I have proposed, one knows more to the extent that one can explain more; knowledge requires, not a vision, and not some special sort of certainty or infallibility, but sufficiently rich, mutually supporting, explanatory account. Knowledge, for Plato, does not proceed piecemeal; to know one must master a whole field, by interrelating and explaining its diverse elements. (1990, p. 114)

The valuable insight here is a relation between explanation and understanding. Mastery of a field requires having the skills to generate mutually supporting and explanatory accounts.

As noted above, these skills are not used in a linear way. Rather, they are interrelated by the epistemic character of the scientist. Explanations are developed and deepened by finding situations in which to test our hypotheses. This requires first order virtues. The scientist who has the ability to make unusual associations can unify explanations. The greater the scientist's epistemic virtues, the greater his creativity, and the more synoptic his understanding becomes.

To see the link between creativity and understanding, we have to see the relation between creatively producing possible alternatives and discoveries. In creativity, some epistemic virtues are highlighted more than others. When we shift to evaluating alternatives, and in the paradigmatic case, justifying the best alternative, a different, perhaps overlapping, set of virtues is highlighted. No cluster of epistemic virtues is necessary or sufficient for discovery. Clusters may even vary depending on the problem to be solved and the long run scientific goal.

For analysis, we can separate producing alternatives from evaluating and justifying them. In practice, we flow between the two. The greater the scientist's ability to move fluidly between producing alternatives and evaluating them and to operate at both levels simultaneously, the better that scientist will be at finding valuable discoveries. Just as the use of scientific methodology is a self-regulating activity, the right exercise of epistemic virtues is a self-regulating activity to develop scientific discoveries. Even though a creative person may generate many possible options that are rejected, given the nature of the epistemic virtues, the *discoveries* that result from the end of this process will, prima facie, meet epistemic criteria. This is what ties creative problem solving to

explanation and understanding.[11]

'Virtue' is a success term. In virtue ethics, someone who is virtuous does not merely have the capacity to be moral. Such a person *is* moral. He or she acts in a way that meets ethical criteria. So too, it can be said that a scientist who is epistemically virtuous creatively constructs hypotheses and theories that meet epistemic criteria. Also analogous to ethical virtues, we can speak of scientists being epistemically virtuous in varying degrees. Thus, the ability to be creative can be had in varying degrees. The more epistemically virtuous a scientists is, the greater will be his creativity. This is especially true if higher order virtues are developed. These higher order virtues are metacognitive, and must be cultivated and practiced if deep insights are to be generated.

## 6. The Virtue-centered Approach and Traditional Philosophy of Science

On the account developed here, generating discoveries is not rule governed. Nor is the focus on propositional knowledge. Discoveries become part of the complex scientific framework with which we understand our world. Scientific understanding is not static as is knowing a proposition. We do display our understanding propositionally, but it is also displayed via our actions. These actions include deciding which experiments to run, which leads to follow, and which hypotheses to test. Propositions are still the bearers of truth just as they are for traditional epistemology. Here, however, their primary use is not to state a putative truth, but rather to convey scientific understanding on the basis of which decisions to act are made.

At this point some questions arise regarding how a virtue-centered approach is related to traditional views in the philosophy of science. In what way is it a third approach? What happens to truth? What happens to objectivity in science? Does the contextual nature of a virtue-centered approach hinder, or worse, make impossible, scientific objectivity?

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[11] It may seem that the account presented here presupposes scientific realism. At a minimum, to meet epistemic criteria, scientific hypotheses and theories must be empirically adequate. Nonetheless, I intend my account to be sufficiently abstract to be of use to both realists and antirealists alike.

To begin, I do not claim that a virtue-centered approach is a complete philosophy of science. There are many issues for which a standard approach is better at providing an answer. Examples are: what is the nature of a scientific law? Is there an historical development of science? How do theoretical terms derive their meaning? Is science unified or are there discipline-specific criteria for what counts as science? I do reject the claim, however, that a completely idealized philosophy of science can be the whole of philosophy of science. There are scientific goals, such as cultivating scientific creativity, on which the standard approaches are mute. Our epistemic goals for science are broader than traditional views have presupposed.

In calling for a widening of scope, I am proposing an *askeptical* philosophy of science. We acknowledge that the ideal situation for gaining scientific knowledge is not realized. We also acknowledge that we have many epistemic goals to fill. The question will not be, "Is it possible to gain scientific knowledge?" but rather, "How do I develop and extend the scientific knowledge that I do have?" Once the shift is made, what becomes central is the scientist and his developed epistemic character. What distinguishes the askeptical approach is the claim that it is possible for any normal scientist to develop epistemic virtues in a way that leads to creativity and eventually, understanding. Focusing on virtues of the scientist, rather than the exclusive focus on the *nature* of justification, is an askeptical move.

In moving to askepticism, we are not likewise setting aside the ability to be skeptical about the truth of a particular hypothesis or theory. There are still appropriate ways to reason, and appropriate ways to use evidence. Thus, it is not part of askepticism to remove the ability to evaluate how well justified an hypothesis is. Observations, guided by what scientific background is had and what further scientific understanding is sought, are subject to critical scrutiny. The issue here is not the epistemic worthiness of our scientific rules for using evidence and our rules for making inferences; rather, what can be subject to criticism is a particular use of the rules and evidence.

Skepticism drives the standard views of logical positivism and its descendents (including van Fraassen's constructive empiricism), historicism, and naturalized philosophy of science. The attempt at "rational reconstruction" of the early logical positivists strips away any of the personal efforts of any scientist. The conditions for gaining

scientific knowledge are stated in the abstract, independent of any particular scientist with particular goals, and particular virtues. The presupposition is that if any of the details about the subject are taken into account, impartiality is lost. There is room for error if an account includes, or makes room for, details that may bias the scientist. Impartiality for a scientist results from being free of bias, especially due to one's situation in life, be that political, social, or economic. As in epistemology, justification is considered in the abstract, independent of the normal capabilities of those engaged in science. This epistemological assumption of the idealized subject underlies views that are descendents of logical positivism as well. On these accounts, discovery is a "flash of unanalyzable insight" rather than the result of hard scientific and epistemic work. On this approach, we have to ignore goals such as how to be successfully creative.

An historicist view such as Kuhn's depends on the context in which the scientist works, but this context is independent of any particular scientist. What is added to the concrete but impersonal social context is a particular scientist's own idiosyncrasies. We can examine a discovery as the result of the disciplinary matrix plus unteachable, perhaps unintentionally developed idiosyncrasies. A scientist is like an enzyme, functioning as a catalyst for change. Beyond "learn the exemplars" there is no advice on how to become a creative scientist.

A virtue-centered account may seem to have an affinity with descendents of Kuhn, especially those who claim that science is not a body of knowledge but a way of life. These philosophers think of scientific knowledge as formed and maintained by scientific practice or scientific culture. What they include as part of the context is not only how scientists perform experiments and set up their laboratories but also how scientists operate in financial, political and cultural networks. A virtue-centered account, on the other hand, narrows the scope to how a scientist functions epistemically. The epistemic virtues a scientist has will likely affect his financial and political life, but a scientist's finances and politics are not constitutive of his scientific life.

A virtue-centered account may seem to have some similarities with a naturalized account as well. That is because like a naturalized approach, we can begin with descriptions. In particular, we begin by looking at the epistemic virtues of successful, creative scientists. A virtue-centered account, however, is not a naturalized approach because of the argued for

relation between epistemic virtues and understanding. It is not opposed to a naturalized approach, but whereas naturalized philosophy of science has given up any normative hold, a virtue-centered approach has not.

A virtue-centered account makes central personal effort to secure truth. Epistemic responsibility is necessary for scientific knowledge. Here the scientist himself and his epistemic character is the seat of justification (but not the seat of truth). We learn how to be successful, creative scientists by developing epistemic virtues. They are normative, not merely cognitive as they may be on Kuhn's account. Scientists' discoveries depend on their epistemic character, not on the historical and social forces manifest in their training and in intellectual fashions (as Kuhn seems to imply). Epistemic virtues are not paradigm bound. A scientist is responsible for his epistemic character and can be evaluated extra-paradigmatically.

Finally, in setting aside skepticism, we are free to shift away from the isolated subject seeking pure truths to a community of scientists all of whom are seeking scientific understanding. Pooling talents gives us a greater likelihood of arriving at the sought for scientific understanding. As such, any understanding I may reach is dependent on other scientists from whom I have learned. It is also dependent on my contributions to the community, for it is the critical scrutiny my hypotheses receive from the community that hones them into deeper understanding for me and the rest of the scientific community.[12]

## 7. Closing Remarks

Embedding the Problem Solving Model in virtue-centered epistemology has two results: first, we see why scientists who fit the Problem Solving Model seem to be so successful at finding hypotheses and theories that meet epistemic criteria. Second, we step outside the distinction between the context of discovery and the context of justification. Virtue-centered epistemology, at the same time, describes successful, creative scientists,

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[12] My account is sympathetic with Longino's view that scientific objectivity is a property of a scientific community rather than of individual scientists. Nonetheless, a scientist who is epistemically virtuous will be less biased than one who lacks epistemic virtues. See: Longino, 1990.

and is an account of the kind of epistemic characters one should have if one is to reach significant, scientific understanding.

The advantages to this view are that: 1) creative discovery is seen neither as an unanalyzable flash of insight, nor as algorithmic, but rather as dependent on rational habits; 2) creativity comes in degrees and can be consciously developed; and 3) it is both descriptive and normative -- describing those who are creative and prescribing the development of like habits of mind. The disadvantage is that there is no procedural guidance. In a virtue-centered approach, a scientist pursues particular information in a given context because of the intellectual virtues he or she has developed whether or not there is a rule to govern the choice. In this way, creativity is consciously developed and used to gain knowledge.

To the detriment of the philosophy of science, the standard research agenda has limited its scope. If the goals are expanded, cultivating scientific creativity can be included. The value of askeptical philosophy of science is that it encompasses this aspect of science. It becomes a useful, pragmatic philosophy that is applicable to the lives we live.

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