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Explaining understanding (or understanding explanation)

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Abstract In debates about the nature of scientific explanation, one theme repeatedly arises: that explanation is about providing understanding. However, the concept of understanding has only recently been explored in any depth, and this paper attempts to introduce a useful concept of understanding to that literature and explore it. Understanding is a higher level cognition, the recognition of connections between various pieces of knowledge. This conception can be brought to bear on the conceptual issues that have thus far been unclear in the literature. Though this notion of understanding is broad, explaining various concepts of explanation, it is robust enough to underwrite an objective and useful notion of explanation.

Keywords Scientific Explanation · Understanding · Explanatory pluralism

1 Introduction

In some of his central works on scientific explanation, Wesley Salmon (1984, pp. 4–20; 1989, pp. 4–8) goes to great lengths just to determine what the subject is that we are trying to explicate. Following Carnap, Salmon is interested in the "clarification of the explicandum" (Carnap 1950). Part of explicating a vague term such as explanation involves articulating "a clear and exact concept to replace it" (Salmon 1989, p. 5). There are a number of conditions which must be met to do this. First, "the explicandum must be clarified sufficiently for us to know what concept it is we are trying to explicate" (Salmon 1989, p. 5). Second, the explication is to be judged according to its similarity to the explicandum, its exactness, its fruitfulness, and its simplicity.

Many authors have argued that a central aim of science is to explain and have tried to explicate the concept in a way that would support that conclusion. Generally, this idea is fleshed out with some specific theory of scientific explanation—causation, unification, etc. More often than not, the argument for such an account involves a two stage justification, approximating that set out by Carnap above. The first stage is to

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define roughly what is meant by explanation—e.g., it is an answer to a why question, it is to provide understanding, it offers comprehension, etc. In particular, since the introduction of the deductive-nomological model of scientific explanation (Hempel and Oppenheim 1948), the association of explanation with *understanding*, or some closely related concept, has been nearly universally present, regardless of the particular theory.[1]

The second stage is to argue that the preferred characterization (e.g., causation, unification, etc.) satisfactorily accounts for intuitively acceptable explanations and, at the same time, for the rejection of intuitively unacceptable explanations. Moreover, it does this in a manner that captures the sense that explanation leads to understanding in a way superior to alternative theories.

Both steps involve conceptual intuitions regarding, first, what we mean by explanation, and second what it takes to understand something. Ordinary language conceptions of explanation, as well as the majority of technical definitions of scientific explanation, treat explanation as something which renders understanding of the explained possible. Which prompts the question: "What is understanding?" If explanation is about gaining understanding, then it seems we ought to have a more thorough understanding of understanding.

Unfortunately, the notion of understanding, apparently so central to the concept of explanation, has until only recently remained largely unanalyzed by philosophers. The above accounts are intuitively appealing. Yes, expectability does seem to be relevant to what I think I understand. And, yes, to know the causal history of some event seems to mean that I understand it better. Likewise for unification. But the deeper question is why? What does it mean to understand something?

The central thesis of this paper is that understanding is about fitting information into a framework of knowledge. The type of framework this can be is broad, and it is limited by our own cognitive capabilities, but evidence suggests that we are able to form knowledge structures by way of logical connections, unifying or reductive connections, causal connections, and no doubt many more. This is a fairly simple thesis, and may thus appear to have little bite, but I hope to show that it in fact does a remarkable amount of work. I will argue that explicating the notion of understanding can play a constitutive role in explicating the concept of explanation. In addition, some of the standard theories of explanation, such as the causal-mechanical or unification accounts, can be explained by this definition of understanding.

In the next section of this paper, I clarify some central concepts and distinctions. In the third section, I look at a view that interprets understanding as an ability. Although I find this approach insightful, it has shortcomings that I argue makes the alternative interpretation outlined in this paper preferable. Section 4 presents a conception of understanding which has received scant attention in the philosophy of science and theories of explanation. In both cognitive psychology and virtue epistemology, there is a dominant conception of understanding (when it is explicitly discussed), which is that understanding is a higher level cognition, the connection and recognition of connections between various pieces of knowledge. I also argue that although this notion of understanding explains the oft noted contextuality of explanation, it can also underwrite an objective notion of explanation. Finally, I consider explanatory pluralism and outline

[1] E.g., see Hempel (1965), Friedman (1974), Achinstein (1983), Salmon (1989), or Kitcher (1989).

important questions in the philosophy of explanation which this conception of understanding can help answer.

2 Understanding the concept of understanding

Epistemology is only beginning to address the concept of understanding in a direct way, and as Zagzebski (2001) points out, much of the emphasis of western epistemology has been on knowledge, certainty, and the problem of skepticism. This has resulted in a lacuna in work on other epistemological concerns, including evaluating what it is to understand something. This has resulted in a deficient vocabulary and clarity of concepts concerning understanding. To a large extent, much of the aversion to giving understanding any philosophical prominence comes from conflating concepts simply because of linguistic poverty.

There have been efforts of clarification, and I wish to add to that endeavor. De Regt (2009, p. 25) differentiates between the *feeling of understanding (FU)*, *understanding a theory (UT)*, and *understanding a phenomenon (UP)*. Of primary importance is that understanding is not the same as, and should not be conflated with, what is often called the "sense of understanding" or "feeling of understanding," which refers to the "aha" or "feels right" phenomenology associated with coming to understand something, as referenced by Trout (2002, 2007) and others.[2]

I will go on to argue that understanding a theory is not different in kind from understanding a phenomenon. The difference lies in the differing objects of understanding. I also wish to make a further set of highly plausible distinctions, which I think pick out distinct concepts. These distinctions are best understood in light of the claim that to understand is to be in a cognitive state and to explain is to bring a subject into this state. As a matter of organization, I will argue for that claim in Section 3, although I think the distinctions hold regardless of that particular view of understanding. For clarity, it is worth defining my terms at the outset, and pursuing their viability and utility later.

If understanding is a cognitive state, it is functionally akin to knowledge (later I will argue that it is a type of knowledge). Knowledge is often described as a justified true belief. That is, it is a cognitive state—a belief—but one made true by a corresponding state of affairs, and restricted by the epistemological criteria that the belief and the truth of that belief be appropriately connected. With respect to knowledge, we call the purely cognitive state a *belief*, and one corresponding to truth a *true belief*. Unfortunately, when it comes to understanding, we do not have independent terms for similarly distinct concepts. Just as it is possible to think that you know something and be wrong (i.e., believe incorrectly), it is possible to think you understand something but be wrong. Let us call the cognitive state, on its own (analogous to belief), the *belief of understanding*, and the belief of understanding combined with a corresponding state of affairs *genuine understanding*, or just *understanding*. The *feeling of understanding* differs from the *belief of understanding*. The closest analogue with knowledge is the

[2] Trout uses "sense of understanding", as does Ylikoski (2009), who differentiates it from understanding. I will adopt de Regt's use of "feeling of understanding", also used by Lipton (2009), who both differentiate it from understanding.

feeling of conviction or certainty. This is a distinct feeling in the emotive sense that may, and characteristically does, accompany a belief. Likewise, the feeling of understanding may accompany the belief of understanding defined above, but it need not.

For example, when I was a child, I believed I understood how my Christmas presents appeared beneath the tree –Santa Claus brought them. However, I did not genuinely understand. When I came to genuinely understand what was going on, I did experience an "aha" moment; however, though today I still understand, that "aha" feeling of understanding is no longer there.

In sum, *genuine understanding* is to be distinguished from the *belief of understanding*, which is to be distinguished from the "aha" *feeling of understanding* that genuine understanding (or the belief of understanding) can produce. The advantages of this set of distinctions over de Regt's will become apparent below.

We can now say that explanation must provide genuine understanding, as opposed to merely the belief of understanding—in which case we might say we have a only a purported explanation—and that it has little substantively to do with the feeling of understanding. Knowledge is an epistemic state which can be evaluated with normative criteria with regard to its truth, level of justification, and so forth. Understanding is an epistemic state that has its own criteria of evaluation, not linked to the feeling of "getting it right," just as mere depth of conviction is not a fundamental guide to knowledge.

3 Understanding understanding—ability or cognitive state?

There is an alternative account of understanding, which defines it not as a cognitive state, but as an ability. Ylikoski (2009), for example, invokes arguments by Wittgenstein that understanding consists in the ability to do certain things. Ylikoski argues that, "When we evaluate someone's understanding, we are not making guesses about his or her internal representations, but about the person's ability to perform according to certain standards" (2009, p. 102). This type of operational or behaviorist view is attractive for a number of reasons. The first is that, in the specific case of understanding, if understanding is an ability, then the concerns about the *feeling of understanding* being too subjective can be avoided since it is just a mental state having only tangential relevance to the concrete abilities which indicate genuine understanding. This is one of Ylikoski's intents. However, the distinctions I outline above also succeed in avoiding this problem, since the feeling of understanding, the belief of understanding, and genuine understanding can be distinguished.

More generally, this definition is attractive in the standard way that operational definitions are desirable. It avoids the complications of dealing with inherently private, inaccessible, and theoretical mental states. On the other hand, it is vulnerable to standard objections and limitations to such accounts—for example, that it characterizes the observable expression of an underlying causal state, thus being inadequate for explaining behavior without reference to mental states. The ability definition does not capture the full concept of understanding found in ordinary language, which does seem to contain the element of its being a cognitive state as opposed to just an ability. It could be argued that understanding always goes hand in hand with ability, but that does not demonstrate that they are identical. We may frequently judge that a person understands

according to their abilities, but we can also judge a computer or emulating robot by the same standards without concluding that it understands. Of course, I may believe I understand and be corrected when I try to use that understanding and fail, but if I do understand, the ability that stems from it is not definitive of the understanding itself. Such an account is like answering the question about what knowledge is by claiming that knowledge is the ability to assert true statements. It is true that this ability is closely linked to knowledge, but it is not a satisfactory definition of what knowledge is. Following Ylikoski's line of argument, when we evaluate someone's knowledge we test an ability, we literally have them take a test. However, it does not follow that the ability to succeed on an exam constitutes knowledge; rather, it demonstrates an underlying state.

Indeed, we find in Ylikoski an odd tension. He says that, "Understanding consists of knowledge of relations of dependence" (2009, p. 101). Again, in most philosophical and ordinary conceptions, knowledge is a cognitive state, so it is hard to see how understanding can both be treated as an ability and a type of knowledge. Alternatively, it would create a tension to maintain that knowledge is a cognitive state whereas understanding is some entirely distinct kind of thing. There is an interesting debate regarding whether understanding is knowledge or not. Some authors (Achinstein 1983; Lipton 2009) have argued that it is, while others (Kvanvig 2003; Pritchard 2009; Zagzebski 2001) have challenged that idea.[3] However, to make sense of this debate one has to treat knowledge and understanding as having the same sort of ontological standing with respect to the subject who has them, even if one concludes that they are ultimately different.

This comparison also removes the final argument by Ylikoski. This is that "scientific cognition employs various sorts of external representations" (2009, p. 103). The argument is that because scientific understanding can be demonstrated by a community of scientists, a lab, a textbook, etc., it cannot be a mental state, which is purely internal. However, the same might be said of scientific knowledge. When we speak of the scientific knowledge of the community, "knowledge" is used in a complex manner where the collective assertions of the community are treated like the beliefs of an individual. That there can be such a thing as communal scientific knowledge does not imply that knowledge is not fundamentally a belief state, likewise for understanding. More will be said regarding the objective vs. subjective nature of scientific understanding in Section 4.

In an effort to construct a positive account of understanding as an epistemically relevant notion, de Regt and Dieks (2005), expanding on an earlier paper by de Regt (2004) and further refined by de Regt (2009), attempt to spell out a concept of understanding which contains both objective and pragmatic, or contextual, features. De Regt and Dieks maintain that science requires more than the pure descriptive component of the theory. A theory must also be deployed by scientists. In addition to knowledge, this requires the skill-set to *use* the theory. The ability to use a theory depends on a combination of the context-dependent skill-set held by the scientists, but

[3] Though I think that understanding is a type of knowledge, the definition of understanding I offer does not depend on that status, and most conclusions reached in this paper could be adapted without detriment if understanding were not a form of knowledge but a distinct, knowledge-like, epistemological achievement.

it also depends on the pragmatic virtues of the theory itself, such as visualizability or simplicity, which are derivative of objective characteristics of the theory.

According to de Regt and Dieks, the *Criterion for Understanding Phenomena* (CUP) is that, "A phenomenon *P* can be understood if a theory *T* of *P* exists that is intelligible (and meets the usual logical, methodological and empirical requirements)" (2005, p. 150). Intelligibility is defined by the *Criterion for the Intelligibility of Theories* (CIT): "A scientific theory *T* is intelligible for scientists (in context *C*) if they can recognize qualitatively characteristic consequences of *T* without performing exact calculations" (2005, p. 151). It is the notion of intelligibility that permits the understanding of a theory (de Regt 2009). This account explicitly acknowledges the role of pragmatic factors such as "capacities, background knowledge and background beliefs of the scientists in *C*" (de Regt and Dieks 2005, p. 151), which often must be present to be able to qualitatively recognize the consequences of a given theory. On the other hand, de Regt and Dieks reject a completely subjective account of understanding. The theory must be able to be used as a tool according to the skills of the scientists. That is, "a conceptual framework is required in terms of which one can argue qualitatively" (2005, p. 154). This is a feature of the theory, and some may have such a framework and others not. Among the characteristics theories can have which can function as tools for understanding are visualizability, familiarity, and continuity since they allow qualitative means of recognizing consequences of the theory.

The approach of de Regt and Dieks brings with it a number of fruitful consequences in addition to supporting the intuitive connection between explanation and understanding. It allows an account of the variation in intelligibility standards across history and in theories of scientific explanation, including casual-mechanical and unification accounts. And it recognizes the intuitive connection between understanding something and being able to put it to use.

However, there are a number of concerns with de Regt and Dieks' approach. Ultimately, I think that these problems stem from the fact that, like Ylikoski, the authors provide an operationally defined conception of understanding by treating it as an ability. On their view, understanding ultimately is about being able to make qualitative predictions. By the end of this section, I hope to show that there is a further interesting question to be answered: what is it about the various intelligibility criteria—causality, visualizability, unification, etc.—that makes them effective in enabling qualitative judgments? In a sense, de Regt and Dieks have just pushed the question one step further, but it leaves the really interesting question unanswered: What enables that ability? By this question, I do not mean the particular training, practice, social skills, etc. which have enabled the ability. Rather, I mean what is the underlying state of the subject which enables the ability. Again, in the case of knowledge, we might ask what enables successful test taking. One answer is having a good teacher, reading the material, studying, practice, etc. However, the more fundamental answer is that the student KNOWS the material, and that is what enables the ability to do well on an exam. Ultimately, my question is what is that underlying state that we call understanding? It may be that understanding is closely tied to the ability to make qualitative predictions, but on its own, that seems to be a consequence or symptom of the state, not the nature of the state itself.

As an ability, de Regt and Dieks' definition allows fictitious mechanisms to provide understanding if one can glean qualitative predictions from them. De Regt (2004, p.

107) claims that the phlogiston theory can explain, even today, and de Regt and Dieks (2005) discuss the heuristic device of the "MIT bag model" of quark confinement in making qualitative predictions about quantum chromodynamics. Many would reject the view that fictitious mechanisms can explain anything. De Regt and Dieks will have little to say about why the Ptolemaic theory should not be regarded as explanatory. Its practitioners have the ability to use it to make qualitative predictions, thus meeting the intelligibility criterion. On the same continuum, it does not seem that a theory about invisible fairies pulling the sun around the earth every 24 h, with which I can make qualitative predictions, means I understand or can explain the phenomenon. We need some mechanism for ruling out such cases. If this is allowed to count as understanding, then the concept is weakened well beyond its general sense. This problem will exist for any definition of understanding based on ability. One may be able to successfully demonstrate an ability while employing erroneous theories.

There are no doubt uses of "explain" and "understand" which fail to have this factivity—e.g., "Persephone's abduction and subsequent forced habitation in Hades during the winter months *explains* the seasons," "Ptolemaic theory *explains* celestial events," "The teacher used the Bohr model to help the students *understand* atomic structure," or "I *understand* Ptolemaic theory." One source of this comes from the conflation of two uses—understanding a theory and understanding that which the theory is about. On this, I will say more below. Other cases involve degenerate and distinct usages. We use "explain" as shorthand for both purported explanations and genuine explanations. There is an sense in which to explain is to simply give an account of why—it has the form of an explanation, and we might say it is *explanation-like*—but there is a separate sense in which to explain is to give a *true* account of why. Most requests for explanation would fail to be satisfied by a false explanation-like account, even if it is predictively useful. It is not enough that it be in the correct form. For example, say I walk into the living room and the lamp is broken and my child is next to it. I say, "Please explain how this lamp broke!" If the child replies that a leprechaun knocked it off the table, then it would be 'explained' in the degenerative sense, but it has not been REALLY explained. Similarly, if pressed—"Does Ptolemaic theory REALLY explain the motion of the planets?"—one is likely to answer no, and importantly, such a question makes sense (it would not if there were no such distinction). Ptolemaic theory gives a purported explanation; at one time people thought it was an explanation, but now we know it is not, nor was it ever one. This argument is made by Hempel and Oppenheim,[4] saying that,

> This does not appear to accord with sound common usage, which directs us to say that on the basis of the limited initial evidence, the truth of the explanans, and thus the soundness of the explanation, had been quite probable, but that the ampler evidence now available made it highly probable that the explanans was not true, and hence that the account in question was not—and had never been—a correct explanation. (1948, p. 138)

Likewise, I do not REALLY understand something unless my beliefs about it are true, or at least approximately true (see also Pritchard 2009). Otherwise anyone can

[4] Truth as a necessary condition for scientific explanation seems to be implicitly or explicitly shared by many authors writing on scientific explanation.

understand anything if a useful story about any fantastical entities is told. I think there are fewer cases where "understand" is used in a completely non-factive sense though. The occasions we do see it, it is when false models or theories are used as heuristic devices, but we are usually careful to acknowledge they are heuristics, and when understanding comes via them, it is due to their partial or approximate manner of expressing what is really going on. Note also, we do find degenerate uses of "to know"—e.g., "I just KNOW Romney will win the election." Of course, a theory of understanding and explanation should be able to make sense of these degenerative uses, and I think that understanding and explanation are more often used in a degenerative fashion because we do not have a separate term for what I am calling the belief of understanding, whereas with knowledge we have recourse to the label of belief. However, the distinction can be made sense of on my view; whereas, it is much more problematic for an interpretation of understanding in terms of ability.

This is a strong and successful objection, but I would like to qualify it. One might be inclined to object that Newtonian mechanics is explanatory though on the whole false, as are many current theories which might turn out to be false, and that heuristic devices can help understanding. I will say more about this in Section 4, but briefly, if there are elements of truth in past theories, or in current ones, then those elements can provide genuine understanding and explanation. On the other hand, if what we take to be our best theories turn out to be entirely false, then it follows that while we currently think they explain the world, we are mistaken. But again, I think that this is consistent with normal usage. We likewise maintain that we have scientific knowledge. But if it should turn out that our theories are false, then we are mistaken about that as well. We would not want to say that we knew about the world using Ptolemaic theory. We thought we did, but we were wrong.

De Regt and Dieks also accept the familiarity view of explanation—i.e., that explanation is about making the phenomena more familiar. The familiarity view is often rejected on the grounds that familiar phenomena are frequently explained in terms of less familiar theories. De Regt and Dieks address this objection, arguing that while this is the case, scientists develop familiarity with new theories and thus develop the ability to understand with them. With this, I agree. However, it is problematic that mere familiarity could determine whether a theory is explanatory or not, and the ability view of understanding seems to allow this. For instance, one could imagine an astronomical table with all of the celestial phases and events of the past 200 years and a scientist who refers to them so often to make predictions about future events based on patterns that this material is essentially internalized. The scientist is capable of making qualitative predictions as a result of familiarity. However, we would not want to say that there is any understanding of the phenomena. Perhaps this example might be rejected since the table is not a theory. However, a theory could be made of the table by incorporating all of the data into a complex equation which tracks the correlations. In other words, similar to the case of false theories, a scientist may demonstrate an ability using a theory with virtually no content about the empirical world, and thus fail to understand or explain. This issue again demonstrates that the abilities that often do accompany understanding can arise without understanding.

Moreover, de Regt and Dieks allow that quantum mechanics may be explanatory. Whether it is or not is, I think still an unsettled question, but it would be useful to be able to say why some take it to be an unsettled question. Some might argue that here the

phenomena are better explained by using a less qualitatively predictive theory. More importantly perhaps, if it is explanatory, can incompatible interpretations all provide understanding if qualitative predictions can be made by their practitioners as this view would seem to allow?

If intelligibility and qualitative prediction are necessary conditions for understanding, I also worry that this approach may rule out some types of theories as explanatory. For example, consider theories that are highly sensitive to initial conditions, making even rough qualitative prediction impossible, but which nevertheless can provide understanding. Even for a system as simple as a double pendulum it is impossible to make any meaningful qualitative predictions without complex computer models, but it is possible to understand it and explain it without them.

In the above cases, and in others where different senses of understanding might be conflated, it is important to note that there is a sense of intelligibility of a false theory, as in "I understand your theory, but it is completely wrong." But to understand a theory should not be conflated with understanding the phenomena the theory is about. One can understand a false theory without thereby understanding the phenomena it is purportedly describing. While it is important in science to understand our theories, the aim of science is to understand the natural world. In other words, a theory may be intelligible and this may lend itself to being able to be used, but though I understand Ptolemaic astronomy, and can use it to make qualitative predictions, I do not understand the phenomena with this theory.

De Regt (2009) is careful to make this distinction, differentiating between understanding a theory (UT) and understanding a phenomenon (UP). This distinction might be employed to solve some of the problems above. De Regt defines UP as "Having an adequate explanation of the phenomenon" (2009, p. 25). In turn, explanations are defined as "arguments that fit a phenomenon into a broader theoretical framework" (2009, p. 32). This definition is meant to maintain a more objectivist notion of scientific understanding, something Hempel might more readily accept. Finally, CUP is amended to include the condition that "the explanation of P by T meets accepted logical and empirical requirements" (2009, p. 32). If I understand this correctly, to understand a phenomenon, one must have an intelligible theory of it AND that theory must explain it in the sense defined above. This is supposed to rule out understanding by way of theories such as astrology, where a theory may be intelligible, but not explanatory. I would argue that it should also rule out theories such as phlogiston and the MIT bag model, where I see no principled difference between them and astrology. De Regt and Dieks have differing intuitions here. I am not sure their theory supports them. A very important question is what exactly are these explanatory criteria, and how do they rule out astrology, but rule in phlogiston or the MIT bag model?

The problem is this: the fix by de Regt seems to leave the intelligibility of a theory logically independent of other key explanatory virtues. Just as this distinction allows for an intelligible theory such as astrology to fail to produce understanding of the phenomenon if it lacks the necessary explanatory requirements, the flip side is that though a theory is unintelligible, and thus one might not understand the phenomenon, the theory might succeed in explaining it. There is a dilemma here. If on the one hand, intelligibility does most of the work, then it remains to be seen how false theories do not lead to understanding. On the other hand, incorporating the condition of

explanation allows the exclusion of understanding via false theories, but the consequence is that it leaves a much weaker role for intelligibility and decouples it from explanation. CIT is necessary for understanding some phenomenon, but not for explaining it. Explanation, at its core, is now not just about intelligibility or usability, but unification within a theoretical framework. A plausible case had been made about the importance of usability for understanding. But it also appears that this explanatory element is necessary. Why? What does it contribute to understanding, and in what way is it necessary for it? And what of explanation? A primary goal for de Regt and Dieks was to provide an underlying theory of explanation by providing a theory of understanding. De Regt's account of intelligibility fails to engage the notion of explanation, defining it according to standard objectivist criteria such as Hempel or Kitcher. Certain explanatory criteria are asserted to be necessary for understanding, but that notion of explanation is not explicated in terms of understanding so as to explain that necessity.

De Regt and Dieks' criterion of intelligibility is both too broad and too narrow for an adequate account of scientific explanation and the operational definition does not seem to capture the basic concept of understanding employed in ordinary language and by scientists. If other criteria such as explanatory adequacy are added to prevent such problems, the work load is critically shifted away from intelligibility to the added criteria, thus leaving an account of explanation and understanding deficient. The issue is that abilities are overdetermined. To rule out unwanted cases, other criteria must be applied. If other non-trivial criteria are applied, then the ability is not constitutive of what it means to understand.

4 Explaining understanding

What I would like to propose is a concept of understanding not readily used in the philosophy of scientific explanation. It is however a concept which can be found in psychology and in virtue epistemology, where understanding has received attention as the focus of analysis.

Corsini's *Dictionary of Psychology* says the following:

> **understanding** 1. Generally, insight into or comprehension of information acquired from unrelated or related observations and organized through a flexible framework of personal knowledge. (Corsini 2002, p. 1034)

According to this psychological conception of understanding, its key characteristic is that it involves assimilation of the information to be understood into an interconnected framework of knowledge.

One comes across similar views, which emphasize the connective aspect of understanding, in the literature of virtue epistemology. For example, Kvanvig says,

> Understanding requires the grasping of explanatory and other coherence-making relationships in a large and comprehensive body of information. One can know many unrelated pieces of information, but understanding is achieved only when informational items are pieced together by the subject in question. (Kvanvig 2003, p. 192)

Virtue epistemologist Zagzebski derives a similar concept of understanding from Plato's view of knowledge and this also shares some features with that of de Regt and Dieks. Understanding involves skill-like *knowing-how*, and it necessarily "involves seeing the relation of parts to other parts and perhaps even the relation of part to a whole" (Zagzebski 2001, p. 241).

I am not endorsing virtue epistemology, its agent-based approach, or its account of virtue-derived justification of true belief. Likewise, one might reject the agent-based approach of virtue ethics, but recognize that virtue ethics, like virtue epistemology, broadens the scope of meaningful ethical or epistemological properties or traits (e.g., courage or understanding). They have opened the door to allow the exploration of epistemological virtues other than knowledge. What the views quoted above share is the idea that understanding is on a par with, though differs from, simple knowledge and that it consists in a higher level cognitive structure or framework.

To understand something is not simply to know it, but to know of its relation to other knowledge and to be aware of those relationships, to know that knowledge structure. On this view understanding comes in degrees. As such, it would not make sense to say that S understands phenomenon p or theory t if and only if S meets conditions c. This implies that there is some threshold for understanding something and once that is met, it is understood. Instead, understanding of x by S who possesses knowledge K is better defined as a function, $U_s(x)$, which increases as knowledge C of how x relates to other knowledge K possessed by S increases, where C may consist in both knowing how x relates to other knowledge and knowing the overall structure of such knowledge.

What types connections are these? On this view there are no a priori restrictions on what those might be. However, it is generally recognized that there are many different ways that we organize and relate the information we know. They can be connected by logical structures, definitional ones, causal ones, reductive/unifying ones, by analogy, etc. Basically, the kinds of relations allowed are shaped by our actual cognitive nature and the actual relations out there in the world. Discovering those connections and capacities is in part an empirical enterprise, while developing norms for the rationality of such frameworks comes from fields such as philosophy, science, mathematics, statistics, logic, linguistics, and so forth. I will introduce more specific examples in Section 5, where I discuss the pluralistic view this implies.

My argument for this position is three-fold. First, it involves an appeal to authority or consensus, at least in terms of its motivation. If conceptual analysis reveals that understanding is a particular kind of cognitive state, then any influential or consensus view of understanding among developmental and cognitive psychologists and those who have tried to define the term as it is used should carry some weight. Second, this concept of understanding fits well with our intuitive grasp of the concept, allowing flexibility while maintaining an objective criterion for understanding. It permits the development of a well-defined concept and vocabulary. Finally, this view yields fruitful consequences when applied to the concept of scientific explanation. If explanation is about providing understanding, any successful theory of explanation should be able to explicate that relationship. Furthermore, what it is to understand should inform our theory of explanation. This theory of understanding has that potential, including a more comprehensive account of various types of explanation such as causation or unification.

On this view, understanding is a kind of knowledge. Understanding involves the relating of some knowledge to other knowledge, so in a minimal sense it is different

from *mere* knowledge. Consider, for example, a brute fact or a piece of knowledge completely isolated from any other beliefs. In such cases, it is reasonable to say that we would merely know such a thing to be the case, but do not understand it. There is a distinction between this kind of isolated knowledge, which is not connected to any other beliefs, and knowledge which is. However, once knowledge is connected, how connected that piece of knowledge is admits of matters of degree. Knowledge which is mere knowledge and knowledge which contributes to understanding are not different in kind from each other in terms of their intrinsic nature as knowledge, but they are different in the sense that understanding is knowledge which involves a higher order connection to other knowledge.[5]

Because I will later appeal to Railton's (1981) account of explanation, I will use his example here of a clicking Geiger counter. If I know nothing of Geiger counters or radiation, the fact that the device clicks near a particular rock is simply an isolated fact that I know. As more knowledge is added and connected to that fact—that the rock is uranium, that uranium is radioactive, what radioactivity is, the mechanics of the Geiger counter, etc.—my understanding increases by degrees. There is therefore a genuine difference between knowledge simpliciter and understanding, and they have different characteristics; but it allows understanding to be a kind of knowledge, and that understanding admits of degrees.

In fact, this view accounts for a particular debate in the history of scientific explanation[6]: is explanation different from description, and if so, how? On this view, explanation is not some scientific aim whose difference from description arises due to some kind of special explanatory relation. Since understanding is a particular form of knowledge, explanation consists in a certain type of description. Understanding is about making connections between various pieces of information. Thus explanation is about describing the various connections between facts. That type of connection is not limited to a causal one, or unification within an argument structure, or any single one of these. What makes explanations different from mere knowledge is not that there is some special explanatory relationship as other theories maintain, but that the level of description is different.

And if understanding is a kind of higher order knowledge, then there is no reason to think that it is less of a scientific aim than knowledge in general.

As discussed, there are a number of alternative accounts of understanding. There is the idea that understanding is more or less equated with the "aha" feeling. But this captures only the emotive feeling that can accompany understanding. There is the definition of understanding by usability. The account under consideration here, however, describes the cognitive state of understanding, as opposed to the behavior

[5] In this paper, I have maintained a neutral position with regards to the nature of knowledge itself. For the most part, I have treated knowledge as propositional knowledge, but I think that this view of understanding is compatible with alternative non-propositional theories of knowledge. Indeed, some philosophers have argued that understanding is non-propositional (see Zagzebski (2001)). I do not think this distinguishes understanding from knowledge, it just highlights the possible distinction between propositional and non-propositional knowledge, which involves a separate debate, but one which does not directly affect the argument presented here.

[6] For example, see (Hempel and Oppenheim 1948; Scriven 1962; Salmon 1989; de Regt and Dieks 2005; Woodward 2009).

characteristic of that state. In addition, it is able to account for the intuitions behind these alternative views.

It allows there to be an emotive feeling which accompanies genuine understanding, the linking together of various ideas, as a feeling of success.[7] This feeling can lead to erroneous conviction if it is attached to a belief that is false. However, it seems likely that, all things being equal, *belief of understanding* is harder to come by that mere *belief*. If you believe you understand something, then it must fit in with other things you believe. That very consistency can lend credence to the truth of the belief. This may also account for the idea expressed by Trout that believing one understands something leads one to believe more strongly that it is true.

With regard to the approach of de Regt and Dieks, the account advanced here explains the intuition that understanding is closely tied to use, since the ability to use some piece of information, often requires fitting it into a larger framework of knowledge—under what circumstances it applies, what tools are needed to implement the knowledge, the technical skills needed to apply it to particulars, etc.

We can also unify the notions of understanding a theory and understanding a phenomenon. When we talk about understanding a *theory*, there is understanding, but the referent is different. What is understood is not the phenomenon the theory is supposed to be about, but the theory itself. This involves understanding the concepts it employs, the connections and analogies it makes, the causal story it is telling, the argument structure, the counterfactuals involved if it were to be true, etc. In this, the difference is explaining a theory versus the theory explaining some phenomena. It is therefore likely that one must understand a theory to understand a phenomenon, as de Regt argues. However, this view need not employ external criteria to explain how one can understand a false theory without understanding the phenomena. One may understand a theory but think it false and not understand the phenomena. One may understand a theory and think it true but be wrong and so not understand the phenomena. In neither case does the intelligible theory explain anything.

This account is not subjective in the sense of depending on feeling or sentiment. However, there is a contextual element since it defines understanding in terms of the knowledge of some subject or subjects. The contextual or pragmatic elements of explanation, which many have remarked upon, can be accounted for. This flexibility allows for the strengths found in the de Regt and Dieks approach. This approach recognizes the contextuality of understanding and explanation, and the practice of science bears this out, as does the ongoing conversation about types of scientific explanation and their reconciliation. Since worldviews, beliefs, and knowledge are contingent and contextual facts, what is seen as producing understanding is likewise contextual.

However, this does not radically subjectivize the notion of scientific explanation or understanding. There are other cognitive states, such as believing, expecting, and knowing, which are proper objective goals of science, and this is generally acknowledged without controversy. Friedman makes this point, saying, "[A]lthough the notion

[7] See Gopnik (1998, p. 102), who argues that "explanation is to cognition as orgasm is to reproduction." What motivates children and scientists to "experiment" and expend energy to develop and reorganize theories is the payoff, not in terms of long term goals of survival, but the "distinctive phenomenology of explanation." The search for explanation is prompted by the "hmm" and the success rewarded by the "aha".

of understanding, like knowledge and belief but unlike truth, just is a psychological notion, I don't see why it can't be a perfectly objective one" (1974, p. 8). Not everyone will believe or know the same things, and this is dependent on many factors, including worldview, access, education, background beliefs, and so forth. One of the more obvious goals of science is to guide such belief states towards accuracy—either towards truth about the world or towards accurate predictive power. Therefore, belief is a subjective psychological state in one sense, but in another sense, there is a great deal that can be said about what constitutes rational belief and how our scientific beliefs ought to be structured. Though understanding, as a psychological state, has received less attention than belief states, that it is psychological does not by itself imply that it is any less legitimate in the aims of science than is knowledge.

This account can be bolstered by appropriating and adapting some of Railton's (1981) account of explanation. Theoretically, there may be some complete or ideal explanation for some phenomena. The *ideal understanding text*, on this view, consists of a complete framework of all possible propositions about the phenomena, including their various relationships. However, access to that ideal text is likely to be limited and focused. Therefore, an explanation can occur whenever understanding is increased by tying beliefs about the phenomena to other beliefs. Thus, explanation and understanding can come in degrees, from the quite trivial to the very expansive, and be pragmatically focused. In addition, knowledge and understanding can be states which apply to the individual, but there is also a collective sense of these concepts when we are talking about scientific knowledge or scientific understanding. So while a particular explanation may not increase my understanding due to my lack of expertise, there is an objective sense in which it is explanation, since it is providing part of the ideal understanding text, and for a subject with different beliefs, that explanation would increase their understanding.

One might also object that this conception of understanding, as a systematization of knowledge, is too broad or too vague, allowing too much to count as explanation, or that it is a deflationary account. However, while on this view of understanding there is no a priori limit to what types of theories might conceivably generate understanding, there are some principled ways of rejecting purported explanations given what else is part of the general body of knowledge. So in a certain sense it is deflationary. It does deflate a strong and independent notion of explanatory relevance. It allows many relations among our knowledge to contribute to understanding. However, it is not vacuous. It does require relation-making knowledge. As such, not everything contributes to understanding, and there is a rough measure of how much understanding is produced, since it is proportional to the strength and number of connections that are made. What counts as understanding is regulated by two things, what our body of knowledge is, and contingent facts about our cognitive capacity for forming knowledge structures.

Suppose I know that p and I know that q. If I conjoin these unrelated beliefs, connecting them together, it follows that I know that *p and q*. While this is a connection between my beliefs, we might be reluctant to say that my understanding has increased. The resolution for this puzzle lies in the nature of the connection in the context of all of my other beliefs. It follows from my definition that my understanding increases by any increase in knowledge C of how x relates to other knowledge K, however small or trivial that connection is. and I think this is so. However, in the case of conjunction, that

increase is vanishingly tiny or zero. If I know what "*p and q*" means, I know what conjunction means, and in particular that I can conjoin any two propositions. Thus, I know that knowing *p and q* automatically follows from any two facts, and thus it never implies anything about other nodes or connections, because my knowledge *C* of how *p* (or *q*) relates to other knowledge *K* has not changed. However, a case like Railton's Geiger counter example related above would increase understanding, and would provide explanatory information, even if that amount is quite minimal.

A corollary of the view, however, is that not everything counts as explanation. My definition, for instance, would allow the rejection of fictitious mechanisms as explanatory since they are inconsistent with other things that are known—they do not provide understanding. Likewise, it would allow for the rejection of false theories, such as Ptolemaic cosmology, in a way that the intelligibility criterion has difficulty with. It would also reject purely predictive instruments such as de Regt and Dieks' hypothetical black box oracle as explanatory. Results generated by such a perfectly predictive device, while empirically accurate, are isolated from other knowledge. Thus, like the approach of de Regt and Dieks, this view anticipates the various types of scientific explanation that have been accepted and that have been suggested in the philosophy of explanation. However, this view is capable of rejecting some theories as non-explanatory where de Regt and Dieks cannot. Since understanding is about coherence with other true beliefs, if a purported explanation fails to connect with or is inconsistent with other true beliefs, then there is not genuine understanding. If some theoretical construct is known to be false, then though it might be of instrumental value, it cannot aid in understanding since it is inconsistent with other things that are known.

Railton's account would also help capture the idea that some overall false theories may in fact explain within a certain domain. Newtonian mechanics, for example, can explain since it systematizes many beliefs such that many of the connections are accurate, despite there being false ones. For those that are true, understanding and explanation are gained within the scope of that particular domain.

A closely related issue is the status of our current theories. Based on current inadequacies and historical precedent, it seems likely our best theories will be revised or replaced. Does this mean we have no understanding? Unfortunately, I cannot respond with an unequivocal yes. However, as a problem, it is a general one, not specific to this concept of understanding. It is a problem closely tied to the issue of scientific realism. Is what we currently call scientific knowledge really knowledge given that it could be, and is perhaps likely to be, false? Whatever we might say about this issue, it will be tied to ideas related to realism and increasing truth, or approximate truth, and so forth. Whatever we might say about the existence of scientific knowledge in the face of incomplete data will apply to understanding.

5 Understanding and explanatory pluralism

The definition of understanding advanced in this paper explains how various accounts of explanation are ones which produce understanding. While part of the same whole, there are broadly two different ways that explanation can occur. One is to increase understanding by connecting various pieces of knowledge. So for example, explanation

by theoretical unification or reduction is certainly a method of tying different knowledge together. Therefore, it increases understanding, and thereby explains.

While my account of understanding accounts for how unification such as Friedman's or Kitcher's can explain, it is different from those accounts. On those views, understanding arises in virtue of reduction of the number of argument patterns or brute facts; less things to know provides global understanding. On my view, understanding is local and arises in virtue of the interconnectedness of knowledge, which may or may not involve reduction or systematization in the former sense. On those views understanding arises in virtue of having a simpler picture of the world, since one is required to accept fewer independent beliefs. In this case, there need be no such global systematization. Understanding something arises simply because it can be fit into a nexus of knowledge, analogous to a causal nexus to co-opt language from causal accounts of explanation. But fitting it into that structure need not simplify the structure in any way.

An explanation can also explain by demonstrating why some alternative, that we might otherwise have expected, is not the case. In cases like this, our beliefs are aligned in a certain way, and the phenomenon to be explained does not fit with those beliefs. An explanation would bring about understanding by accounting for apparent conflicts, or by removing them. If we are aware of conflicting knowledge, then we are aware of a deficiency in understanding. Research suggests that the stronger our schemas are, the more we attend to inconsistent knowledge and seek to incorporate it or to alter our schemas (Legare et al. 2010).

This is how this notion of understanding can account for the intuitive link between causation and explanation, but not be as inflexible as some, such as Cushing (1991), who asserts that causality is necessary for understanding (which seems unjustifiably restrictive). As philosophers such as Hume and Kant argue, and as developmental psychologists are finding, humans understand many aspects of the world—physically, biologically, and psychologically—in terms of causal structure. For example, there is evidence that infants as young as 2 1/2–5 months have expectations regarding hidden objects and can detect violations in continuity, object permanence, solidity, and persistence; that is, that objects exist and move continuously in time and space and retain their physical properties (Baillargeon 2008; Spelke 1994). In a series of experiments by Gopnik (2011), young children have demonstrated fairly complicated causal reasoning including using conditional probabilistic reasoning, inferring hidden variables, and that they can make inferences using causal interventions.

I cannot summarize all of the research on causal reasoning in this paper, and though the work is all very exciting, there remain more questions than answers. Nevertheless, there is good evidence that causal reasoning, whether learned or innate, is an early and fundamental belief, and I do not think this is a particularly controversial claim.

As a core belief about the world, causation is an important, and permeating, component of our network of knowledge, insofar as our causal understanding reflects genuine features of the world. On my account of understanding, information is better understood if it fits into that network of knowledge, and in tension with fundamental causal beliefs if it does not. So, while causation is not necessary for understanding in principle (other types of explanation, such as unification, can make connections in our knowledge), as a fundamental—perhaps native—worldview, phenomena which are not fitted to a causal framework remain conspicuously outside a comprehensive body of information, and thus not fully understood. Information which *conflicts* with that causal

framework, likewise, presents a blatant barrier to satisfactory understanding. The only way to understand such information fully requires a significant revision in beliefs. From an early age, children seem to exhibit the same kind of surprise and registration of a violation of causal expectations. Legare et al. (2010) showed that children are more motivated to provide explanations for events inconsistent with prior knowledge than consistent ones.

The ideal explanatory text involves the strong and overriding belief that all events have a cause, and this sets up, more often than not, the most relevant contrast class as a causal one. A theory such as quantum mechanics shows how difficult it is to accept a theory as explanatory if it contradicts standard causal reasoning. In this case, it is not simply that the theory does not connect with our causal beliefs, but that it actually conflicts with them, thus leading many to balk at the theory's explanatory capacity. Any cases of conflicting knowledge pose a challenge to complete understanding, and thus beg for explanation.

This view would also account for other modes of explanation such as covering law models, functional explanations, and types of explanation which occur by establishing a coherent conceptual framework, as does special relativity by defining meaningful concepts of simultaneity and inertial motion (Van Camp 2011). Similar types of understanding are considered by Lipton (2009), who discusses understanding by necessity or possibility in addition to causality or unification. For example, Galileo offers a thought experiment against the Aristotelian idea that bodies accelerate at rates proportional to their mass by showing that it is conceptually incoherent. If mass determines acceleration, then two bodies connected together should accelerate at different rates, the lighter body slowing the heavier, and thus accelerating at a slower rate than the heavier body would alone. Considered as a combined object, however, they ought to accelerate at a greater rate than the heavy mass alone since the total mass is greater. Lipton's point is to argue that not all instances of understanding arise from or involve an explanation. Lipton concludes, "I understand why acceleration must be independent of mass; but if you ask me to explain why acceleration is independent of mass, I can't do it" (Lipton 2009, p. 47). I do not intend to address that issue here.[8] It does not really impact my argument since my claim is that explanation produces understanding and not that all instances of understanding result from explanations. However, it is relevant to note that Lipton's intuitions are that there are four types of understanding, "of causes, of necessity, of possibility, and of unification" (2009, p. 43). The virtue of the account developed in this paper is that it can explain all of these forms of understanding without mere appeal to intuition or the feeling of understanding.

If understanding is produced by connecting information to a framework of knowledge, and explanation is about producing understanding, then a theory is explanatory if it is has characteristics that are conducive to connecting knowledge—that offer structures that facilitate higher order knowledge structures. To explain is to provide a true description, but what makes it different from mere description is the same kind of higher order structure which makes understanding differ from mere knowledge. Thus

[8] I do not want to challenge Lipton's intuitions here, but I could imagine equally well-considered intuitions on the other side—e.g., that the thought experiment is explanatory. And I suspect there is a small but meaningful slippage in language from understanding the *necessity* of the phenomenon to explaining the phenomenon *itself*. If those are made consistent, the discrepancy might disappear. I do not think this is any easy question to answer, since it depends a great deal on intuitions about what is and is not an explanation and understanding.

an explanation cannot just be an instrument of prediction. It is a higher order description that establishes a relation between informational items—theories, various facts, facts and theories, the structure of a theory, etc.

When we ask for an explanation, we are asking why something is the way that it is. We are asking a *why* question, expecting a *because* answer. It has been recognized for a very long time that there is no one answer, or even one type of answer to such a question. Aristotle's four causes are proffered as the list of possible types of answers that can be given to a why question. All are correct, though they answer it in different ways. One thing underwrites them all however, and that is that the question of why something is the way that it is a call for understanding that thing. There are different ways to understand it, but in all cases, the understanding is realized by connecting the explanandum to other things we know.

So yes, on this view a great deal does count as explanatory—and this accords with the recent interest in explanatory pluralism. But there is a defining structure to explanation as well. To a large extent, while I view this as a somewhat descriptive enterprise about what we call explanation, what cognitive structures can provide understanding, and what scientists view as understanding, for those who want a normative theory of explanation, this view can meet that need as well. Without being able to definitively and objectively determine that one proposed explanation is superior to another, this view can say something. It does this not by imposing an external criterion on explanatory goodness. Rather, according to the nature of understanding, there is a non-trivial and non-circular internal self-evaluative mechanism. Instead of requiring that an explanation have a certain form (except in a very broad sense) the definition establishes an internal coherence condition and thereby a rough gauge of the level of understanding—some theories will rank above others based on other knowledge. Sometimes there will be no definitive ranking, but this accords with the pragmatic nature of explanation. Sometimes two or more explanations can explain the same phenomenon. Other times it is clear that an explanation comes up short. The reason for this is that the explanation fails to connect the phenomenon to be explained with other knowledge we possess, or only does so in a way that is weak according to other things we know.

6 Conclusion

The question of what explanation is has been shifted to what understanding is, and thereby shifted to what it means to build a coherent structure of knowledge. Interestingly, the philosophy of explanation becomes the study of what types of cognitive connections between information there are or are possible. This is as much an empirical question as a philosophical one. What counts as fitting knowledge into a pattern? How are humans successful at cognitive organization? What are the structures by which our minds must organize knowledge and beliefs, and how? We already have answers to some of these questions—causal-mechanical explanation and unification being prime examples. More is being done to determine what working scientists consider understanding. But many open questions remain: What psychological mechanisms are involved in theory formation? How do we represent objects, processes, etc.? As Knuuttila and Merz (2009) describe, models seem to play an important role in

producing understanding. How can the literature on models be tied to the theory of understanding as a cognitive structure? One of the most interesting and important questions involves the empirical investigation into the nature of causal reasoning. What is the structure of our causal worldview? How flexible is it? How innate is it?

The primary lesson here is that it is only if we understand understanding that such questions can really be addressed and that the concept of understanding argued for in this paper has the promise of having all the conceptual potential to address them. In terms of addressing Salmon's (1989, p. 5) goal of meeting Carnap's criteria for successful explication the definition of understanding as outlined in this paper is promising. The definition is similar to the explicandum—it matches the intuitive notion of what explanation is. It is more exact than the term it replaces. It is fruitful in terms of what it allows us to say about explanation and understanding. And it is a simple definition, not requiring some special explanatory relation.

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