Scientific Understanding and Explanatory Integration in the Cognitive Sciences

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Abstract. Scientific understanding in the field of cognitive sciences is a multifaceted concept that necessitates the reflection on the integration of various explanations. In this paper, I argue that different kinds of explanations regarding cognitive sciences can be integrated into an account of explanatory scientific understanding, as proposed by Khalifa. Moreover, I propose that scientific understanding should be distinct from mere knowledge and should be conceptualized as a nexus of explanation. This paper explores the theoretical foundations of scientific understanding, discusses different types of explanations in cognitive sciences, criticises a reduction problem in Khalifa's account and elucidates how these explanations can be effectively integrated to foster a holistic understanding of cognitive phenomena. Through an interdisciplinary approach, the aim of this paper is to enrich our comprehension of cognitive sciences and promote a more unified perspective on scientific understanding.

Keywords: Explanatory Integration · Scientific Understanding · Cognitive Sciences.

1 Introduction

Scientific understanding is a pivotal concept in the scientific domain and the specific area of cognitive sciences in the last decades has tremendously increased our understanding of cognitive phenomena. Cognitive scientists endeavour to provide an explanation of the functioning of our minds, including our capacity to comprehend language and grasp concepts such as the reason why the sky appears blue or why reducing carbon emissions is crucial to mitigate climate change. Therefore, philosophers who study understanding and scientific comprehension should concentrate on refining their theoretical frameworks and methodologies. This is indeed the case of Khalifa, Islam, Gamboa, Wilkenfled and Kostić (2022), which advance a way to illuminate the explanatory integration issue in the cognitive sciences on the base of Khalifa's account of scientific understanding. Given the interdisciplinary origins of cognitive sciences, we find between their theoretical posits and methodological tools. In particular, cognitive sciences to comprehend the intricate workings of the human mind must employ diverse explanations that span various disciplines, such as psychology, neuroscience, philosophy, and artificial intelligence. Tracking back to the development of the cognitive sciences reveals two main approaches towards the object of research and the methodologies implied: unification and pluralism. These two approaches reflect the philosophical view about the unity of science as debated in the Vienna Circle. According to Neurath (1937), a defender of pluralism, sciences should have been coordinated. Carnap instead argues that all sciences should be reduced to one grand unifying theory. While, according to Getner (2019), at the foundation of cognitive sciences researchers were predominantly pluralistic, views of reductive unity were prominent in the 1960s thanks to the manifesto of Oppenheim and Putnam (1958), but the received view on reduction cannot be applicable to cognitive theories. In the last years, some scholars have argued that it is possible to attain a unified science of cognition "by showing how functional analyses of cognitive capacities can be and in some cases have been integrated with the multilevel mechanistic explanations of neural systems" (Piccinini and Craver 2011). It remains although the crucial problem is that we do not have an efficient account of what explanatory integration entails (Miłkowski 2016).

Khalifa's account of explanatory scientific understanding provides a framework to integrate these diverse explanations into a unified understanding. However, it is imperative to distinguish scientific understanding from mere knowledge and emphasize its role as a nexus of explanation. In this paper, I delve into the theoretical underpinnings of scientific understanding, elucidate the different types of explanations in cognitive sciences, and argue for the integration of these explanations to facilitate an integrative perspective on cognitive phenomena.

2 Contrasting Khalifa's and De Regt's Accounts of Scientific Understanding

Scientific understanding is a multifaceted concept that has garnered significant attention among philosophers of science. Two prominent scholars, Khalifa and De Regt, have proposed distinct accounts of scientific understanding that illuminate different aspects of this complex phenomenon. In this discussion, we will explore and contrast Khalifa's (2012, 2013a, 2013b, 2017, 2019, 2023) account of scientific understanding with De Regt's (2005, 2017) perspective, shedding light on their fundamental differences. Khalifa's account of scientific understanding emphasizes the importance of integrating diverse explanations to achieve a holistic grasp of natural phenomena. According to Khalifa, scientific understanding goes beyond mere knowledge acquisition; it involves gaining insight into the causal-mechanical, structural, and functional aspects of a phenomenon. This perspective contends that understanding arises when we appreciate the interplay of these three explanatory components. Khalifa's framework is rooted in the idea that scientific understanding is not a mere collection of facts but a deeper comprehension of the underlying mechanisms, organization, and purpose behind natural phenomena.

Khalifa's account places a strong emphasis on interdisciplinary collaboration and the integration of different types of explanations from various scientific disciplines. It underscores the need to connect the dots between causal-mechanical, structural, and functional explanations, recognizing that a comprehensive understanding emerges when these facets are interwoven. It is one of the most demanding accounts of scientific understanding and it requires that experts evaluate their explanations according to the best available methods and evidence. There are three main principles supporting his model of scientific understanding, called Explanation, Knowledge and Science (EKS). The first is the *Explanatory Floor*: Understanding why Y requires possession of a correct explanation of why Y. scientific understanding can improve and Khalifa describes the *Nexus Principle*: Understanding why Y improves in proportion to the amount of correct explanatory information about Y (=Y's explanatory nexus) in one's possession. The third principle is the *Scientific Knowledge Principle*: Understanding why Y improves as one's possession of explanatory information about Y bears greater resemblance to scientific knowledge of Y's explanatory nexus. This last principle gives the idea that even the same explanatory information could be linked to different degrees of understanding, given the abilities and the information of relevant theories, models, empirical observation and experience scientists can have. Khalifa gives also a detailed definition of scientific knowledge of explanation (SKE): An agent S has scientific knowledge of why Y if and only if there is some X such that S's belief that X *explains* Y is the safe result of S's scientific explanatory evaluation (SEEing). He concludes that thanks to SEEing and safety, the epistemological concept that requires an agent's belief to not easily have been given the way in which it was formed (Pritchard 2009), scientific knowledge of an explanation is achieved when "one's commitment to an explanation could not easily have been false given the way that one considered and compared that explanation to plausible alternative explanations of the same phenomenon" (Khalifa, Islam, Gamboa, Wilkenfled and Kostić 2022: 8). Khalifa and colleagues then argue that his framework of scientific understanding provides a "fruitful account how different explanations, such as the ones discussed above, can be integrated. The Nexus Principle is the key engine of integration" (Khalifa, Islam, Gamboa, Wilkenfled and Kostić 2022: 8).

In contrast, De Regt's contextualism cannot fit well to address the explanatory integration in cognitive sciences. In fact, due to his Criterion of Understanding Phenomenon (CUP), supporting scientific understanding, he cannot account for the integration of different kinds of explanations. According to CUP: A phenomenon p is understood scientifically if and only if there is an explanation of p that is based on an intelligible theory T and conforms to the basic epistemic values of empirical adequacy and internal consistency. Given the multiplicity of the entangled kinds of explanations in cognitive sciences, we should eschew De Regt's contextual theory, if we want to improve the explanatory integration in cognitive sciences.

De Regt's account of scientific understanding focuses also on the role of scientific models in the acquisition of understanding. He argues that understanding arises from an intimate familiarity with and a deep engagement in the use of scientific models. De Regt contends that scientific understanding is closely linked to our ability to manipulate, apply, and navigate these models effectively.

De Regt's account places less emphasis on the integration of different types of explanations and more on the centrality of models in scientific practice. For De Regt, understanding is intimately tied to our ability to make predictions, explain phenomena, and solve problems using these models. The more proficient one can employ a model to achieve these goals, the deeper one understands the relevant scientific domain.

The critical distinction between Khalifa's and De Regt's accounts lies in their conceptions of what constitutes scientific understanding. Khalifa's perspective emphasizes a broader understanding that integrates various types of explanations, fostering a comprehensive grasp of complex phenomena. In contrast, De Regt's account narrows the focus to the practical utility of scientific models in achieving understanding.

Additionally, Khalifa's account highlights the importance of interdisciplinary collaboration, encouraging the integration of insights from different scientific disciplines to enrich understanding. While acknowledging the importance of models, De Regt's account does not explicitly emphasize interdisciplinary integration to the same extent.

In summary, Khalifa and De Regt offer distinct perspectives on scientific understanding, with Khalifa focusing on the integration of diverse explanations and De Regt highlighting the role of scientific models in achieving understanding. These accounts provide valuable insights into the multifaceted nature of scientific understanding and offer different lenses through which we can explore and appreciate the richness of this concept in the philosophy of science.

3 Kinds of Explanations in Cognitive Sciences

Those defending the integration of mechanistic explanations "will take integrations of these explanations to be able to explain cognitive competencies such as language production and comprehension, memory, perception, problem solving, categorisation, and reasoning; but also general, flexible behaviours and real-time performance, as well as the processes of learning and development that are characteristic of the human cognitive system" (Taylor 2019: 4575-76).

3.1 Mechanistic

Mechanistic (Bechtel and Richardson, 1993; Machamer et al., 2000; Craver, 2007; Illari and Williamson, 2010; Glennan, 2017; Craver and Tabery, 2019). Widespread in the cog sciences. There is no consensus on the proper characterization of mechanisms or how exactly they figure in mechanistic explanations. Glennan's conception of mechanism: A mechanism for a phenomenon consists of entities (or parts) whose activities and interactions are organized so as to be responsible for the phenomenon.

Action potential: a mechanistic explanation of this phenomenon specifies parts such as voltage-gated sodium and potassium channels. It describes how activities of the parts like influx and efflux of ions through the channels underlie the rapid changes in membrane potential. - - - mechanistic explanations spell out the relevant physical details.

Hodgin and Huxley model is a major achievement that is not a mechanistic explanation of the action potential.

Marraffa and Paternoster (2013: 14) describe well how the account of explanatory integration given by Craver (2007) and collegues such as Becthel (2009), entails a sort of "inter-level" mechanistis explanations: "Craver (2007) examines the development of the explanations of Long-Term Potentiation (LTP) and spatial memory. He distinguishes at least four levels. At the top of the hierarchy (the behavioral-organismic level) are memory and learning, which are investigated by behavioral tests. Below that level is the hippocampus and the computational processes it is supposed to perform to generate spatial maps. At a still lower level are the hippocampal synapses inducing LTP. And finally, at the lowest level, are the activities of the molecules of the hippocampal synapses underlying LTP (e.g., the N-methyl Daspartate receptor activating and inactivating). These are "mechanistic levels" or "levels of mechanisms": the N-methyl D-aspartate receptor is a component of the LTP mechanism, LTP is a component of the mechanism generating spatial maps, and the formation of spatial maps is a part of the spatial navigation mechanism. Integrating these four mechanistic levels requires both a "looking up" integration, which will show that an item (LTP) is a part of a upper-level mechanism (a computational-hippocampal mechanism); and a "looking down" integration, which will describe the lower-level mechanisms underlying the higher-level phenomenon (the molecular mechanisms of LTP)". According to mechanists, this account is well-suited to define the explanatory integration in cognitive sciences. Due to the redefinition of explanations under the label of information concerning mechanisms involved in cognitive phenomena, this kind of explanation gives rise to what Khalifa (2022) calls the Mechanistic-Based Integration of explanations in cognitive sciences.

3.2 Computational

Most prominent alternative to mechanistic explanations in the philosophical literature: they are considered a subset of functional explanations – explain phenomena by appealing to their function and the functional organization of their parts (Fodor, 1968; Cummins, 1975, 1983, 2000) The functions to which they appeal involve information processing. In computational explanations, a phenomenon is explained in terms of a system performing a computation. A computation involves the processing of input information according to a series of specified operations that results in output information. Many computational explanations describe the object of computation as having representational content, but some challenge this as a universal constraint on computational explanations.

3.3 Topological

In topological explanations a phenomenon is explained by appeal to graph-theoretic properties. Scientist infer a network's structure from data, and then apply various graph-theoretic algorithms to measure its topological properties. Node's neighborhood. A triplet of nodes is any three nodes that are connected by at least two edges.

3.4 Dynamical

Phenomena are accounted for using resources of dynamic system theory. A system is dynamical if its state space can be described using differential equations, paradigmatically of the following form:

The equation describes the evolution of the system over time. Dynamic explanations of bimanual coordination – explanation rests on the fact that only the in – and – anti – phase oscillations of the index fingers are basins of attraction.

4 Scientific Understanding and Explanatory Integration

Scientific understanding is a multifaceted and dynamic concept that plays a central role in the field of cognitive science. Understanding the science behind human cognitive functions is a complex and ever-evolving area. The human mind is intricate and demands explanations from various disciplines, such as neuroscience, psychology, philosophy, and artificial intelligence. Case studies in cognitive science demonstrate that scientific understanding can act as a unifying framework that brings together various explanations from these different fields. This does not mean that explanations get reduced to a singular framework, rather it embraces the diversity of explanations and offers a more holistic and integrative perspective. This integrative scientific understanding is characterized by its depth, coherence, pragmatism, and ability to encourage interdisciplinary collaboration, ultimately enriching our understanding of cognitive phenomena. Khalifa and colleagues (2022) propose two main ways to integrate different kind of explanations in cognitive sciences: the Understanding-Based Integration (UBI) and the Mechanism-Based Integration (MBI). UBI is ultimately a new view about explanatory integration in cognitive sciences, while MBI concerns the received view about explanatory integration aiming at unifying the different levels of explanation in a mechanistic one. According to Taylor (2021) we should not accept to dismiss cross-explanatory integrations of mechanistic, dynamicist, psychological, computational and topological explanations in cognitive sciences, as instead some philosophers argue (Kaplan and Carver 2011; Miłkowski 2016; Piccinini and Craver 2011). Khalifa defends pluralism in cognitive sciences for explanatory integration, proposing an account based on scientific understanding. On the other hand, MBI provides that all models in the cognitive sciences are explanatory only insofar as they give information about mechanistic explanations. Against this, defenders of pluralism provide examples of putatively non-mechanistic explanations. In response, MBI philosophers use two strategies. The negative strategy consists in revealing that the putatively non-mechanistic explanation are no explanation at all (Kaplan 2011; Kaplan and Craver 2011).

The other strategy is assimilation and reveals the putatively non-mechanistic explanation to be a mechanistic explanation but with an elliptical nature (Piccinini 2006, 205, Piccinini and Craver 2011, Miłkowski 2013; Povich 2015; Hochstein 2016). I do not contrast the argumentation of Khalifa and colleagues, although I suggest that they imply some conditions to be outlined: Dept of Understanding, Coherence Across Explanations, Pragmatic Utility, Interdisciplinary Collaboration, and Non-Reductive Nature of Understanding. I sketch these conditions in the following lines, suggesting that their satisfaction could improve Khalifa and colleagues' account of UBI, even if they leave some open problems.

Depth of Understanding:

Scientific understanding, as demonstrated in cognitive sciences case studies, delves beyond surface-level knowledge. It encompasses the ability to penetrate the layers of causality, mechanisms, structures, and functions that underpin cognitive processes. For instance, when exploring the concept of mirror neurons, scientists go beyond the mere awareness of their existence and investigate the neural mechanisms (causal-mechanical explanations), how they relate to imitative behaviours (structural explanations), and why they evolved (functional explanations). This depth of understanding allows cognitive scientists to gain a comprehensive insight into the phenomena they study, providing a richer and more nuanced perspective than mere factual knowledge.

Coherence Across Explanations:

One distinguishing feature of this integrative scientific understanding is its capacity to weave together disparate threads of explanation into a cohesive tapestry. Rather than isolating causal-mechanical, structural, and functional explanations, it seeks to align and integrate them. In doing so, it not only connects the dots but also identifies the points of convergence and divergence within the explanations. This coherence fosters a more comprehensive and interconnected view of cognitive phenomena, highlighting the intricate relationships between different facets of understanding.

Pragmatic Utility:

Scientific understanding, in its integrative form, is pragmatically useful. It is not a purely theoretical construct but rather a tool that aids researchers in making predictions, explaining observations, and solving complex problems. Consider the study of working memory and executive function. Integrating insights from neuroscience, cognitive psychology, and artificial intelligence enables researchers to develop practical models that simulate and predict these cognitive processes. This pragmatic utility not only deepens our understanding but also allows for the application of cognitive science findings in practical domains like education, healthcare, and technology development.

Interdisciplinary Collaboration:

Perhaps one of the most striking features of this form of scientific understanding is its ability to foster interdisciplinary collaboration. In the case studies mentioned earlier, the integration of neuroscientific, psychological, and computational explanations exemplifies how cognitive scientists from diverse backgrounds can come together to tackle complex problems. The exchange of insights and methodologies across disciplines enriches the overall understanding of cognitive phenomena. Moreover, it encourages researchers to embrace the diversity of explanations, recognizing that different disciplines bring unique perspectives and tools to the table.

Non-Reductive Nature:

Importantly, this kind of scientific understanding is not reductive. It does not seek to reduce complex cognitive phenomena to a singular, oversimplified explanation. Instead, it acknowledges the multiplicity of factors and dimensions that contribute to our comprehension of these phenomena. While it integrates diverse explanations, it does so in a way that respects the complexity and richness of cognitive science, recognizing that no single explanatory approach can capture the entirety of the field. While scientific understanding comes with a context-sensitive nature, recognized also by Khalifa, Knowledge as a de-contextualising device to structure information in a coherent, justified and approximately true form. Understanding is then a tool to get knowledge and to get scientific knowledge in many areas of inquiry.

To conclude, scientific understanding in cognitive science provides a framework that unifies and integrates the diverse kinds of explanations inherent in this multidisciplinary field. It is marked by its depth, coherence, pragmatic utility, and capacity to promote interdisciplinary collaboration. This form of understanding does not seek to reduce cognitive science to a singular explanation but rather embraces the plurality of explanations, enriching our comprehension of the intricate workings of the human mind. It is a testament to the dynamic and evolving nature of scientific understanding, which continues to drive progress and innovation in the field of cognitive science. Given the fruitful connections made by Khalifa and colleagues, they should specify whether according to their view, UBI does or does not lead to new scientific knowledge. If the aim of explanatory integration is to ensure and expand the relevant scientific knowledge of cognitive phenomena, UBI should play an important role in affirming it.

5 Conclusion

In conclusion, scientific understanding in cognitive sciences requires the integration of diverse explanations. Khalifa's account of explanatory scientific understanding provides a valuable framework for achieving this integration. Moreover, we emphasize the distinction between understanding and knowledge, highlighting the need for a deeper comprehension of cognitive phenomena. By embracing an interdisciplinary approach and showcasing case studies, this paper advocates for a more unified and comprehensive perspective on scientific understanding in cognitive sciences, ultimately advancing our understanding of the human mind.

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