［論文］

Eliminability and Meaning Specification of Theoretical Terms: Reexamination of C. G. Hempel's Theoretician's Dilemma

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ABSTRACT

This paper purports to consider the very aim and eliminability of theoretical terms in the empirical sciences. We use the terms as indispensable means or tools for the sciences. Usually, knowledge without the terms cannot be accepted even in the non-scientific communities. C. G. Hempel inquires the eliminability and indispensableness of the terms fundamentally, in the question named as "theoretician's dilemma". The philosopher group of science so-called the structuralists examine and reformulate Hempel's very basic question for the empirical sciences by the set-theoretical approach. The massive set-theoretical reformulation provides the useful insights of the scientific theories. However, this paper concludes that even the structuralists cannot provide the convincible reasons to eliminability of the theoretical terms.

Key Words：theoreticity, empirical adequacy, set-theoretical

1. Introduction

The main purpose of this paper is to reexamine the essential problems of scientific theories pointed out in a series of C. G. Hempel's papers, "The theoretician's dilemma: a study in the logic of theory construction," "On the 'standard conception' of scientific theories" and "The meaning of theoretical terms: a critique of the standard empiricist construal," by comparing with the so-called structuralist approach. The most significant reasons I chose Hempel's papers are the theoretical comprehensiveness and the historical position in the development of the philosophy of science. Historically, we must admit that theories have played the most important role in the development of science and technology, particularly of the modern one, even though, as I. Hacking（1983）says, they tend to be overly emphasized in the philosophy of science. For scientists, practically, the theories have been the most important means to generalize their endeavors more efficient and universal. A basic orientation in scientific research is how their simplified frameworks（theories）can systematically explain much more information than any other ones; in other word, the objective is simplification with affluent empirical contents.

In spite of the historical and practical significance, so much remains to be discussed in the subject of scientific theories. One of the significant questions is the methodological aspect of scientific theories, as pointed out in Hempel's papers. As mentioned above, the aim of scientific theories is to explain certain phenomena systematically by the simplified frameworks. H. Feigl（1970）calls it "unification": that is, "the comprehending of a maximum of facts and regularities in the terms of a minimum of theoretical concepts and assumptions." Regardless of the antagonism between the scientific realists and empiricists, the most important requirement for the scientific theories is the interrelationship of the domain they attempt to explain. For the realists, the domain is the so-called "world" as existential entities; on the other hand, for the empiricists, it is the empirical adequacy or significance. Notwithstanding the fact that the metaphysical opposition is essential, the interrelationship of the domain cannot be omitted in the scientific theories at all. This basic requirement（empirical adequacy）makes scientific activities more important and reliable than any other activities, usually based on common sense or ideology, in our society.

However, along with the increase of importance, scientific theories require very wide and deep elaboration. Analytically, there are three questions. The latter two are very difficult to be separated.

（1）The most basic question is the *raison d'être* of theoretical terms: put more simply, why we must use these kinds of hypothetical entities which do not exist in the domain to be explained. This question is strongly discussed as eliminability, which is Hempel's starting-point of the whole arguments about the theoretician's dilemma.

(2) The second question, certainly related to the first one, is the inner-structure of scientific theories, i.e., the interrelationship among the elements of theories such as the domains, measurements, models, and the theoretical terms themselves.

(3) Another, also related to the first one, is the meaning specification of theoretical terms: to be precise, whether the meaning of theoretical term can be determined fully. This question is originally derived from the logical empiricists’ strict requirement for the empirical significance: that is, if and only if the meaning of theoretical term is fully specifiable, the theoretical statement can explain empirical phenomena significantly. This requirement is a logical consequence from the logical empiricist approach which tries to construct the axiomatized system by logically abstracted ordinary language.

Hempel expresses a set of the substantial issues as the so-called problems of the theoretician’s dilemma. In particular, his main interest is the methodological aspects. In fact, there have been many people who attempt to solve the dilemma: however, we still have no final consensus. Since the emergence of modern philosophy of science stimulated by the logical empiricists, the discussions about the dilemma have been continued because of the essential methodological, epistemological, and metaphysical significance included in the problems of the dilemma. In the discussions, Hempel occupies a very important position, historically and theoretically. In addition to the theoretical comprehensiveness, his idea, emerging in the internal criticism of the logical empiricist tradition, is not only a compilation of the discussions but also the starting-point of the next generation of the philosophers of science such as the structutalists and the constructive empiricists. Therefore, even now, it is very significant to trace and reexamine his idea. In other words, the primary objective in this paper is to analyze his main arguments about the theoretician’s dilemma critically.

2. ESSENCE OF THE THEORETICIAN'S DILEMMA

As shortly mentioned above, in order to consider the problems of the theoretician's dilemma, the views on the aims and fundamental requirements for scientific theories need to be specified. With respect to the aim of scientific theories, Hempel (1958) emphasizes the establishment of "general laws" for postdiction, explanation, and prediction based on the discoveries of certain regularities in the empirical domain. To accomplish this goal, there are two kinds of systematization: deductive and inductive systematization. Deductive systematization is the process that the conclusion sentences stating the empirical phenomena to be postdicted, explained, and predicted, are logically deducible from the premises in a theory. Hempel's basic intention in his whole project of the philosophy of science is to construct the basis of this kind of systematization. Conversely, Hempel, as a pragmatist, recognizes another kind of systematization whose conclusion cannot be logically deduced from the premises, i.e., inductive one.

Theoretical terms, whose statements do not refer to the directly observable entities, occupy the most important role in the axiomatized formal system as the framework of the systematizations. On the other hand, another important element in empirical theories is the empirical or observational terms which basically refer to the directly observable entities. To hold empirical adequacy as the most basic requirement in the empirical sciences, the observational terms play the most significant role in the systematizations. Hempel states that the deductive formal system, consisting of the primitive and derivative terms and the postulates "can function as a theory in empirical science only if it has been given an interpretation by reference to empirical phenomena." Based on people's agreements on the interpretations about certain phenomena, the observational terms basically ensure the requirement. In short, the agreements in the theoretician's dilemma emerge from the tensions between the formal deductive system and the empirical adequacy related to the aims and basic requirements of empirical theories. To harmonize the tensions in empirical sciences, Hempel tries to show how to use the formal system with ensuring the empirical adequacy.

His arguments of theoretician's dilemma are summarized as follows:

(1) The purpose of the theoretical terms and the general principles of a scientific theory is to fix definitive connections among empirical phenomena.
(2) The evaluation of the accomplishment only has dichotomous answers, either the terms and principles serve the purpose or they do not.
(3a) If they accomplish the purpose, then they are not needed.
(3b) If they do not accomplish it, then they are meaningless.
(4) Hence, in empirical sciences, the theoretical terms and the general principles are not needed at all.

3. ELIMINABILITY OF THEORETICAL TERMS

To consider the first question, the eliminability of the theoretical terms, in the theoretician's dilemma, what we need to specify is Hempel's view on the empirical theories. His view, the so-called "received," "orthodox," or "standard" view of empirical theories, has gradually been developed in the critical extension of the logical empiricists tradition. Strongly influenced by D. Hilbert and H. Poincaré, the standard view was specially advocated by N. R. Campbell, R. Carnap, M. Schlick, attempting to formalize scientific theories by means of the standardized usage of ordinary language, that is, logic. With this purpose, their followers, e.g., H. Reichenbach, R. B. Braithwaite, and E. Nagel, have significantly elaborated empirical theories as the basis of the philosophy of science. In particular, Hempel has been one of the most influential advocators and the important critics in this view. Even now, regardless of the positions, either proponents or opponents, the basic questions proposed by the standard view are still the main issues in the philosophy of science.

With respect to the structure of empirical theories, as Feigl (1970) and Hempel (1970) summarize, in the standard view, theories as hypothetico-deductive systems are consisted of two major subcategories consisting of a set of statements: the axiomatized system, the so-called "pure calculus," and the category to ensure the empirical adequacy. The basic elements of the pure calculus are the primitive undefined concepts, and the postulates. Not including the empirical content, they are only within a formalized and axiomatized linguistic system which purports to present the corresponding proofs for the validity of certain derivation, as in pure mathematics. These concepts are also called the "internal principles," which characterize the theoretical settings, the "theoretical scenario" which Hempel calls. However, in spite of the formal strength by the deductive proof, the internal principles cannot function as an empirical theory without connecting to the empirical domain. Therefore, the latter subcategory, the so-called "bridge principles," which ensures the empirical adequacy is needed. That is, the bridge principles state the relationship between the scenario and the previously examined phenomena. There are two basic elements in the bridge principles. One is called the "correspondence rules" which connect the primitive and derivative terms in a theory to certain empirically definable concepts. Another is the empirically definable concepts, the "operational definitions," which determine the rules of measurements in a general sense in order to correlate the internal principles to the empirical domain.

Based on the framework, Hempel discusses the definability of theoretical terms, which is one of the most important questions including in the theoretician's dilemma: the *raison d'être* of theoretical terms. Examining the extreme attempts defining theoretical terms by the observational terms or the explicit definitions alone, he criticizes that they are not rigorous and universal. Then, he questions whether the bridge principles as the connectors between theoretical concepts and the empirical domain can be a means for the rigorous approach to define the theoretical terms. However, he also denies the definability of theoretical terms by the operational definitions alone, a major tool in the bridge principles since they cannot determine the correctness of the test conditions. He says, "for any object which does not satisfy the test conditions *C*, and for which therefore the antecedent of the definiens is false, the definiens as a whole is true; consequently, such an object will be assigned the property *Q*." Conversely, he more positively recognizes Carnap's bilateral reduction sentences, an extension of the operational definition approach: that is, "if an object is under test conditions of kind *C*, then it has the property *Q* just in case it exhibits a response of kind *E*." However, it cannot prove the nonexistence of the property even if the response does not occur under certain test conditions. Thus, even the bridge principles, alone, by reference to observables cannot sufficiently define the theoretical terms *per se*.

Besides the above-mentioned logical difficulties, Hempel points out that the elimination of theoretical terms by means of the observational terms has many methodological disadvantages. For example, with regard to the eliminability of theoretical terms, there are more methodologically elaborated methods which attempt to define the theoretical terms by the antecedently available terms, presented by W. Craig and F. P. Ramsey. Ramsey defines interpretative sentences as the sentences that explicitly define some antecedently available terms by means of theoretical ones, as terms like 'water' or 'chlorophyll' might be definable in terms of theoretically characterized molecular structure. It is too cumbersome to use in practice. And also, cognitively, it is very difficult to understand the very complex structure as well as empirical phenomena as it is. The simplification and schmatization introduced by the theoretical terms make our understanding very easier and more economical. In addition, the simplification lets the mathematical tools highly elaborated for postdiction, explanation, and prediction, apply. And also, since the observational and the antecedently available terms are the accumulation of past events and experiences, they alone are very difficult to fit certain new situation in addition to methodological difficulties of prediction.

Finally, examining not only the aim and requirements of empirical theories but also the logical, practical, and methodological difficulties caused by the elimination of theoretical terms, Hempel concludes that theoretical terms, essentially, cannot be reduced to observational, definitional, or antecedently available terms alone. I basically agree with his conclusion on the issues of the eliminability and definability of the theoretical terms. However, as Putnam (1962) criticizes, he shows the necessity and definability only negatively; indeed, he does not present the positive definability that theoretical terms are defined internally, at all. We need more positive approach to the issue. By comparison, although discussed in the later section, as W. Diederich（1989）points out, one of the significant contributions of the so-called structuralists such as P. Suppes, W. Stegmüller, J. D. Sneed, W. Balzer, C. U. Moulines, U. Gähde, is attempting the positive definition of theoretical terms, as “*theoreticity.*”

4. CORRESPONDENCE RULES AND MEANING SPECIFICATION

The next question Hempel asks is what kind of formal account we can give to the partial interpretation. Compared with the definitional chain approaches such as the nominalists, he positively evaluates R. Carnap’s reduction sentences pointed out in the earlier section because of the consideration of empirical adequacy. Yet he strongly questions the logical and practical limitations, as mentioned above. Conversely, N. R. Campbell（1920）insists that the partial interpretation is not simple definitions but the “dictionary” defining “rules of translation” between theoretical statements and empirical ones, especially experimentation by certain detecting devices: in his account, the most basic assumption is that “a certain theoretical sentence is true if and only if a corresponding empirical sentence, couched in antecedently available experiment terms, is true.” However, Hempel criticizes the very strict requirement on the connectivity between the theoretical terms as hypothetical entities and the antecedently available ones, particularly based on experimentation. As the consequences of the limitations, Hempel concludes that both approaches are not sufficient to reconstruct the partial interpretation formally. Therefore, he proposes his own framework for the formal account on the partial interpretation.

In his account（1958, 1970）, a theory, as a set of postulates in terms of a finite theoretical vocabulary, is empirically supported by the so-called basic vocabulary, i.e., a set of extra-logical（empirical）terms unable to be contained in the theoretical vocabulary. To ensure the empirical adequacy, he emphasizes the importance of an interpretative system, a set of bridge principles or correspondence rules, which connect theoretical terms to the empirical ones. Although only providing the parts of necessary and sufficient conditions for the connections, the system logically provides the understanding of a set of sentences which is finite, is logically compatible with the theory, contains no extra-logical term that is not contained in the theoretical vocabulary and the basic vocabulary essentially. Fundamentally, I admit Hempel's compromise between theoretical terms and empirical ones. However, he does not show how to deal with the correspondence rules which is the most important key element in the partial interpretation.

5. HEMPEL'S REEXAMINATION OF MEANING SPECIFICATION OF THEORETICAL TERMS BY THE STANDARD EMPIRICIST CONSTRUAL

Hempel (1973) changes his position about empirical theories in the critical reexamination of the standard construal: i.e., the logical empiricist tradition, attempting to reconstruct empirical theories by a logically elaborated language. We must consider why he changes the position to understand our problem, the theoretician's dilemma. His basic theme is whether the problem of the meaning specification of theoretical terms is essentially meaningful or not; more specifically, "the problem of characterizing those [clearly specifiable] meanings and indicating how they are assigned to the theoretical terms."

One of his main criticisms is on the overemphasis of the axiomatized system only by a logically elaborated language in the tradition: their basic orientation is that the meanings of any elements should be fully specified by the language. The standard empiricist, he says, presupposed that "the solutions to the meaning problem were tacitly subjected to what I [Hempel] shall call the requirement of explicit linguistic specification of the meanings in question." He insists that the tools for scientific theorizing should not be limited only within the meaning of language. I agree with his insistence because a scientific theory is a compilation of many other different aspects, such as modeling by mathematics or analogy, in scientific theorizing. Moreover, the mathematical modeling can provide more rigorous systematization that the linguistic tools can, as the structuralists show. The modeling by analogy used to be dealt with the problem of psychology by the difficulty of formalization. However, as van Fraassen（1986: 291-306）presents, we can have the formal account now. Thus, we do not have any reasons to limit our scope of scientific theorizing within the formal linguistic framework.

As mentioned above, Hempel, in the theoretician's dilemma paper（1958）, clearly admitted the specification of the meaning of theoretical terms by the axiomatized system consisting of the theoretical calculi and the corresponding rules: partial interpretation. The basic idea was that the meanings of theoretical terms are logically deducible only within the axiomatized framework so that the truthness exists only by logical manipulation. However, he（1973）criticizes the most fundamental idea, truth by convention. As the bases of this argument, he critically discusses four grounds supporting the logical empiricist tradition: implicit definition by postulates, basic vocabulary of correspondence rules, logical form of correspondence rules, and "force" of correspondence rules.

Related to the first point, the standard empiricists take the position of which theoretical terms are implicitly definable by the postulates of a theoretical calculus. Their basic assumption is that, "if the truth of theoretical postulates were enforced by terminological *fiat*, then the entire theory would be made true a priori." Therefore, the theoretical terms are only the logical extensions of what the postulates are true. However, Hempel strongly disagrees with the position based on the basic requirement of empirical science, i.e., requirement that the theories of empirical science must be subjected to empirical tests: empirical significance.

Secondly, the standard empiricists believe that the vocabulary whose terms have definite and fully understandable empirical meanings can specify the intensions or the extensions of the theoretical terms. As also describes in the section three, Hempel strongly disagrees with it. One major reason is the relational characteristics of observational predicates; to be specific, the agreement of the meanings quite essentially depends on the interpreter's "prior conditioning," particularly on his/her linguistic and scientific trainings. Another is that, historically and pragmatically, the interpretation base of a scientific theory has not been observational predicates but antecedently available vocabulary. However, the vocabulary is "unnecessary artificial."

The third ground he criticizes is specially related to the arguments in the theoretician's dilemma, mentioned above. His criticisms are the practical and methodological insufficiencies in the four approaches which attempt to specify the meanings of theoretical terms by the empirical terms, i.e., operational definitions, observational terms, he emphasizes that, in scientific theorizing, the antecedently available or pre-theoretical vocabulary is more useful. Moreover, so as to specify the meaning of theoretical terms, we must apply a theoretical system as a whole.

Finally, Hempel denies the fourth ground of the standard empiricists: operational definitions, for example, are viewed as signaling terminological conventions. Exemplifying the term 'temperature', he emphasizes the arbitrariness; in other words, the choice among the alternative changes in the scientific theory is "a matter of decision, informed by considerations of overall theoretical simplicity and fit." He concludes that "to single out the interpretative sentences of a theory" is not caused by "truth by convention" but epistemic acceptance.

In sum, instead of the very rigorous approach by the logical empiricists, Hempel emphasizes the importance of the pragmatic aspects in scientific theorizing. Indeed, we have to think, for example, why many new concepts can obtain high interpersonal agreement without rigorous linguistic formalization. For Hempel, the agreement is a consequence of the "explicit formulation of a body of theoretical principles linking the new theoretical terms to each other and to antecedently available terms," where there are no partition into interpretative or descriptive sentences. Also, the agreement is secured through various kinds of conditioning. Conclusively, he says that, not only there is no clear distinction between axioms and bridge principles, but also there is no such kind of interpretative system to specify the meanings of theoretical terms. Thus, there are no problems of meaning specification, in the logical empiricist sense. He summarizes these points as follows:

> … it is unnecessary and indeed unwarranted to think of theoretical terms as introduced or governed at all by sentences with a special interpretative function characterized by a distinct logical or methodological status. There are no such sentences, and there is no need, therefore, in an analytic account of scientific theories, to make provision for them. Hence at least one of the major problems to which the standard conception was addressed, the problem of meaning specification for theoretical terms, rest on a mistake presupposition and thus requires no solution.

Hempel seems to change his worldview about the existence of theory. It is useful to borrow the Hacking's distinction between the realists and antirealists（pragmatists）about theory. The former believes the existence of the ultimate and universal truth in theories whereas the latter thinks the truthlikeliness of a theory depends on people's agreement itself. This can be subcategorized into two positions by the opinions about the existence of the final community to describe what theory is the most agreeable one. In the stage of the theoretician's dilemma paper, he was a realist about theory; conversely, in the paper of the meaning of theoretical terms, he has become antirealist who positively admits the existence of ultimate community. I agree with the general direction Hempel proposes. Like I. Lakatos' "research programme," the research based on the proposal can justify the past research practice and established knowledge. However, it is very difficult not only to predict the future practices and knowledge but also to understand the present ones. That is because the theories having the same truthlikeliness at the present are very difficult to evaluate. We can evaluate them only retrospectively. Compared with the Hempel's later idea on empirical theories, the structuralists approach more formally by the set-theoretical reconstruction. When we need more rigorous approach to scientific theorizing, they will provide very useful suggestions.

6. STRUCTURALIST APPROACH TO EMPIRICAL THEORIES

H. Putnam（1962）strongly criticizes that no one has successfully explained the specific role played theoretical terms within a theory. Stimulated by the so-called "Putnam's challenge," W. Stegmüller and his followers, the so-called structuralists, have vigorously attempted to elaborate the meaning and structure of theoretical terms from the early 1970s. By the rigorous and systematic approach by means of the set-theoretical axiomatization, originated by P. Suppes, they have become one of the most influential communities in the philosophy of science. Related to our study, one of the important concepts they propose is "*theoreticity*." Before discussing the concepts, we first need to consider the structuralist reaction to Hempel's solutions, presented by C. U. Moulines (1985).

In the paper, Moulines has two purposes. One is to specify the reasons why Hempel changes his position on the meanings of theoretical terms. Another is to reconstruct, according to the structuralist program, the concept of the interpretation sentences which is denied in the later Hempel's paper. The reason that Hempel finally discards his attempt to reconstruct the interpretation sentences formally is not the influence of Quine's extentionalism, Feyerabend's relativistic approach, and the definability of observational vocabulary, but the essential difficulty included in the linguistic approach, in the tradition of logical empiricists. That is, as mentioned by Moulines, "the linguistic determination of theoretical terms through interpretative sentences … would make *empirical* theories true by convention."

With respect to our direct interest, Moulines, a structuralist, presents a reconstruction of the intertheoretical relationship to identify individual theories and individual links between theories, based on "the idea that to any given scientific theory a class of models can univocally be associated." The most important idea is this set-theoretical definability of concepts, models, theories, and methodologies. At first, he states two premises which consist of the foundation of the structuralist approach as follows:

(I) There are numerically distinct scientific theories; or, more exactly, the term "scientific theory" is meaningful and it applies to certain numerically distinct things.

（II）Not all scientific theories are methodologically isolated from each other.

As stated in the second premise, “scientific theories are not ever self-satisfying individuals.” In the theorizing, every individual theory has certain network internally and externally. Although there are a hierarchical order, metatheories, theories, models, measurement, by the levels of abstraction, the elements are closely connected to each other as a system. The structuralists think that these elements cannot be defined by themselves but by network structure which the elements have. To define the meaning of theoretical terms, which is our interest, there are two key concepts in the structuralist program: the class of models of a theory *T, M[T],* and structure species of the elements of *M[T],* $M_p[T]$: a set of the potential models of theory. In this theorizing, the most important concept is $M_p[T]$, as a base for identifying links between theories. It determines the space of possibility （applicability） of success for T. Between two concepts, there is the following relationship: *M[T]* is subordinated to $M_p[T]$, i.e., $M[T] \subseteq M_p[T]$. However, in general, we should not presuppose of all links *l* that they have this form: $l \subseteq M[T] * M[T']$. On the contrary, we must see that link really relates some terms of *T* with some terms of *T'*: $l \subseteq M_p[T] * M_p[T']$. Thus, to formally reconstruct a scientific theory *T*, the following two kinds of traditional divisions, although Hempel denies them in the later paper, are needed: internal principles or axioms to fix the class of models of *T*, and bridge principles to fix the links of *T*. The structuralist approach, attempting to specify the theoretical terms by the theoretical terms by the network structure has the great possibility to elaborate the internal- and inner-structure of empirical sciences, that is, specially related to our interest. However, it also has many unsolved questions; for example, how we can get certain agreement about the boundary of the key concepts such as the potential models. If the more rigorous methods to ensure the agreements are not developed, their purpose, axiomatization, will not be accomplished at all.

Then, he proposes the criterion of *theoreticity*（*CT*）which is our interest. Let *f* be a fundamental term such as theoretical term of a theory *T*. Related to this concept,

J. D. Sneed (1971) originally proposed the concepts: a term *f* of theory *T* as *T-theoretical iff* every measurement (*determination*) of term *f* presupposes *T* to be true for at least some applications. Due to the practical difficulty, in the definition, of which all measurement methods should be contained, Balzer and Gähde propose the new definitions, loosing the strict requirement. In our discussion, we only need the essential feature expressed by Sneed. Let $M_f[T]$ be the set of all potential models of a theory *T* that are used as methods of determining *f*. Among the conditions that fix the *f*-determining structure in $M_f[T]$ the fundamental laws or axioms of *T* will always appear. In that case, *f* is *T-theoretical iff* $M_f[T] \subseteq M[T]$. That is, if the determination methods for the term *f* is set-theoretically included in the class of models of a theory *T*, then we say the term is theoretical. Conversely, the conditions for non-theoretical terms (*LNT*), i.e., observational and antecedently available terms, are specified by the theoretical information included in the potential models $M_p[T]$ and information coming from some other theories through appropriate links, rather by the actual class of models $M[T]$. In sum, he states that "Internal axioms (particularly fundamental laws) are practically essential to determine theoretical terms; bridge principles are practically essential to determine non-theoretical terms."

The discussion about the concept of *theoreticity*, such as exemplified by Gähde (1990) and Schurz (1990), are strongly related to the arguments in a series of Hempel's paper. On the one hand, Gähde necessarily requires that theoretical terms be uniquely determined with the help of the theory's basic axioms plus suitable special laws. That is, he emphasizes the internal underdetermination of the meaning of theoretical terms not only to ensure the flexibility of empirical theories but also to understand empirical phenomena having holistic characters. On the other hand, Schurz emphasizes the necessity of clear distinction between empirical terms and pre-theoretical ones. In addition, to ensure the empirical adequacy, he insists that we should be admited the importance of these empirical and pre-theoretical terms as the independent entities. My position is on the latter. That is because, although the axiomatization is only a means to keep the theoretical system, the terms to ensure the empirical adequacy is the basic requirements to accomplish the goal of empirical sciences.

7. CONCLUDING REMARKS

Finally, I will show my position by the comparisons of Hempel's and structuralist positions. However, it is not easy to make the final decision, what is the best answer to solve the theoretician's dilemma. To consider the problem schematically, we must basically set the basic analytical framework, as in the decision sciences. To simplify the issues and choices, we will set two axes in this paper. The first axis is whether the theoretician's dilemma is either a formal-logical issue or practical one; that is to say, which answer should be given for the problem. This axis is the projection of the problem of the *raison d'être*. The second important axis is whether the interpretation sentences or bridge principles are individual entity as an analytical tool or only the logical connector between the theoretical terms and the observable ones. This axis is related to the problem of meaning specification.

With regard to the first axis, Hempel changed his position from the formal-logical approach to the more pragmatic one. In the structuralist tradition, as well as Hempel's turnover, there are two orientations to approach this issue. Some, including Gähde, strongly direct themselves to the formal axiomatization. Although it is a matter of degree within the structuralist tradition, others, such as Schurz, admits the importance of empirical concepts and pre-theoretical ones, to ensure empirical adequacy and significance. On the other hand, in regard to the second axis, whereas Hempel admitted the correspondence rules as the individual entities to specify the meaning of theoretical terms in the theoretician's dilemma paper, he mostly denies the existence of the correspondence rules. For the structuralists, they play the very important role in the meaning specification.

In addition, I have to add one more axis: the role of the philosophers of science. That is, if their role is descriptive, Hempel's later approach must be more suitable. Conversely, if it is ontological, the structuralist approach must be adequate. However, historically, philosophers have played the ontological and teleological roles. Therefore, I will omit Hempel's latter approach regardless of the significance as the source of ontological analysis. And also, by the reasons mentioned in the Hempel's self-criticism, I cannot agree with his first position. Compared with Gähde, I support Schurz' position. That is because the former pays little attention to the empirical adequacy even though he/she sets the concept of measurement as a tool to provide the requirement. Empirical adequacy is, essentially, not related to a problem of a means or tool but the problem of the domain.

Conclusively, I agree with Moulines' attempt although it has several limitations. The necessity of bridge principles is the fundamental prerequisite of scientific theories, as shown in Hempel's first paper. And also, we do not limit our task only to the logical construction of elements in scientific theories. One major problem of bridge principles, as mentioned in Hempel's self-criticism, is that the truth of theories is necessarily determined by the structure of the bridge principles. However, based on the grounds of empirical science, we cannot ignore the connection between theoretical terms and observational ones.

Furthermore, one of the limitations in the suructuralists tradition, I must say, is how to deal with the problems used to be said only the practical matter such as analogous model building. We must not limit our scope within the material suitable for the axiomatization. van Fraassen shows one significant attempts to this kind of limited view. Moreover, the problem should not be solved only within the boundary but between the boundaries. The problems presented by other traditions have the great usefulness to elaborate the structulalist approach itself.

BIBLIOGRAPHY

Balzer, W., C. U. Moulines, and J. D. Sneed, 1986, "The structure of empirical science: local and global," B. Marcus et al., eds., *Logic, Methodology and Philosophy of Science VII*, Amsterdam: North-Holland, 291-306.

Campbell, N. R., 1920, *Physics: the Elements*, Cambridge: Cambridge Univ. Press.

Diederich, W., 1989, "The development of structurism," *Erkenntnis*, 30: 363-86.

Dilworth, C., 1984, "On theoretical terms," *Erkenntnis*, 21: 405-21.

Feigl, H., 1970, "The 'orthodox' view of theories: remarks in defense as well as critique," M. Radner and S. Winokur, eds., *Minnesota Studies in the Philosophy of Science*, vol. 4, Minneapolis: Univ. of Minnesota Press, 3-16.

Gähde, U., 1990, "On innertheoretical conditions for theoretical terms," *Erkenntnis,* 32: 215-33.

Hacking, I., 1983, *Representing and Intervening : Introductory Topics in the Philosophy of Natural Scienc*e, Cambridge: Cambridge University Press.

Hempel, C. G., 1958, "The theoretician's dilemma: a study in the logic of theory construction," C. G. Hempel, 1965, *Aspects of Scientific Explanation and Other essays in the Philosophy of Science*, New York: Free Press, 173-226.

----, 1970, "On the 'standard conception' of scientific theories," M. Radner and S. Winokur, eds., *Minnesota Studies in the Philosophy of Science*, vol. 4, Minneapolis: Univ. of Minnesota Press, 142-63.

----, 1973, "The meaning of theoretical terms: a critique of the standard empiricist construal," P. Suppes et al., eds., *Logic, Methodology and Philosophy of Science IV*, Amsterdam: North-Holland, 367-78.

Moulines, C. U., 1984, "Links, loops, and the global structure of science," *Philosophia Naturalis*, 21: 254-65.

----, 1985, "Theoretical terms and bridge principles: a critique of Hempel's（self-）criticisms," *Erkenntnis*, 22: 97-117.

Moulines, C. U., and J. D. Sneed, 1979, "Suppes' philosophy of physics," R. J. Bogdan, ed., *Patrick Suppes*, Dordrecht: D. Reidel, 59-91.

Putnam, H., 1962,"What Theories are Not," E. Nagel, P. Suppes, and A. Tarski, eds., *Logic, Methodology and Philosophy of Science*, Stanford, CA: Stanford University Press, 240-252.

Quine, W. V., 1951, "Two dogmas of empiricism," W. V. Quine, 1953, *From a Logical Point of View*, Cambridge, MA: Harvard Univ. Press, 46-70.

Schurz, G., 1990, "Paradoxical consequences of Balzer's and Gähde's criteria of theoreticity: results of an application to ten scientific theories," *Erkenntnis*, 32: 161-214.

Sneed, J. D., 1971, *The Logical Structure of Mathematical Physics*, Dordrecht:

Reidel.

Van Fraassen, B. C., 1986, "Aim and structure of scientific theories," B. Marcus et al., eds., *Logic, Methodology and Philosophy of Science VII*, Amsterdam: North-Holland, 307-318.