Assessing metaphor as mediator between Christianity and science

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Abstract: There are many studies on the mediating role of analogy and metaphor in science. But few address whether metaphor mediates between science and religion. This paper explores the implications of the work of Mary Hesse on metaphor for the interaction between scientific and religious knowledge. I focus on the mediating role of metaphor between science and Christianity because that was the focus of Mary Hesse. I take this interaction as a special case of the engagement of science and society. My thesis is that metaphor can mediate between science and religion and satisfy Hesse's requirement that their relative independence be respected. After explaining my approach, I summarize Hesse's views on science and religion. Next I show that standards of assessment of metaphors that mediate between science and religion are needed. Two sections follow assessing the applicability of contemporary conditions for the adequacy of metaphor in general to the mediation between science and religion. I review error correction as well as its failure in ideology and strategies for correction of the latter. I conclude that the possibilities for metaphor to mediate between science and Christianity are limited, but that it is possible while respecting the integrity of both.

Keywords: metaphor; science and religion; Mary Hesse; science and Christianity; error; ideology; Christian theology.

1. *Introduction*

Mary Hesse engaged in the history and philosophy of science as a means to fulfill her "hope […] to contribute to a lessening of tension between the scientific and the Christian attitudes to the world". Her strategy was to level the playing field between science and the Christian religion by showing the subjectivity of both (Hesse 1954: 9-10). This strategy enabled her to argue that science and religion have equal cultural authority. Metaphor played the crucial role of mediating between science and its context and revealing that science was as subjective as religion.

She published on the engagement of Christianity and science throughout her career (Hesse 1954; 1965; 1969; 1975; 1978; 1980; 1981; 1983; 1989; 1994;

1998; 2000; 2001; *The Stanton Lectures* 1978; 1979; 1980).[1] This paper explores the implications of her work for the interaction between scientific and religious knowledge as a special case of the engagement of science and society. For Hesse science is the context of religion and religion is the context of science. Each can be used as source or target of metaphoric mediation. My thesis is that metaphor can mediate between science and religion and satisfy Hesse's requirement that their relative independence be respected. After explaining my approach, I summarize Hesse's views on science and religion. Next I show that standards of assessment of metaphors that mediate between science and religion are needed. Two sections follow assessing the applicability of contemporary conditions for the adequacy of metaphor in general to the mediation between science and religion. I review error correction as well as its failure in ideology and strategies for correction of the latter. I conclude that the possibilities for metaphor to mediate between science and Christianity are limited, but that it is possible while respecting the integrity of both.

2. *Focus, Definitions and Approach*

Analogy plays a key role in the mediation between social context and science as well as between the different natural sciences. I will take that role for granted and focus on its implications for the interactions between science and religion. I see metaphor as a property of utterance in which a speaker usually intends to refer to a single entity (Soskice 1985: 85).[2] Cognition is metaphorical. Therefore, exploring metaphoric mediation between science and religion is limited to this cognitive dimension of their interaction. This dimension has been described by Brooke (1991) and Brooke, Osler and van der Meer (2001).

Grasping the interactions between any domains of knowledge requires a determination of the identities and differences between them, i.e., of their analogy. An analogy consists of the *known* identities and differences between two domains of knowledge. A metaphor is a *hypothetical* analogy in which a feature of the source domain is *hypothesized* to apply to the target domain based on the known identities and differences. That is, thinking metaphorically is thinking about one thing in terms suggestive of another. This paper is about the cognitive role of metaphor in the mediation between science and religion, not between domains within science or within religion.

The definition of religion one employs determines how pervasive its relation

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[1] *The Stanton Lectures* (unpublished), delivered in 1978, 1979 and 1980 at the University of Cambridge address a wide range of aspects of science and religion.

[2] For evaluations of theories of metaphor other than the interaction theory, see: Soskice, 1985: 24-51.

with science is judged to be. In the positivist era this relation was denied by defining religion as subjective and science as objective. But Polanyi (1946; 1967; 1974) showed that tacit subjective knowledge is essential in science. Hesse (1954: 9-10) affirmed the interaction of science and religion by arguing that science is as subjective as religion particularly when it functions as mythology (Hesse 1998). I affirm this interaction by using a functional definition of religion as a relation with something believed to have absolute independence (Botha 1993; Clouser 2005; Van der Meer 2000). Metaphysics functioning as religion or functioning tacitly (Polanyi 1974) can then be seen to interact with science. This definition of religion covers all religions including Christianity. I limit myself to the Christian religion for three reasons. First, the Christian religion was Hesse's concern. Second, Christianity is the most suitable because it differentiates sharply between Creator and creation thereby providing the key condition for the operation of metaphor, namely to think about the one in terms of what is known about the other. Religions without this differentiation such as pantheism do not satisfy that condition. Finally, the most likely source of case studies is the history of science in Christian Western Europe. In particular, the Christian belief that one can know something of God from the world because the latter is a divine self-expression promises the existence of terms referring both to God and to the world.

Whether and how metaphor mediates between domains of knowledge involves evaluation. Standards for evaluation are taken from aspects that characterize the relation between source and target. Similarity may be manifest linguistically, logically, cognitively, semantically and otherwise. Is a metaphor based on sound analogies? Are the analogs selected for mapping relevant to the goal? Does the metaphor achieve its purpose? Together, these aspects function as criteria for the use of metaphor. Two clarifications are necessary. First, an early version of the so-called structure mapping approach to comparing domains suggested to some that this approach used syntax to the exclusion of concepts (Gentner 1983: 155, 168). However, syntax (sentence grammar) is completely irrelevant (Gentner and Markman 2005: 7n3). Structure-mapping has always been about semantic content. The central idea is that analogical mapping depends on finding identical relations or at least partial identities between relations. The objects can be arbitrarily different. For instance, the following two assertions would be an analogical match, because they express the same relation, even though the syntax is different.

> Fred LOVES New York
> and
> Paris is BELOVED BY Susan

Secondly, the difference between the structure mapping approach (Gentner

1983; Gentner and Gentner 1983; Gentner and Jeziorski 1993) and the multi-constraint approach (Holyoak and Thagard 1996) to comparing domains is one of emphasis and logistics, not of kind. Both incorporate semantic similarity, structural consistency and purpose. But, whereas the multiconstraint approach counts all three standards equal and competing, structure mapping emphasizes structural consistency and semantic similarity (specifically, relational matching) over goals and pragmatics (Gentner, personal communication). Logistically, in structure mapping consideration of purpose precedes and follows the actual comparison of structure. They are parallel in multiconstraint mapping. To avoid discussing purpose twice, I included it in the introduction to pre- and post-inference assessment. In exploring the usefulness of these approaches to comparing science and religion, I review the standards used in both and leave questions of emphasis for later.

A discussion of how analogy mediates between science and Christianity cannot ignore the debates about the analogy of being. For Thomists the analogy of being justifies speaking about God in terms of what is known about creation in addition to and independent of scripture. For Protestants this justification lies in the fact that in scripture God speaks about himself in creaturely terms. Their paradigm is the letter to the Romans (Romans 1: 20) in which Paul says that the eternal power and divinity of God can be perceived in what he has made. It is impossible to do justice to this aspect of analogy within the confines of this paper. Here, I note that Protestants and Catholics select different standards for thinking about God in terms of nature. This difference entails an evaluation of the content of potential source domains for appropriateness in Christian theology and thus in science and theology.

3.   *Mary Hesse on Science and Religion*

According to Hesse (1954: 155), human experience is where science and religion meet. They meet in their attempts at telling a story that functions not only as explanation of the world, but also as myth. This view was inspired by Durkheim (Durkheim 1915; Durkheim and Mauss 1963; Hesse 1983: 52-53; Hesse 1994: 247-248). He reduced all knowledge to a social phenomenon except scientific knowledge which was grounded in objective reality, but could function socially. Hence science can both explain and function as myth. Hesse adopted Durkheim's view of science. Further, she rejected the reduction of science to mythology or religion for three reasons. Firstly, when scientific theories change, the associated ontology changes. When science also functions religiously, the changes in the ontology imply changes in how one thinks about

God destabilizing the Christian understanding of God. For instance, the phenomena of electricity have been described with two very different mathematics which translate into different theories each of which posits different ontologies (Hesse 1988: 188). When these ontologies become the source domain in terms of which one thinks about God, different models of God result. Hence, secondly, "physics may provide useful models for theology, but physical theory will not in itself have any logically necessary implications for metaphysics or theology" (Hesse 1988: 187). Finally, the concept of nature does not have the resources to think adequately about God. For instance, since nature is impersonal, it cannot yield a personal God. "Nothing follows that is like the God of Abraham, Isaac and Jacob and our Lord Jesus Christ, nor of any of the other traditional religions" (Hesse 1988: 198). Thus, for Hesse scientific and religious knowledge are of different kinds, each relatively independent of the other and capable of functioning socially as myth or narrative. Hesse exempted religious knowledge from Durkheim's socialisation of reason because, she asserted, his rejection of the concept of God did not depend on it. Thus she does not consider "Durkheim's attempt to reduce religion to a purely social phenomenon […] sufficient to *disprove* religious belief in the existence of God, […]" (Hesse 1983: 53). Hesse (1998: 132) rejects the metaphor of religion as a social phenomenon ('society is God') because it ignores the transcendent reality that characterizes many religions. In sum, for Hesse science belongs to the social context of religion and religion to that of science, but the knowledge of either cannot be reduced to a social phenomenon. When brain physiology is used as a source of knowledge about religion, she means that it may explain an aspect of religion without reducing it to physiology. My thesis made more precise is, therefore, that the metaphoric transfer of knowledge between science and religion requires source and target to provide their own truth conditions and that this prevents science from becoming a religion.

4. *Assessing Metaphoric Mediation Between Science and Religion*

4.1. Need for standards of evaluation

In principle metaphor mediates between science and religion as it does between any source and target simply because religions are found in the context of science and may become the source of metaphoric inferences about nature. However, attention for this mediating role is rare (MacCormac 1983; Gerhart and Russell 1984) and standards for the evaluation of metaphoric mediation have been developed only for mediation within science and within religion, but not between them. Hesse's work illustrates this point.

Hesse developed separate standards for analogy in religion and in science. Standards for appropriate metaphors for God, Hesse asserts, must come from domains of human life, history and society that transcend science. She refers to "Past religious ages" which did not adopt Baconian measures of objectivity.

They had others, such as divine revelation in scriptures and in the individual soul, the authority of religious institutions, sometimes linked with state power, and certain a priori rational and ethical values of the mind. Our difficulty about models of God is precisely that we have no socially acceptable standards of objectivity and truth that will accommodate such theological (or even ethical) talk. The models remain, as far as their epistemology is concerned, imaginative constructions inherited from tradition, or woven anew by individuals and groups who reject a purely naturalist vision of the world (Hesse 1994: 253).

Holyoak and Thagard (1996: 168-169) conclude that "Theological analogizing is clearly a tricky business, because it is difficult to decide which characteristics of humans ought to be transferred to God or a set of gods". Hence, Hesse (1994: 252) is correct in calling for criteria for the appropriateness of metaphors for God. But she leaves the details open.

Hesse (1966: 59, 87, 91) also proposed three criteria for evaluating metaphor in *science*. Relations between source and target (horizontal relations) must include observable similarities (material analogy). Relations within source or target (vertical relations) must be causal relations "in some acceptable scientific sense". Source and target must not differ in essential features. But, as she expected, these do not apply to religion. Likewise, Gentner (1983) and Gentner and Gentner (1983) developed their principles of analogical reasoning for science. Clearly, standards are needed for evaluating metaphors and analogies by which to think about the relation of God and nature.

4.2. Possible standards for assessing metaphoric mediation between science and religion

I start the development of criteria for the evaluation of metaphors mediating between science and religion with the idea of Pepper (1942) that an analogy can generate a hypothesis that encompasses all of reality. In such a world hypothesis, knowledge of the source domain can be said to function as a religion (Botha 2007: 153-164). Its all-encompassing character creates relations with knowledge of nature. Black (1962) describes these relations as relations between primary and subordinate metaphors. Thus the world hypothesis or primary metaphor has its all-encompassing influence by controlling its subordinate metaphors. Wolterstorff (1976) specified how primary metaphor ought to control subordinate metaphor by suggesting that the ultimate commit-

ments of a Christian ought to control theory decision in scholarship. Brümmer (1982: 260; 1993) identified the primary metaphor of Christianity: "Because the Biblical God is the *primary determinant of meaning* in the Christian's view of life, the meaning of *everything* or every situation in our world is ultimately determined for the Christian by the way this thing or situation is related to God". Thus, what a Christian knows about God can function as a primary source domain that in the words of Wolterstorff (1976: 63ff) controls her interpretation of the natural world as the target. This applies even when the natural world functions as a secondary source domain from which knowledge about God is inferred. For instance, the knowledge that God is good controls the interpretation of natural disasters even when the latter function as a secondary source domain from which knowledge of God is inferred. As a result, the inference from natural disaster that God is evil is rejected. In sum, knowledge of God may function as source or as target. As a primary source, knowledge of God controls subsequent interactions in which this same knowledge of God may function as target domain. As a secondary source, knowledge of God controls knowledge of the natural world.

4.3. Purpose as a Pre- and Post-Inference Standard

Mapping of source to target is guided by the purpose of the analogy. Therefore, a metaphor must be evaluated in terms of whether it is fitting and relevant for the intended purpose both before and after metaphoric inference. Brümmer (1993: 19-29) proposed that metaphors for God ought to satisfy four purposes. They are: comprehensive coherence, consonance with tradition, adequacy for the demands of life and personal authenticity. More common in science, the purpose of an analogy can range from developing a hypothesis about the target to justifying an explanation of the target (Holyoak and Thagard 1996: 34). The encompassing character of these purposes invites application to evaluating metaphors for science and religion. Satisfaction of each of these purposes counts as a criterion for assessing the metaphor.

First, satisfaction of comprehensive coherence requires that when Christians use metaphors to describe God, they do not merely describe human religious experience. "It would be incoherent to live my life as a life in the presence of God if I were to deny that there really is a God in whose presence I live!" (Brümmer 1982: 32, 213, 268, 281; 2006: 152). MacCormac (1983: 63) argues that the basic metaphor of Christianity suggests an ultimate reality. Secondly, people would not be affected by or act upon fictions or illusions (Soskice 1985: 106-107) for that would not be adequate for the demands of life.

Thirdly, when Christians speak about God in terms of what they know about nature, they do so in consonance with how a tradition understands God to

speak about himself in terms suggestive of nature.[3] Anthropomorphic descriptions of God are prominent among them. In the Christian scriptures they are not the result of thinking about God in terms of human religious experience without further qualification of the term 'experience,' but they are received as revelations in which God accommodates himself to human limitations. One might say that God uses analogies (teaching metaphors) to speak about himself. It is God who uses the human as source and himself as target. This divine use and its interpretation in a tradition limits the hypotheses humans can suggest about God to those who are consonant with how God speaks about himself metaphorically. For instance, in automobile design, human designers deal with competing demands such as between energy efficiency and safety. Analogously, Polkinghorne (1989: 66-67) argued, God as 'designer' deals with competing demands between creating a nature that is both free to evolve and free of natural evil. He developed this analogy into the so-called free process defence of natural evil in which God has to pay the price of natural evil in order to create a nature free to evolve. The question is whether this limitation of divine power is consonant with the Christian tradition. In these three ways, decisions are made as to which human characteristics can be transferred to God. The use of metaphor is subject to restrictions. Provided they are respected, analogy has been used in the Christian theological tradition.

Consonance with tradition depends on how a tradition has developed its criteria for analogy. As indicated, Thomists and Protestants have developed such metaphors differently. First, there must be an ontological ground for similarities between God and nature before one can postulate new similarities. For both Thomists and Protestants, consonance with scripture and their respective traditions provides such grounds. But for Thomists nature is a source of metaphors for God independent of scripture whereas for Protestants scripture is the sole source. Thus, as Hesse observes, the natural sciences may supply metaphors for God. But, as Torrance (1970) emphasises, such metaphors cannot serve to create a natural theology independent of a pre-existing faith.[4] Consonance with the Protestant tradition prevents such independence.

Thus, Brümmer's criteria do not provide socially acceptable standards of objectivity and truth for theology. This used to be considered as a problem because positivists believed objective knowledge existed in science and they required objectivity of all knowledge. Hesse argued that scientific *knowledge*

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[3]   For an analysis of how God speaks, how humans recognize this speech, and how it is distinct from human speech, see Wolterstorff 1995.

[4]   For an assessment of the place and purpose of natural theology in Calvin, Barth and Torrance, see McGrath 1999: 175-194.

is as subjective as religious knowledge by showing that selectivity is inherent in the use of analogy and metaphor. They select a dimension of the source domain and use it as a hypothesis about a selected dimension of the target domain (Gentner 1983: 164). This selectivity introduces subjectivity in *knowledge*, scientific as well as religious.

Hesse's strategy can be applied also to experience. The absence of objective experience in theology was also taken to be a difficulty because positivists believed objective experience existed in science and required it of all experience-based knowledge. But there is no unreflected and uninterpreted experience except in very young children or in illusion (Mavrodes 1970: Ch. 3, Barbour, 1974: 119-120; Gerhart and Russell, 1984: 19-35; Van Fraassen 1997: S386-S391). Those exceptions are irrelevant for scholarship. No scholar is exempt from having beliefs whether tacit or reflected which shape the interpretation of experience because no one can escape her context. In this respect science and religion also find themselves on the same playing field.[5] Given that all people desire to know, the experience of nature is interpreted in science in terms of belief systems articulated as research traditions and paradigms. Likewise, people are by nature religious. They have a faculty for sensing and knowing the divine (Plantinga 2000: 170-172).[6] Therefore, given the systems of religious beliefs as articulated in the various religions, the experience of the divine, whether personal or impersonal, is interpreted in terms of one of these religions. There is no objective experience in science and so its equivalent cannot be required in religion. To account for her philosophical and religious decisions, Mary Hesse (1983: 53) looked "to belief in God for the providence that underlies our shifting cultural schemata, and for the inspiration for countless cognitive decisions that are taken within them in history". This is the human condition whatever the sense of the divine. Science and religion are equally subjective with respect to knowledge as well as experience.

5. *Pre-Inference Assessment*

5.1. Introduction

Before a hypothesis about a target domain can be inferred from a source domain, the similarities between the two must be evaluated because these

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[5]   This is not to equate scientific experience which is repeatable and intersubjective with personal experience which is neither.

[6]   Plantinga refers to John Calvin for the natural knowledge of God. For a critical analysis of Calvin on natural knowledge of God and Plantinga's interpretation of Calvin, see Jeffreys 1997. For evidence in support of natural knowledge of God, see Kelemen (2004), Barrett (2011).

similarities are to ground the hypothesis. For instance, Faraday saw the electric and magnetic powers associated with matter as manifestations of God's power (Cantor 1991: 174-184). He did so explicitly on the basis of Scripture – citing Romans 1: 20 – rather than in the tradition of the analogy of being (Cantor 1991: 172, 198-200). This was the ontological ground for his analogies. His analogy between divine and natural power has cognitive content in that it caused Faraday to reject atomic theories of matter because of the void between atoms which contradicted his belief that God had created nature without gaps (the principle of plenitude) and that, therefore, power is a property of space (Cantor 1991: 172-173, 181-184). God's perfection expressed in nature's perfection did not allow for gaps in the economy of nature. Moreover, the tri-unity of God combined with the belief that natural forces are expressions of God's power suggested to Faraday the unity of natural forces. This belief led him to the discovery of the unity of electric and magnetic force (Cantor 1991: 171-172).[7] Thus, an analogy between divine and natural power enabled Faraday to transfer meaning from the religious concept to the scientific concept. Finally, Faraday employed the analogy between divine and natural power selectively. Perfection and unity were just two sides of divine power. Faraday did not select other sides such as the power to create or to save presumably because he assessed them as irrelevant for his purpose. Such assessments need to be done before the analogy can serve to justify inferences about the target from the source.

The value of a hypothetical similarity between source and target (metaphor) depends on the extent to which it is supported by known similarities and differences (analogies) between them. Thus evaluation of a metaphor begins with considering whether domains share attributes, first-order relations and higher-order relations (relations of relations). The predictive value of a metaphor increases as one adds similarities between domains in that order. Evaluation also considers how the comparison is performed. This would include whether the comparison is one-to-one, structurally consistent, relevant for the purpose of the metaphor, and fitting in the wider context.

5.2. Attributes

Whether object attributes are relevant for establishing the degree of simi-

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[7]   Torrance (1984: 229-231, 1989: 150-151) has suggested that the patristic understanding of the Trinity, namely that the relations among its persons are an integral part of the persons themselves, has come to expression in the idea that the relations among material particles are integral to the particles themselves, and that this suggested the concept of a physical field to James Clerk Maxwell. In light of what Cantor has revealed about Faraday's conception of God, it may be possible that this patristic understanding also affected Faraday's conception of physical power.

larity between domains depends on the purpose of the comparison (Black 1962: 222-223; Gentner 1983; Gentner and Gentner 1983). They can be made irrelevant by abstracting from the particular character of the objects and focussing instead on relational structure. For instance, bacteria and knowledge grow exponentially. But if the purpose of the comparison is to identify the causes of this growth, abstraction from the particular character of bacteria and knowledge will hide these causes. Likewise, in comparing knowledge of God and nature their attributes are relevant to the purpose of the comparison. Without them one cannot identify God and nature as essentially different. Neither can one abstract the relations among God's attributes from God himself.

In Christian theology, comparison between knowledge of God and knowledge of nature would involve the so-called attributes of God. They include graciousness, holiness, immutability, incorporeality, oneness, trinity and infinity.[8] Many attributes cannot serve in comparisons with knowledge of nature because they assert what God is not. Positive attributes of God include mercy, love, grace, omnipotence, unity and infinity. Among these, personal attributes such as mercy, love and grace do not apply to nature because nature is impersonal. Some positive personal attributes have served as a source of inferences about nature as a target, either isolated from relations (infinity, immutability) or associated with relations (unity) because they can be applied to impersonal nature. Attributes functioned in isolation when Cantor inferred the actual infinite in mathematics from God's infinity and when Agassiz derived the immutability of biological species from God's immutability. The zoologist Louis Agassiz (1807-1873) opposed Darwin's theory of biological evolution on the ground that God had created animals according to eternal ideas in his mind (Lurie 1959). These ideas were none other than the Forms of Christian neo-platonic theology which turned God the personal spirit of the Christian scriptures into the impersonal highest being of Plato and entailed that animals could not change. Thus, inferences from knowledge of God about nature can come with contextual baggage that replaces God's self-revelation in the Christian Bible. This violates the integrity of both Christian theology and of science.

Unity is a divine attribute describing the relations between the persons of the Trinity. Faraday transferred this attribute to electric and magnetic powers. Graciousness and holiness are also positive attributes, but because they are personal attributes they limit inferences about nature to human nature. Posi-

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[8]   Differences over the classification of the attributes of God and over the term attribute are beyond the scope of this essay. Some distinguish incommunicable attributes such as oneness and infinity from communicable ones such as love and grace. This distinction which originates in Protestant theology does not apply because incommunicable attributes such as unity and infinity are shared by creatures.

tive attributes are understood to be analogies between Creator and creatures revealed by God to make himself understandable either in scripture alone (Protestants) or in scripture and in nature independently of scripture (Roman Catholics). The rationale for the use of positive attributes in inferences about nature would be that if God wants to be known from nature, he would have created nature according to his positive attributes. How he acts is unknown and, therefore, there is no guarantee that such inferences will apply except empirical test. In conclusion, attributes can be relevant for comparing domains within science as well as between science and religion, but infrequently so and depending on the purpose of the comparison.

5.3. Relations within a domain

In general, relations within a domain include, but are not restricted to onto-logical relations between objects (causation, facilitation, hindering, inhibition) and epistemological relations (implication, explanation, presupposition (Holy-oak and Thagard 1996: 36). Black and Hesse introduced the importance of comparing within-domain relations for the predictive power of metaphor. For an analogy to have predictive power, Black (1962: 222-223) required similar-ity of object roles in matching relations. Hesse (1963: 59, 87) demanded causal relations within the source domain to be similar to those in the target so that new causal relations could be predicted for the target domain. A comparison between domains becomes stronger the more it shifts from comparing isolated object attributes to comparing relations existing between objects within the domains compared. Relations introduce coherence whereas attributes apart from relations do not. Mapping a coherent pattern of relations on a target yields more inferential power than mapping individual predicates. For example, Ke-pler compared the relations of Father, Son and Holy Spirit in the source domain with the relations of centre, surface and volume of a sphere. He ignored divine attributes such as omnipotence and omniscience. Analogous relations between the domains are (1) as the Father generates the Son so the centre of the sphere generates the surface (mathematically by projection of the centre point on the sphere), (2) as the Spirit is equal to the Son and the Father so any point inside the sphere is equal to any other in relation to an appropriate distance from the centre point and a point on the surface, (3) as the Son is an image of the Father so every point on the surface is an image (projection) of the centre point of the sphere (Howell 2002: 128-129). Likewise, Faraday inferred the unity between electric and magnetic force from the unity of relations between the persons of the Trinity. He also omitted divine attributes except for perfection. Finally, the power of Rutherford's analogy between the solar system and the hydrogen atom derives from the similarity between the relationship in the solar system and that

in the atom. Analogous relations between the domains are (1) as the sun is more massive than the planets so the nucleus is more massive than the electrons, (2) as planets orbit the sun so electrons orbit the nucleus, and (3) as planets are at a distance from the sun so are the electrons from the nucleus.

The relations discussed above are first-order relations, i.e., relations between two relata. Hesse's causal relation is an example. A higher-order relation is a relation between first-order relations. Gentner (1983: 162) defines the order of a relation by the order of its arguments. "A first-order relation takes objects as its arguments". For instance, in the Rutherford analogy between solar system and atom, first-order relations in the solar system are that the sun is more massive than a planet, that a planet orbits around the sun, and that there is a distance between sun and planet.

"A second-order relation has at least one first-order relation among its arguments; and in general, an nth order relation has at least one (n-1)th order argument". Newton's inverse square law of gravitational attraction exemplifies a second-order relation which is the force of attraction between bodies. According to this law, the force of attraction between sun and planet is proportional with the product of their masses and inversely proportional with the square of their distance. This law includes two first-order relations, namely the relation of greater than between the masses of the bodies and the relation of their distance. Abstraction from the first-order relations produces the second-order relation. Coulomb's inverse square law of electrostatic attraction is a second-order relation which is analogous to Newton's law. In this example, the higher-order relation is a causal one. In the solar system this causal relationship consists of the mutual gravitational attraction between the sun and the planets in which the largest attraction is exerted by the sun because it is more massive than the planets. Similarly, in the atomic system the causal relationship consists of the mutual attraction of opposite electrical charges between the nucleus and the orbiting electrons. Higher-order relations may also include relations of implication. In conclusion, higher-order relations have a higher degree of abstraction than first-order relations. Adding attributes, first-order and second-order relations to analogies between domains progressively strengthens the inferential power of metaphors grounded in them.

This conclusion has limited application to assessing metaphors between God and nature for two reasons. First, there is an essential difference between God and nature. Taking properties and causal relations together, Hesse (1966: 91) proposed a necessary and sufficient condition for predictive capability of a metaphor or model *in science*, namely that "[t]he essential properties and causal relations of the model have not been shown to be part of the negative analogy between model and explicandum". A negative analogy is a known

difference between source and target. If this difference is essential, there is no analogical basis for prediction about the target. In Christian theology such an essential difference exists between Creator and creature. We have seen that many attributes of God cannot serve in comparisons with knowledge of nature because they assert what God is not. This may be one reason why historically there have been few inferences from knowledge of God about knowledge of nature. This essential difference has two implications.

First, there are very few within-domain relations that are relevant for science. As in scientific metaphor, inferences about nature from knowledge of God are also grounded in matching attributes and within-domain relations. But, the within-domain relations between God's attributes would be relations of implication, not of causality. Theologians do not consider causal relations between the attributes of God because causal relations are temporal, but the attributes are eternal. Also, temporal causal relations between the attributes would diminish the maximal degree in which God possesses them. As for relations of implication, God's goodness implies his kindness, love, grace, mercy and longsuffering (Berkhof 1996: 70-72). The infinity of God implies his infinity in relation to space, i.e., his omnipresence to creatures and his infinity in relation to time (eternity) (Hodge 1873: 383-384). The sovereignty of God implies his omnipotence, providence, kingship, and freedom. But, there are very few relations of implication among the divine attributes that apply to nature. The infinity of God as understood by Georg Cantor is an exception. In a letter to Hermite, Georg Cantor explained that both separately and collectively as an infinite totality, the natural numbers "exist at the highest level of reality as eternal ideas in the *Divine Intellect* (*Intellectu Divino*)".[9] Dauben (1977: 95) concludes that "the efficacy of Cantor's theory was ultimately referred to the Divine Intellect where the Transfinitum, all the transfinite numbers, existed as eternal ideas. This was a strong form of Platonism, but one to which Cantor repeatedly returned for support". Thus Cantor took what he saw as the implications of God's infinity for God's ideas about numbers as a sanction for his ideas on mathematical infinity. Further, Louis Berkhof (1996: 70-72) sees God's goodness as including kindness, love, grace, mercy and longsuffering. Their predictive value in humans is doubtful because humans do not possess the divine perfection that ensures that its implications are realized in God's actions. Finally, most divine attributes are not mutually related. In conclusion, within-domain relations of implication have little relevance for inferences about nature for it is causal relations that are the main interest of science and they are not included in the source domain.

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[9]   Cantor to Hermite, Nov. 30, 1895 in Meschkowski 1967: 262; Dauben 1977: 94.

The second implication of the essential difference between God and nature concerns natural theology. In the comparison of attributes as well as in that of relations, the movement of thought from Creator to creature could be reversed. Christian theology can speak about God only analogically as God does in the Scriptures when he speaks about himself analogically using human characteristics such as love and grace. But, inferring knowledge of God from nature is rarely thought possible because the Creator is categorically different from his creatures There are few if any similarities between a personal God and an impersonal nature. As Pascal observed, arguments for a personal God based on impersonal forces would lead to the neglect of the person of Christ, the mediator between God and humankind (Pascal 1965: Pensées 242-245, 547; Brooke 1991: 194). While Roman theologians accept the possibility of such inference, Pope Benedict (2006) put the *analogia entis* in its place by asserting that

[…] the faith of the Church has always insisted that between God and us, between his eternal Creator Spirit and our created reason there exists a real analogy, in which – as the Fourth Lateran Council in 1215 stated – unlikeness remains infinitely greater than likeness, yet not to the point of abolishing analogy and its language.

Thus for Roman theologians the possibility of inferring knowledge of God from knowledge of nature exists, but is rare while for Protestants such inference is not possible except when revealed by God. As Thomas F. Torrance emphasized, Barth's rejection of the analogy of being was a denial of the possibility to know God from nature without revelation, not of the possibility of such knowledge in the context of a pre-existing faith.

These qualifications went unheeded by Faraday and in natural theology. According to William Paley, the "uniformity of plan observable in the universe" establishes the unity of God (Brooke 1991: 192). The problems with inferences from nature about God were well-known. Cusa (1401-1464), for instance, had distinguished created relative infinity from the uncreated absolute infinity of God, yet was suspected of pantheism. Aquinas, in particular, had argued against the possibility of any absolute infinity in creatures. Centuries later, theologians such as Constantin Gutberlet (1837-1928) and Cardinal Johannes Franzelin (1816-1886) accused Cantor of undermining God's infinity. They regarded the actual infinite in Cantor's mathematics as a challenge to the absolute infinity of God. But Cantor like Cusa argued that God's infinity is the Absolute Infinite, which transcends other forms of infinity such as the actual infinity in his mathematics (Dauben 1977: 99-103, Nagasawa 2011: 111).

The second reason why adding attributes, first-order and second-order relations to analogies between God and nature rarely strengthens the inferential power of metaphors grounded in them is that causal relations between them

do not increase their similarity. Higher-order relations are particularly important for the evaluation of metaphoric mediation between science and religion because the relation between Creator and creature is a higher-order relation. This is easily misunderstood. The relation between Creator and creation can be viewed as a relation within the source domain of theology, but also as a relation between that domain and the target domain of the knowledge of nature. In both perspectives God is the 'cause' of all created first and higher-order relations. But only the higher-order relations within the theological domain are potentially relevant in a comparison with the scientific domain. For instance, the relation of divine designer to designed in theology is relevant for the analogous relation of human designer to designed and vice versa. In contrast, causal relations between source and target do not increase their similarity. For instance, the belief that God's having designed creatures (source) 'causes' a human designer to create things (target) does not increase the similarity between source and target. Therefore, they should not enter assessment of inferential power (Hesse 1966: 86; Gentner and Jeziorski 1993: 451). There are good theological reasons for this prohibition. First, God is not a created cause and cannot serve as a controllable parameter in experiment. Second, the notion that the Creator in some sense 'causes' creatures does not increase their similarity because God is free to create things unlike himself. Third, for voluntarists the belief that God creates according to his will combined with the fact that this will is not known, makes inferences from knowledge of God to knowledge of nature impossible. For them the prohibition is irrelevant. Faraday is an exception because he relied on revealed knowledge about God's will. His belief that the Creator causes the existence of creatures combined with his belief that God's power is manifest in creation (Rom. 1: 20) warranted an inference from God's power to created powers. Fourth, the prohibition is relevant for those like Agassiz who hold that God creates according to his reason. If this reason includes a plan to create a concrete object with relations between parts, then his acting according to his reason entails that these relations are created in concrete reality. This increases the similarity between Creator and creature and increases the predictive value of metaphoric inferences. Other than that, this condition is largely irrelevant for the mediation of metaphor between science and religion.

5.4. One-to-one mapping

All comparisons should map one unique attribute or relation in the source with one unique attribute or relation in the target. This standard is intended to prevent that two different source domains are mapped on a single target domain such that the analogy lacks coherent higher-order structure or is contradictory (mixed analogy: Gentner and Jeziorski 1993). One might consider

the God of Christian neo-platonism and the God of the Christian scriptures as two contradictory source domains. The God of the Christian scriptures is revealed as both immutable and as changeable. There is no contradiction because God changes if it serves God's unchangeable goals. However, the God of Christian neo-platonism is immutable in the absolute sense of not permitting even such subsidiary changes. It is important for two or more source domains to be able to be mapped on a single target both in science and in theology. The use of multiple metaphors overcomes the limitations of a single metaphor and allows for their mutual constraint (see below). This is possible provided the higher-order structures of the source domains do not contradict each other.

5.5. Structural consistency

A comparison of relations should include the objects related. For instance, in the analogies between the Trinity, spherical geometry, and the physical universe, Kepler not only employs similarities between the relations of the persons in the Trinity (see above), but also three object correspondences. The first one between God the Father as a spiritual being, the geometric centre of a sphere, and the sun as the physical centre of the universe. The second correspondence between God the Son, the geometrical volume of a sphere, and the physical space between the sun and the fixed stars. The third one between God the Spirit, the geometrical surface of a sphere, and the physical surface of the universe where the fixed stars are located.[10] Such a comparison satisfies the condition of structural consistency. In contrast, Faraday ignored object similarities. Yet his analogy also was a strong one with correspondences between divine and natural force, between unity in trinity and unity of natural forces, and between divine perfection and perfection in nature.

6. *Post-Inference Assessment*

6.1. Correction of error

Analogies can generate error in science (Gentner and Gentner 1983: 126; Nersessian 1988: 42) as well as in theology. Only a subset of errors are associated with the metaphoric mediation between science and religion. In science, when Kepler failed to describe the planetary orbits as circles, this failure was due to an analogy with the idea of divine perfection transferred from Christian neo-platonism. In theology, when Arius developed a theory about the Son of

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[10]   Kepler, 1938, *Myst. cosm*. XX, Werke I p. 70: "Hîc iam longè rectiùs in Solem competunt illa nobilia epitheta, Cor mundi, Rex, Imperator stellarum, deus visibilis, et reliqua". Hübner (1975: 188-189); the analogies are far more detailed than sketched here, see Howell 2002: 128-129.

God, his errors could be traced to an analogy with human fatherhood. In human fatherhood, Arius reasoned, the father exists before the son. Therefore, God the Son was not eternal (Bethune-Baker 1903: 160).

In science, knowledge is revisable. Truth criteria for the study of natural phenomena vary, but include prediction, experimental test, correction, elegance, beauty and fit with metaphysical assumptions. The massive literature on this topic falls outside the scope of this paper. But is it possible to test hypotheses when knowledge of nature is inferred from knowledge of God and vice versa? As in science, in Christian theology, correction of error due to metaphor makes sense only if metaphor is reality-depicting. In contrast to science, truth criteria for metaphors in theology come from Scripture and the interpretive tradition. Such criteria include biblical metaphors for God (Soskice 1985: 115). The many metaphors for God in the Christian scriptures suggested to Bethune-Baker (1903: 160n3) and Ramsey (1965) that correction of error is possible also by mutual limitation of metaphors describing God. Take the metaphors that God is good and all-powerful. Some infer from natural disaster that God is evil because he has the power to prevent disaster, but does not prevent it. In Christian theology, the knowledge that God is good controls the interpretation of natural disasters when the latter function as a secondary source domain from which the knowledge that God is evil is inferred. As a result, that inference is rejected. The analogies 'God is good' and 'God is omnipotent' interpret each other without one or the other being incorrect.

6.2. Errors due to ideological derailment

The appropriate standard response to error is correction. But when metaphor functions tacitly, its effects can go undetected (Polanyi 1966, 1974). When metaphor functions ideologically or religiously, its influence is hard to escape (Pepper 1942: 98-99). For instance, Kepler tried for many years to fit Tycho Brahe's measurements on planetary orbits into the circularity transferred from the Christian Platonism in his source domain before he accepted their elliptical shape. One imagines that for Kepler the neo-platonic meaning of divine perfection had changed. Nevertheless, ideological derailment can be detected. The inherent selectivity of analogy and metaphor can be a manifestation of ideology at work. The effects of ideology include refusal to let metaphors limit each other (see above), refusal to reject a metaphor that produced an empirically inadequate inference about the target, and a refusal to reject a metaphor that cannot interpret the facts with precision or denies their reality (Pepper 1942: 100).[11] I discuss the latter two.

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[11]   For a deeper analysis of the ideological functioning of metaphor and its evaluation, see Botha 2007: 160-164.

Empirical inadequacy: When an explanation suggested by a metaphor fails to account for the facts, and it is not corrected, the metaphor functions as an ideology or world hypothesis (Pepper 1942). World hypotheses are generated by analogy (Pepper 1942: 87-98). For instance, in early sociobiology, Wilson and Lumsden transferred the upwardly causal relations characteristic of the emergent materialism in their source domain to the target domain of organisms. There it was used to explain the production of optically active molecules and genes. This was an error because the production of genes and of optically active populations of molecules is a result of (i) downward causation, (ii) involving information transfer, (iii) affecting individual parts rather than averages over parts. That is, molecules and genes, physical and biological levels of organization were not distinguished (van der Meer 2000). Wilson and Lumsden were thinking about the world in terms of what they knew about physical matter which was their root metaphor (Pepper 1942: 87) or basic metaphor (Botha 2007: 158). Their error may be corrected by an alternative explanation within their root metaphor. Failing that, the root metaphor from which the explanation was developed has become empirically inadequate and needs to be rejected (Pepper 1942: 110).

Interpretative inadequacy. According to Pepper (1942: 118-129) a world hypothesis is inadequate if it fails to interpret the facts with precision or denies their reality. For instance, animism interprets all things in the world as analogous with the human spirit. But since little is known with precision about the human spirit the knowledge inferred from it is imprecise. Mysticism negates the reality of knowledge acquisition by any other means than mystical experience. More generally, mysticism negates the reality of the world and thus fails to interpret it. Therefore, both animism and mysticism are inadequate world hypotheses. When they are not rejected, they function as ideologies.

Christianity can also assume an ideological function. In the past it has denied the reality of deep geological time and failed to interpret the facts on which it is based. But, as Thomas F. Torrance (1980: 8) put it from the perspective of Christian theology, both the scientist and the theologian have the moral obligation to submit to objective reality. This is an appeal to the Christian awareness of a mind-independent reality and the limitations of human knowledge which can protect it from becoming an ideology.

The possibility of ideological derailment of theories in science and religion implies that there are standards by which derailment can be identified. These standards can be provided by Christian theology: "Science can purify religion from error and superstition" and "religion can purify science from idolatry and false absolutes [...]. Only a dynamic relationship between theology and science can reveal those limits which support the integrity of either discipline, so that

theology does not profess a pseudo-science and science does not become an unconscious theology" (John Paul II 1988: M13, M14).

7. *Conclusion*

My thesis is that metaphor can mediate between science and religion. I have assessed the use of metaphor within science and within theology for applicability to this mediating role. The highest standard for assessing metaphoric mediation between science and religion is consonance with the purpose of the comparison. The subjectivity of scientific and religious knowledge levels the playing field for intentions to function as a subjective standard. Two of these purposes are comprehensive coherence and consonance with a tradition. For the Christian tradition these entail consonance with the essential difference between Creator and creation. This difference explains why including attributes and relations in analogies between God and nature does not strengthen the inferential power of metaphor grounded in these analogies as it does in science. For inferences from knowledge of God to knowledge of nature this essential difference implies that negative divine attributes cannot be used while positive attributes have limited application. Also, within-domain relations of implication have little relevance for inferences about nature for it is causal relations that are the main interest of science and they are not included in the source domain. As for converse inferences from knowledge of nature to knowledge of God, the essential difference in the Roman tradition limited them and led Protestants to exclude them. A subsidiary reason for the failure to strengthen the inferential power of metaphor is that causal relations between God and nature do not increase their similarity. In sum, metaphor can mediate between science and the Christian religion, but its role is severely limited.

My thesis is not only that metaphor can mediate between science and religion, but also that this mediation can satisfy Hesse's requirement that their relative independence be respected. Hesse holds that one can study the physiology of religious experience, but that nature is a very limited source for metaphoric inferences about God. Two conclusions follow. First, Hesse allows that science can offer models for theology. But her restrictions on the use of nature as a source for metaphoric inferences about God continue the tradition of classical Protestant theology as expressed by Calvin, Barth and Torrance. Second, science has no necessary implications for theology. Thus theology has its own sources of knowledge and ways of justifying this knowledge. In classical Christianity metaphors for God are taken to be supplied by God. That tradition may be the context within which to understand Hesse's stated reliance on divine

guidance for the selection of such metaphors in the face of a lack of socially agreed criteria for metaphors for God.

Given that according to Hesse religion has its own methodology, how does one respect the differences between criteria for truth when science and religion are source and / or target? Since Hesse did not comment on that question let me venture a suggestion inspired by her notion that both the interpretation of nature and of scripture are socially shaped (Hesse 1983). Extra-scriptural sources (the social context) can be an occasion for considering a different interpretation of a text in the scriptures, provided the scriptures offer the justification for the re-interpretation. Likewise, extra-scientific sources (the social context, Agassiz's Christian neoplatonism) can be an occasion for considering a different interpretation of nature in a scientific theory, provided nature offers the justification for the re-interpretation. The differences between science and the scriptures are intended to be respected by stipulating that each provides its own justification. In conclusion, opportunities for metaphoric mediation between science and religion are limited, but metaphoric mediation is possible if these qualifications are met.

Acknowledgements

References

Barbour, Ian G., 1974, *Myths, Models and Paradigms*, Harper & Row, San Francisco.

Barrett, Justin L., 2011, *Cognitive Science, Religion and Theology: From Human Minds to Divine Minds*, Templeton Press, West Conshohocken.

Berkhof, Louis, 1996, *Systematic Theology*, Eerdmans, Grand Rapids.

Bethune-Baker, J.F., 1903, *An Introduction to the Early History of Christian Doctrine to the Time of the Council of Chalcedon*, Methuen & Co., London.

Black, M., 1962, *Models and Metaphors. Studies in Language and Philosophy*, Cornell University Press, Ithaca.

Botha, M. Elaine, 1993, "The mediating role of metaphor and analogy in the relationship between science and religion", in *Tydskrif vir Christelike Wetenskap*, 29, 4: 60-73.

Botha, M. Elaine, 2007, *Metaphor and its Moorings: Studies in the Grounding of Metaphorical Meaning*, Peter Lang, Bern.

Brooke, John Hedley, 1991, *Science and Religion: Some Historical Perspectives*, Cambridge University Press, Cambridge.

Brooke John Hedley, Margaret J. Osler, Jitse M. van der Meer, 2001, eds., *Science in Theistic Contexts: Cognitive Dimensions*, *Osiris*, 16.

Brümmer, Vincent, 1982, *Theological and Philosophical Inquiry: An Introduction*, The Westminster Press, Philadelphia.

Brümmer, Vincent, 2006, "Metaphorical Thinking", in Brümmer, Vincent, ed., *Brümmer on Meaning and the Christian Faith*, Ashgate, Aldershot, Hampshire-Burlington Vt: 143-154.

Cantor, Geoffrey N., 1991, *Michael Faraday: Sandemanian and Scientist*, MacMillan, London.

Clouser, Roy A., 2005, *The Myth of Religious Neutrality: An Essay on the Hidden Role of Religious Belief in Theories*, rev. ed. University of Notre Dame Press, Notre Dame, IN.

Dauben, Joseph W., 1977, "Georg Cantor and Pope Leo XIII: Mathematics, Theology, and the Infinite", in *Journal of the History of Ideas*, 38, 1: 85-108.

Durkheim, Étienne, 1915, *Elementary Forms of Religious Life*, Allen&Unwin, London; ed. or. *Les formes élémentaires de la vie religieuse*, Alcan, Paris, 1912.

Durkheim, Étienne, Marcel Mauss, 1963, *Primitive Classification*, Routledge, London; ed. or. "De quelques formes primitives de classification. Contribution à l'étude des representations collectives", in *Année Sociologique*, 6: 1-78 (1903), reprinted in Mauss, Marcel, 1968, *Essais de sociologie*, Minuit, Paris: 162-230.

Gentner, Dedre, 1983, "Structure mapping: a theoretical framework for analogy", in *Cognitive Science*, 7: 155-170.

Gentner, Dedre, Donald R. Gentner, 1983, "Flowing Waters or Teeming Crowds: Mental Models of Electricity", in Gentner, Dedre, A.L. Stevens eds., *Mental Models*, Lawrence Erlbaum, Hillsdale, NJ: 99-129.

Gentner, Dedre, Michael Jeziorski, 1993, "The shift from metaphor to analogy in Western science", in Ortony, A. ed., *Metaphor and Thought*, 2nd ed. Cambridge University Press, Cambridge: 447-480.

Gentner, Dedre, Arthur B. Markman, 2005, "Defining Structural Similarity", in *Journal of Cognitive Science*, 6: 1-20.

Gerhart, Mary, Allan Russell, 1984, *Metaphoric Process: The Creation of Scientific and Religious Understanding*, Texas Christian University Press, Fort Worth.

Hesse, Mary B., 1954, *Science and the Human Imagination: Aspects of the History and Logic of Physical Science*, SCM Press, London.

Hesse, Mary B., 1963, *Models and analogies in Science*, Sheed & Ward, London.

Hesse, Mary B., 1965, "Miracles and the Laws of Nature", in Moule, Charles Francis Digby ed., *Miracles. Cambridge Studies in Their Philosophy and History*, London: 33-42.

Hesse, Mary B., 1969, "Talk of God", in *Philosophy*, 44, 170: 343-349.

Hesse, Mary B., 1975, "On the Alleged Incompatibility between Christianity and Science", in Hugh Montefiore ed., *Man and Nature*, Collins, London: 121-131.

Hesse, Mary B., 1976, "Criteria of truth in science and theology", in *Religious Studies*, 11: 385-400. Reprinted in: Hesse, Mary B., 1980, *Revolutions and Reconstructions in the Philosophy of Science*, The Harvester Press, Brighton, Sussex: 235-255.

Hesse, Mary B., 1979, "The ideological and theological debate about science: introduction and a statement of the issues", in *Anticipations*: 4-5 and 8-11.

Hesse, Mary B. 1978, 1979, 1980, *The Stanton Lectures*, University of Cambridge. Unpublished lecture notes deposited in the History and Philosophy of Science Library, Cambridge.

Hesse, Mary B., 1980, *Revolutions and Reconstructions in the Philosophy of Science*, The Harvester Press, Brighton, Sussex.

Hesse, Mary B., 1981, "Retrospect", in A.R. Peacocke ed., *The Sciences and Theology in the Twentieth Century*, Oriel Press, London-University of Notre Dame Press, Notre Dame IN: 281-295.

Hesse, Mary B., 1983, "Cosmology as Myth", in *Concilium*, 6, 166: 49-54.

Hesse, Mary B., 1988, "Physics, Philosophy, and Myth", in Russell, Robert J., William R. Stoeger, S.J., and George V. Coyne, S.J. eds. *Physics, Philosophy, and Theology: A Common Quest for Understanding*, Vatican Observatory: Vatican City State / University of Notre Dame Press: Notre Dame: 185-202.

Hesse, Mary B., 1991, "Essay Review", [Philip Clayton, *Explanation from Physics to Theology: An Essay in Rationality and Religion*, Yale University Press, New Haven 1989: 230], in *CTNS Bulletin*, xi, 2: 39-40.

Hesse, Mary B., 1994, "The sources of models for God: metaphysics or metaphor?", in J. Hilgevoord ed., *Physics and Our View of the World*, Cambridge University Press, Cambridge: 239-254.

Hesse, Mary B. 1998, "Is Science the New Religion?", in *Science Meets Faith: Theology and Science in Conversation*, F. Watts ed., Society for Promoting Christian Knowledge, Holy Trinity Church, London: 120-135.

Hesse, Mary B., 2000, "Philosophy of Language and the Renewal of Biblical Hermeneutics: Response to Neil B MacDonald" [Neil B. MacDonald, "How Might the Philosophy of Language Aid the Renewal of Biblical Hermeneutics"] in Bartholomew, C.G., C.J.D. Greene, K. Möller eds., *Renewing Biblical Interpretation*, Paternoster Press, Carlisle and Zondervan, Grand Rapids MI: 141-144.

Hesse, Mary B. 2001, "How to be a Postmodernist and remain a Christian", in Bartholomew, C.G., C.J.D. Greene, K. Möller eds., *After Pentecost: Language and Biblical Interpretation*, Paternoster Press, Carlisle and Zondervan, Grand Rapids MI: 91-96.

Hodge, Charles, 1873, *Systematic Theology*, Vol. 1, Scribner, Armstrong&Co., New York.

Holyoak, Keith J., Paul Thagard, 1996, *Mental Leaps: Analogy in Creative Thought*, MIT Press, Cambridge MA-London.

Howell, Kenneth J., 2002, *God's Two Books: Copernican Cosmology and Biblical Interpretation in Early Modern Science*, University of Notre Dame Press, Notre Dame IN.

Hübner, Jürgen, 1975, *Die Theologie Johannes Keplers zwischen Orthodoxie und Naturwissenschaft*, Mohr (Paul Siebeck), Tübingen.

Jeffreys, Derek S., 1997, "How Reformed Is Reformed Epistemology? Alvin Plantinga and Calvin's 'Sensus Divinitatis'", in *Religious Studies*, 33, 4: 419-431.

Kelemen, Deborah, 2004, "Are Children 'Intuitive Theists'?", in *Psychological Science* 15: 295-301.

Kepler, Johannes, 1938, *Mysterium Cosmographicum. De Stella Nova*, Max Caspar ed., in *Gesammelte Werke*, herausgegeben im Auftrag der Deutschen Forschungsgemeinschaft und der Bayerischen Akademie der Wissenschaften, begründet von Walther von Dyck und Max Caspar, C.H. Beck, München, Vol. 1.

Lurie, Edward, 1959, "Louis Agassiz and the idea of evolution", in *Victorian Studies*, 3: 87-108.

MacCormac, Earl R., 1983, "Religious metaphors: mediators between biological and cultural evolution that generate transcendent meaning", in *Zygon*, 18, 1: 45-65.

Mavrodes, George I., 1970, *Belief in God: A Study in the Epistemology of Religion*, Random House, New York NJ.

Meschkowski, H., 1967, *Probleme des Unendlichen. Werk und Leben Georg Cantors*, Vieweg, Braunschweig.

McGrath, Alister E., 1999, *T. F. Torrance: An Intellectual Biography*, T&T Clark, Edinburgh.

Nagasawa, Yujin, 2011, *The Existence of God: A Philosophical Introduction*, Routledge, New York NJ.

Nersessian, Nancy J., 1988, "Reasoning from Imagery and Analogy in Scientific Concept Formation", in *Philosophy of Science Association*, 1: 41-47.

Pascal, Blaise, 1965, *Pensées: Thoughts on Religion and other subjects*, Washington Square Press, New York NJ.

Pepper, Stephen C., 1942, *World Hypotheses*, University of California Press: Berkeley, Los Angeles.

Plantinga, Alvin, 2000, *Warranted Christian Belief*, Oxford University Press, Oxford, England.

Polanyi, Michael, 1946, *Science, Faith and Society*, University of Chicago Press, Chicago.

Polanyi, Michael, 1966, *The Tacit Dimension*, Doubleday & Company, Garden City NJ.

Polanyi, Michael, 1974, *Personal Knowledge: Towards a Post-Critical Philosophy*, University of Chicago Press, Chicago.

Polkinghorne, John C., 1989, *Science and Providence*, Society for Promoting Christian Knowledge, London.

Pope Benedict XVI, 2006, "Faith, Reason and the University: Memories and Reflections", Lecture, University of Regensburg, September 12, 2006, Libreria Editrice Vaticana, accessed August 4, 2014: http://www.vatican.va/holy_father/benedict_xvi/speeches/2006/

Pope John Paul II, 1988, "Message of His Holiness Pope John Paul II", in Russell, Robert John, William Stoeger, S.J., George V. Coyne, S.J. eds. *Physics, Philosophy and Theology: A common Quest for Understanding*, Vatican Observatory, Vatican City.

Ramsey, Ian, 1965, *Christian Discourse: Some Logical Explorations*, Oxford University Press, London-New York.

Soskice, Janet M., 1985, *Metaphor and Religious Language*, Clarendon Press, Oxford, England.

Torrance, Thomas F., 1970, "The problem of natural theology in the thought of Karl Barth", in *Religious Studies*, 6: 121-135.

Torrance, Thomas F., 1980, *Christian Theology and Scientific Culture*, Christian Journals Ltd., Belfast.

Torrance, Thomas F., 1984, "Christian Faith and Physical Science in the Thought of James Clerk Maxwell", in Thomas F. Torrance ed., *Transformation and Convergence in the Frame of Knowledge*, Eerdmans, Grand Rapids, MI.: 215-242.

Torrance, Thomas F., 1989, *The Christian Frame of Mind: Reason, Order, and Openness in Theology and Natural Science*, Helmers & Howard, Colorado Springs, CO.

Van der Meer, Jitse M., 2000, "The Engagement of Religion and Biology: A Case Study in the Mediating Role of Metaphor in the Sociobiology of Lumsden and Wilson", in *Biology and Philosophy*, 15: 669-698.

Van Fraassen, Bas, 1997, "Sola Experientia? Feyerabend's Refutation of Classical Empiricism", in *Philosophy of Science*, 64: S385-S395, Supplement. Proceedings of the 1996 Biennial Meetings of the Philosophy of Science Association. Part II: Symposia Papers.

Wolterstorff, Nicholas, 1976, *Reason Within the Bounds of Religion*, Eerdmans, Grand Rapids.

Wolterstorff, Nicholas, 1995, *Divine Discourse: Philosophical Reflections on the Claim that God Speaks*, Cambridge University Press, Cambridge.

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