Historical and Conceptual Foundation of Diagrammatical Ontology

Peter Øhrstrøm

Department of Communication and Psychology
Aalborg University

Sara L. Uckelman

Institute for Logic, Language, and Computation
Universiteit van Amsterdam

Henrik Schärfe

Department of Communication and Psychology
Aalborg University

Abstract. During the Renaissance there was a growing interest for the use of diagrams within conceptual studies. This paper investigates the historical and philosophical foundation of this renewed use of diagrams in ontology as well as the modern relevance of this foundation. We discuss the historical and philosophical background for Jacob Lorhard's invention of the word 'ontology' as well as the scientific status of ontology in the 16th and 17th century. We also consider the use of Ramean style diagrams and diagrammatic ontology in general. A modern implementation of Lorhard's ontology is discussed and this classical ontology is compared to some modern ontologies.

Keywords: Ontology, diagrammatical reasoning, conceptual structures

It is commonplace in modern computer science to present ontologies in terms of diagrams. In this way the ontologies are supposed to be more readable than they would be if presented as sets of logical formulae. In addition, the use of diagrams has been supposed to facilitate and support conceptual reasoning. According to Peirce, the use of diagrams in logic can be compared with the use of experiments in chemistry. Just as experimentation in chemistry can be described as "the putting of questions to Nature", the conceptual experiments upon diagrams may be understood as "questions put to the Nature of the relations concerned" (CP: 4.530). This should not be misunderstood. Logic is not psychology. Peirce made it very clear that logic is not "the science of how we do think", but it determines "how we ought to think" (CP: 2.52). In this way, logic is not descriptive, but, according to Peirce, it should be seen as a normative science. In fact, he considered diagrammatical reasoning as "the only

really fertile reasoning", from which not only logic but every science could benefit (CP: 4.571).

However, logicians have had similar views for centuries, although the points may not have been stated so elegantly as Peirce did. In particular, diagrammatical representation has been regarded as useful within the study of ontology. An early example of this is the often cited 'Tree of Porphyry'. Whether Porphyry actually did use diagrams, we cannot say for certain, but the literature on this particular structure points in general to a rendering by Peter of Spain from the 13th century. Diagrams were used in medieval discussion of conceptual structures, but the emphasis on the importance of diagrammatical reasoning within conceptual studies became much stronger during the Renaissance. In this paper we intend to discuss the historical and conceptual foundation of this renewed use of diagrams in ontology. We intend to show that scientists working with the development of ontologies may benefit from reflections on this historical and philosophical foundation of their enterprise. In section 1, we discuss the historical and philosophical background for Jacob Lorhard's invention of the word 'ontology'. In section 2, we consider the scientific status of ontology in the 16th and 17th century. In section 3, we shall focus on the use of Ramean style diagrams in science in general and in ontology in particular. In section 4 we discuss selected elements of Lorhard's diagrammatic ontology. In section 5, we discuss how Lorhard's ontology can be implemented in a modern context using the Amine platform, and compare Lorhard's ontology with some modern ontologies. Finally, we discuss the modern relevance of the beliefs incorporated in the ontology of the 16th and 17th century.

1. The Invention of the Word 'Ontology'

The word 'ontologia' is not an original Greek word, i.e., it was never used in ancient philosophy. As we have argued in [Øhrstrøm, Andersen, Schärfe 2005] the word was constructed in the beginning of the 17th century by Jacob Lorhard (1561-1609), who, probably mainly for pedagogical reasons, wanted to present metaphysics, i.e., the conceptual structure of the world, in a diagrammatical manner. In a sense, Lorhard used 'ontology' as a synonym for 'metaphysic'. But by introducing the new word he probably also wanted to indicate that the field was being renewed.

Jacob Lorhard was born in 1561 in Münsingen in South Germany. We do not know much about his life. But it appears that the 10 years younger Johannes Kepler met him at Tübingen University, where Kepler is known to have studied in the period 1587-91. At that time Lorhard was probably a young teacher. Kepler listed Lorhard as one of the persons whom he regarded as hostile to him, and he added: "Lorhard never communicated with me. I admired him, but he never knew this, nor did anyone else". [Koestler: 235-6]

Lorhard was (like Kepler) a Protestant, and he was involved in various religious studies and discussions. In fact, the new way of treating and presenting conceptual structures signaled by the introduction of the word 'ontology' can easily been seen in the context of the general openness that characterized academic life within the Protestant circles in the late 16th century. This general and scientific openness was clearly essential for many of the important contributions to the new approach to science which was being developed during the same period, with Kepler

as one its most important representatives. Clearly, this new approach to science could easily be related to discussions regarding worldview in general, and thereby also to metaphysics and ontology.

Lorhard was deeply interested in metaphysics, understood as the study of the conceptual structure of the world. In 1597 he published his *Liber de adeptione*, in which he wrote:

> Metaphysica, quae res omnes communiter considerat, quatenus sunt οντα, quatenus summa genera & principia, nullis sensibilibus hypothesibus subnixa. [1597: 75] Metaphysica, which considers all things in general, as far as they are existing and as far as they are of the highest genera and principles without being supported by hypotheses based on the senses. (Our translation.)

Lorhard came to the Protestant city St. Gallen in 1602, where he worked as a teacher and a preacher. The year after, in 1603, he became 'Rektor des Gymnasiums' in the protestant city of St. Gallen. He was accused of alchemy and also a heretical view on baptism. He was, however, able to defend himself rather convincingly, and his statements of belief were in general accepted by the church of St. Gallen. (See [Hofmeier et al. 1999: 28 ff.] and [Bätscher 1964: 171 ff.]) In 1606 he published his *Ogdoas scholastica*, a volume consisting of eight books dealing with Latin and Greek grammar, logic, rhetoric, astronomy, ethics, physics, and metaphysics (or ontology), respectively.

Although Lorhard only used his new word a few times in the book, he did present his new term in a very prominent manner letting "ontologia" appear in the frontispiece of *Ogdoas scholastica*. This was probably the very first use ever of the term 'ontology' in a book. The title of the book is stated as "Metaphysices seu ontologiæ" indicating that 'ontologia' is to be used synonymously with 'metaphysica'.

As suggested by Marco Lamanny [2006], it is very likely that Lorhard's book on ontology in *Ogdoas scholastica* is in fact mainly based on Clemens Timpler's *Metaphysicae Systema methodicum* [1604], which was published in Steinfurt. Lamanny [2006] has convincingly demonstrated that all the essential philosophical terms in the book also appear in Timpler's book with the same mutual relations. However, it is evident that Jacob Lorhard in composing his version of the metaphysical system made two very important contributions to the understanding and presentation of the field:

1) He introduced the new word "ontology", which has been important since then in philosophical discourse and much more recently also in computer science.
2) He presented his material (in fact, all eight books of *Ogdoas scholastica*) in diagrammatical manner representing the conceptual structure in terms of graphical relations.

As we shall see in section 3, Lorhard did his work under the influence of the works of Peter Ramus. It should be emphasized that Lorhard in transforming Timpler's metaphysical ideas into Ramean style diagrams did in fact make original contributions relevant for the understanding and presentation of the conceptual framework of reality.

In 1607, i.e., the year after the publication of *Ogdoas scholastica*, Lorhard received a calling from Landgraf Moritz von Hessen to become professor of theology in Marburg. At that time Rudolph Göckel (1547-1628) was also professor in Marburg in logic, ethics, and mathematics. Göckel apparently also paid great attention to Timpler's work. In fact, he had written a preface of Timpler's book [Timpler 1604]. It seems to be a likely assumption that Lorhard and Göckel met one or several times during 1607, and that they shared some of their findings with each other. In this way the sources suggest that Göckel during 1607 may have learned about Lorhard's new term 'ontologia' not only from reading *Ogdoas scholastica* but also from personal conversations with Lorhard. For some reason, however, Lorhard's stay in Marburg became very short and after less than a year he returned to his former position in St. Gallen. Lorhard died on 19 May, 1609. Later, in 1613, Lorhard's book was printed in a second and revised edition under the title *Theatrum philosophicum*. In this new edition the word 'ontologia' had disappeared from the front cover, whereas it has been maintained inside the book. In 1613, however, the term is also found in Rudolph Göckel's *Lexicon philosophicum*. Here the word 'ontologia' is only mentioned briefly as follows: "ontologia, philosophia de ente seu Transcendentibus" (i.e., "ontology, the philosophy of being or the transcedentals"). It is very likely that Göckel included this term in his own writings due to inspiration from Lorhard.

2. The Scientific Status of Ontology

Lorhard introduced metaphysics (or ontology) using the Greek term επιστημη for which we in [2005: 429] suggested the translation 'knowledge'. However, as argued by Claus Asbjørn Andersen [personal communication], it appears from the context that Lorhard must have used επιστημη as corresponding to the Latin *scientia*. Taking this into account, Lorhard's definition of 'ontology' becomes "the science of the intelligible as intelligible insofar as it is intelligible by man by means of the natural light of reason without any concept of matter" [1606: Book 8, p.1]. This science is obviously not just any 'knowledge' among many other branches of human knowledge. Being "the science of the intelligible" it is clearly logically and systematically prior to other discipline of the human intellect, i.e., a first philosophy.

As mentioned above, ontology according to Lorhard is about what can be understood by man "by means of the natural light of reason without any concept of matter", and as emphasized in his *Liber de adeptione*, it should not rely on assumptions based on the senses primarily. This means that in working with the ontology we should not involve any concept of 'matter'. As convincingly argued by Claus Asbjørn Andersen [2004: 96 ff.], Göckel's presentation of ontology includes an even stronger emphasis of the importance of abstraction from the material. In this way ontology may be characterized as the study of what can be understood by the human intellect organized in a system reflecting the order of the conceptual understanding in a proper manner.

It is an important guiding principle in Göckel's ontology that the fundamental terms in the structure are organized in pairs of concepts. The same is clearly the case in Lorhard's ontology. His system is presented in terms of dichotomies whenever possible, i.e., he probably wanted to divide any complex class of concepts into two subclasses characterized by contradictory terms.

Lorhard's approach to ontology was probably very much inspired by the

Peter Ramus (1515-72), who had strongly criticized Aristotelian scholasticism, and who had suggested that the liberal arts should be organised and presented in a new manner. Ramus emphasized the importance of mathematics in the contexts of knowledge in general, but he also insisted on a practical and operational approach to mathematics. As emphasized by R. Hooykaas [1987] Ramus was interested in how the making of instruments could support the application of mathematics in the study of reality. This interest was probably based on the belief in a mathematical structure of the physical and conceptual universe. This view when taken together with the practical approach mathematics turned out to be essential for the rise of modern natural science.

In 1562 Ramus converted to Calvinism, and he was murdered in Paris in the St. Bartholomew's Massacre on August 26, 1572. The fact that he was considered to be a Protestant martyr made many intellectual Protestants interested in his ideas. In fact, his religious and scientific ideas became very influential in the Protestant world during the 16th and 17th century.

Lorhard (like Ramus) accepted the idea that we may understand reality (or at least important aspects of reality) by means of the natural light of reason, i.e., we have as rational beings access to necessary truth in mathematics and in reality in general. Ontology is the science of the structure of the conceivable truth about the material and immaterial world. In this way, ontology may be seen as included in natural theology according to which man as a rational being may understand essential aspects of the world without having to base his understanding on any special revelation. If seen in this way, ontology must be something universal, in principle accessible to every rational human being. In addition, ontology does not depend on anything physical, although as a science it is certainly very important, since it forms the background for our interaction with the world. Given this kind of practical importance, it was obvious to Lorhard that ontology should be one of the sciences taught to young people early in the education.

3. The Diagrammatical Approach to Ontology

As noted above, Lorhard's approach to ontology and in particular his use of diagrams, was probably very much inspired by Peter Ramus (1515-72), who had argued that scientific knowledge at least, for pedagogical reasons, should be simplified using diagrams organised in dichotomies.

Walter J. Ong [1959: 436 ff.] has pointed out that there seems to be an interesting relation between invention of printing and the impact of the development associated with Ramus' ideas. Shortly after the invention of printing the use of tables of dichotomies or bracketed outlines of subjects became very famous. As in Lorhard's books the subjects were often organised as long series of dichotomies presented in terms of brackets. This way of organising and presenting subjects can also be found in manuscripts written before that time, but they seem to have been relatively rare before the invention of printing. It is very likely that the new technology of printing facilitated the spread of what was considered to be a very impressive and powerful way of presenting a subject matter. According to Ong [1959: 437] there was a kind of "addiction to such outlines" during the 16th and 17th century. The ideology behind this tendency seems to have been that the diagram in a very effective manner, can make

the conceptual relations clear to us, and that the very conceivability of a term may fundamentally depend on its relations to other terms or concepts, i.e., that "words are made intelligible by being diagrammatically related to one another" [Ong 1959: 437].

Ramus himself often used diagrams based on dichotomies. As argued by Stephen Triche and Douglas McKnight [2004], his main purpose for representing knowledge in terms of diagrams was pedagogical. In fact, he argued that following his ideas and pedagogical logic the various studies of the liberal arts could be united in one course. Triche and McKnight state:

> Ramus's primary intellectual accomplishment was the refinement of the art of dialectic by transforming dialectical reasoning into a single method of pedagogical logic for organizing and demonstrating all knowledge. In addition, his invention of method completes humanism's transformation of medieval scholasticism's courses of study in the liberal arts into a recursive singular course of studies called curriculum. [2004: 40]

According to Ramus this kind of new order in the higher studies should be established using the laws of logic (dialectic). Given that logic operates with two truth-values, true and false (corresponding to yes/no), this can easily lead to the idea of dichotomies. In this way, he believed, that every subject can be represented in terms of a diagram of dichotomised concepts. Also, the order in which the concepts appear in the diagram is not arbitrary. According to Ramus there is a natural order of the concepts, which should used in the construction of the diagram. This order should be taken into account when teaching the subject in question. In his own words:

> Through the light of artistic method, everything is more clearly taught and much more easily understood, since universal, general matters come first with subsidiary parts following, and all things arrainged by that wonderful, linking organization of antecedents and consequents (Quoted from [Triche & McKnight 2004, p.46]).

It is obvious that this view may lead to a high degree of standardisation in teaching, since it follows from the Ramean view that there is only one optimal way of organising the subject in question, and since every teacher should take this order of concepts into account.

The Ramean use of dichotomies has often been discussed e.g. in confessing his own "leaning to the number Three in philosophy", Peirce noted that other numbers have had their champions, and he gives as an example that "Two was extolled by Peter Ramus" [CP: 1.355]. It is in fact quite obvious that Ramus believed that every subject can be presented in terms of his dichotomistic diagrams. As pointed out by Bruce MacLennan "the Ramean Tree (or Ramean Epitome) proceeds by logical dichotomy from the most general term of any subject matter. In effect the Ramean Tree is an abstract geometrical diagram of the (supposed) essential structure of reality" [MacLennan 2006: 96].

4. Elements of Lorhard's ontology

Jacobus Lorhard presented his ontology in terms of connected Ramean style diagrams written in an elaborated manner. This means that he wanted to use the principle of dichotomy as far as possible. Fig. 1 is a translation of the first page of his ontology, and the chapter continues with 58 pages of similar structures. The capital letters (A, B, C, EE, RRR) refer to continuations on subsequent pages in a way that almost resembles modern day hypertext.

In the presentation of his ontology, Lorhard uses the Ramean style bracket as his basic representational tool. However, he uses these brackets in three distinct ways. Most commonly, the brackets are a tool for dividing complex terms into two or more disjunctive subsets represented by contrasting terms. For example, infinity is either absolute or restricted (§I), necessity is either absolute or hypothetical (§L), goodness is either apparent or true (§O), and so on.

The second way that these brackets are used is in introducing explanatory notes. This usage occurs only in the very top levels of the tree, and instead of the brackets dividing a complex term into two subsets, one branch of the bracket gives a further gloss on how a term should be understood and the other then introduces how the term may be further divided. For example, before dividing 'the intelligibles' into 'nothing' and 'something', there is a note (λόγος) defining what intelligbles are. (See Fig. 1).

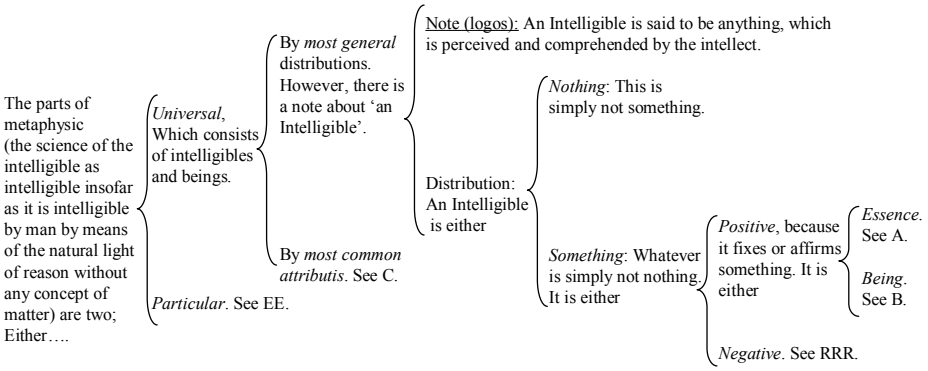

Fig. 1 First page of Lorhard's ontology

He uses the brackets in a third way not to divide one complex term into two more specific terms, but to gather two sub-terms back together before dividing them as a group. For example, when Lorhard is discussing time, he first divides it into the subgroups of momentary time and successive time. However, members of both of these classes are either real or imaginary, and he indicates this by having opposite-facing brackets collect the categories of successive time and momentary time together before dividing the entire group into that which is real and that which is imaginary (§D). See Fig. 2.

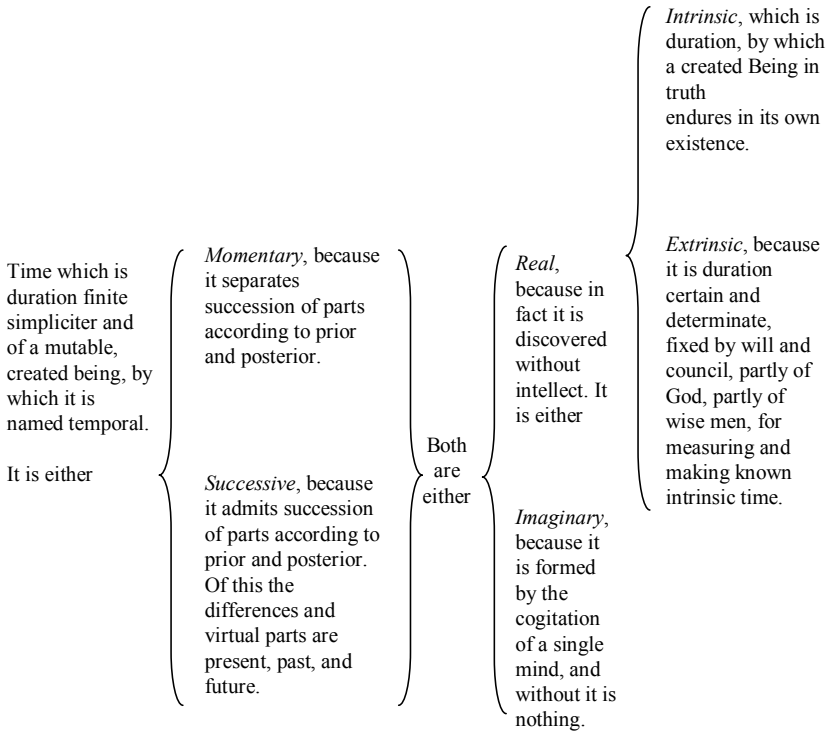

Fig. 2 Fragment concerning time

Wherever possible, Lorhard divides terms into two, exclusive and exhaustive, sub classes. However, there are cases where this is not possible, such as when he divides respective or relative goodness into the three categories of 'honor', 'utility', and 'jocundity' (§P). In these cases, it is no longer immediately clear that the chosen categories do in fact exhaustively represent the space. Certainly it is not obvious to a 21st century person that these three types of respective goodness are the only three types, or even that they are mutually exclusive (which Lorhard appears to think they are).

One thing which is clear is that Lorhard, in making this tree, is not attempting to give *definitions* of classes, but rather *divisions* (or, as he sometimes says *distributions*) of classes. This is easily seen, for example in Fig. 1, when he divides intelligibles into the two classes 'something' and 'nothing', as he describes 'nothing' as that which isn't something, and 'something' is glossed as that which isn't nothing; or when a 'principle' is glossed as that on which a principiate depends, and a 'principiate' is glossed as that which depends on a principle (§§VV, vv). If these glosses are taken as definitions of the terms, then circularity results. One must know in advance the meanings of the terms before one can proceed to classifying and codifying the relationships between the classes.

5. A Modern implementation of Lorhard's ontology

As part of this investigation, Lorhard's ontology was translated into English, and also into a present-day notation. The problems related to translating the ontology from Renaissance Latin to English is discussed in the annotated translation [Lorhard 2007]. Here, we shall report some of the most interesting aspects of turning this 400 year old system of thought into a modern ontology. Lorhard's text was represented using the Amine platform and resulted in a formal ontology, understood here as a hierarchy of types. We are assuming that the Ramean brackets correspond to a subtype relation, that is: for the most parts. Certain aspects of the notation will be discussed below.

The use of meta-constructs

In modern ontologies it can be very difficult to see how distinctions are made, and types are derived from these distinctions. In particular, it is often difficult to see clearly what the author(s) of a given ontology was aiming at through their distinctions, which again makes it difficult to decipher the intention behind the represented distinctions. In a context where agents are supposed to operate amidst a large number of ontologies, such considerations become increasingly important. To some extend this problem can be solved by collecting the supertypes of a type in question, but that does not necessarily reveal the strategy by means of which the knowledge in question was represented. Lorhard chose to incorporate his comments directly into the diagrammatical representation, using the Logos – Distribution distinction, mentioned above. Although this part of the representation is presented as part of the actual ontology, when dealing with formal ontologies this part should in fact be considered a meta-construct, designed to aid the reader to understand how the definitions at hand work. This seems like a very elegant solution, although a modern implementation requires a separate notation for such information.

The inverted brackets

The use of inverted brackets as mentioned in Fig. 2. is very widespread throughout Lorhard's ontology, and indeed throughout the *Ogdoas*. However, the semantics of this notation was not initially clear to us, and we did in fact speculate as to whether this could be seen as a forerunner of multiple inheritance. A closer study of the original texts does, nonetheless, reveal that the inverted bracket is a shorthand notation for a simple tree structure.

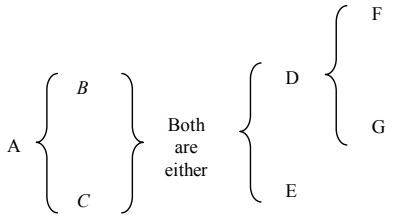

Fig. 3 The inverted brackets

So in fact the structure shown here can be unfolded as seen below in the left, which again corresponds to the more modern graphical of a hierarchy shown below to the right.

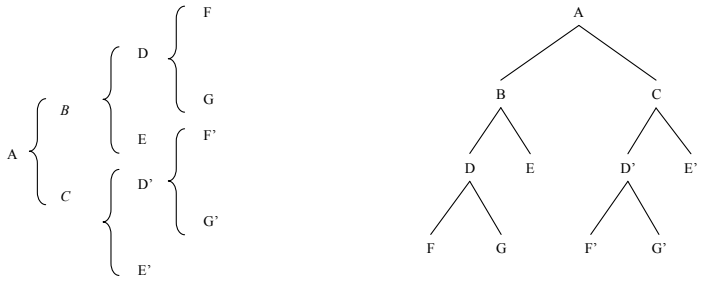

Fig. 4 Rendering of the inverted brackets

It is striking that the Renaissance texts all show the hierarchies written from left to right, whereas in modern representations it is usual to draw hierarchies in a vertical manner. Quite probably, this manner of representation is inherited from Ramus, and possibly also became conventionalized through printing practises of that time. The shift in style of representation from horizontal to vertical is however interesting because it reflects our conceptualization of the models at hand – a condition that is also reflected in our use of language, e.g. *sub*-types. However, the history of such preferences in representation style must be left for enquiry elsewhere.
In terms of translating this ontology into a contemporary system, the shorthand notation requires a separate naming of the types that are part of the structure to be duplicated.

The top ontology

The layout of the original text does not offer a single overview of the top structure of the ontology. The elaborate system of references guides the reader through the pages from section to section. Each section is organized as if one was traversing a tree. The top structure can therefore be extracted and reproduced as in fig. 5.
It is worth noticing that Lorhard's ontology does not begin with a distinction between *physical* and *abstract*, as many other ontologies do, but rather the first top distinction is between *universals* and *particulars*. Universal is then divided into a class of the *general intelligible* and a class defined by *common attributes*. The *particular* is divided into *substantial* (on its own) and *accidental* (through something else). It turns out that these distinctions are rather typical in Lorhard's thinking, and it hints at a guiding principle for the construction of many subsequent divisions, as will be described next.

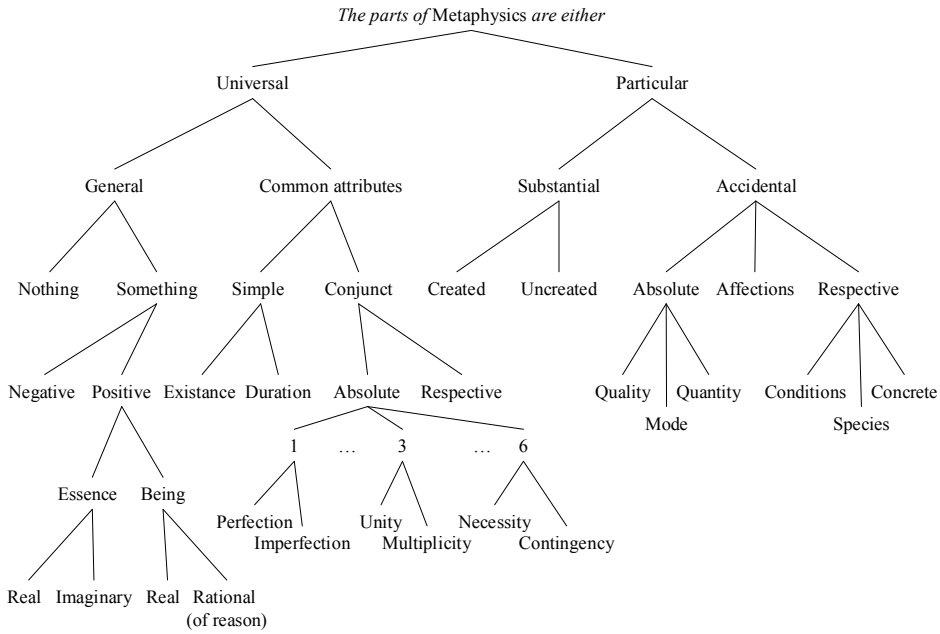

Fig. 5 The top distinctions

Iterations

Throughout the ontology there is an extensive use of repeated terms. As discussed at the end of section 4, the reader of the diagrams must follow the path from the earlier distinctions on order to grasp the meaning of mentioned of recurring terms, such as *real* and *imaginary*. See fig. 2 and 5. Such contextual readings are obviously not practical in computational environments, but do point to a guiding principle of Lorhard's thinking.

In terms of Knowledge Representation (KR), some of these recurring distinctions can be said to belong to a KR meta-language, employing such terms as: *generic* and *specific* (which occur 7 times) *universal* and *singular, immanent* and *transcendent etc.* Other distinctions are of a more striking, and, in our opinion, also more revealing nature since they seem to reflect Lorhard's metaphysical beliefs and thus give rise to a more detailed understanding of his world view. For example, the distinction between *created* and *uncreated* occurs 3 times, and the distinction between *real* and *imaginary* occurs 6 times, all in the *universal* section of the ontology. In the *particular* section of the ontology, *real* is more often opposed to *rational*, that is: things that exist in their own right versus things that exist through some intelligence.

The matters of the ontological status of the real and the imaginary certainly deserve further investigation in another context. Here, we shall confine ourselves to suggest that the extensive use of iterations indicates a principle for handling complex knowledge representations, namely that a few select distinctions are applied frequently rather that once and for all in a top distinction. This constitutes a problem

when the ontology is translated into a contemporary KR system in that the repeated distinctions seem to be intended to have the same meaning regardless of there they occur. Since formal ontologies require unique names for types, we have resorted to a numbering system in our implementation. This does not, however, seem to be a completely satisfactory solution.

Conclusion

Lorhard's use of diagrams was probably inspired by the work of Peter Ramus. In fact, they were used in Lorhard's presentation of all subjects. This probably had to do with the general belief that logic is important for the understanding of reality. Realising that logical reasoning can be strongly supported by diagrams, it obviously becomes attractive to represent ontology in a diagrammatical manner. Based on the belief in a logical structure of reality it also appears to be natural to represent reality in terms of the most fundamental logical structure, the contradiction. In this way the use of dichotomies in the formal and diagrammatical description of reality becomes attractive. The resulting structure is obviously a mathematical structure representing the conceptual relations in the world. In this way reality is believed not only to be logical but also mathematical, in the sense that there is a conceptual structure that may be said to represent a geometry of meaning.

All these classical beliefs held by Lorhard and the other founders of the Renaissance approach to ontology are to a large extent still held in modern ontology. There is, however, one major difference between Lorhard's and modern ontology. According to the classical belief there is only one ontology corresponding to reality and truth. There may of course be other suggested structures different from the true ontology, but they will simply be false descriptions of reality. According to the classical view there will be no room for the alternative ontologies fit for different purposes. In other words, whereas an ontological structure in a modern context may be seen as a model or a tool fit for certain purposes and unfit for others, an ontological structure will classically be much more than a tool. It will be an attempted description of reality, which is true or false.

Acknowledgements

We would like to express our gratitude to Jørgen Albretsen, who pointed us to the information on Kepler, to Claus Asbjørn Andersen, Albertus Magnus Institut, Bonn for discussions of issues pertaining to our previous work. The authors also acknowledge the stimulus and support of the 'European project on delimiting the research concept and the research activities (EURECA)'sponsored by the European Commission, DG-Research, as part of the Science and Society research programme — 6th Framework.

References:

Andersen, Claus Asbjørn. *Philosophia de ente seu transcendentibus. Die Wissenschaft vom Seienden als solchem und von den Transzendentalien in der spätscholastischen Metaphysik. Eine Untersuchung im Ausgang von Franciscus Suárez.* Konferensspeciale. Københavns Universitet 2004.

Bätscher. Theodor Wilhelm (1964). *Kirchen- und Schulgeschichte der Stadt St. Gallen*, Erster Band 1550-1630. St. Gallen: Tschudy-Verlag.

Göckel (Goclenius), Rudolf (1613). *Lexicon philosophicum*, quo tanquam clave philosophicae fores aperiuntur. Francofurti, (1613), Reprographic reproduction, Georg Olms Verlag, Hildesheim, (1964).

Hofmeier, T. Gantenbein, U.L., Gamper, R., Ziegler, E. and Bachmann, M. (1999): Alchemie in St. Gallen, St. Gallen: Sabon-Verlag.

Hooykaas, R. (1987): "The Rise of Modern Science: When and Why?", *British Journal for the History of Science*, 1987: 453–73.

Koestler, Arthur (1989). *The Sleepwalkers: A History of Man's Changing Vision of the Universe*, Arkana, New York.

Lamanny, Marco (2006). *Correspondences between the works of Lorhard and Timpler.* Bari University, http://www.formalontology.it/essays/correspondences_timpler-lorhard.pdf

Lorhard, Jacob (1597). *Liber de adeptione veri necessarii, seu apodictici*. Tubingae.

Lorhard, Jacob (1606). *Ogdoas scholastica*. Sangalli.

Lorhard, Jacob (1613). *Theatrum philosophicum*, Basilia.

Lorhard, Jacob (forthcoming 2007). *Diagraph of Metaphysic or Ontology*. Trans. by Sara L. Uckelman. IMPACT – an electronic journal on formalisation in media, text and language. http://www.impact.aau.dk/articles.html

MacLennan, Bruce (2006): *From Pythagoras to the Digital Computer: The Intellectual Roots of Symbolic Artificial Intelligence* (forthcoming)

Ong, Walter J. : From Allegory to Diagram in the Renaissance Mind: A Study in the Significance of the Allegorical Tableau, *The Journal of Aesthetics and Art Criticism*, Vol. 17, No. 4. (Jun., 1959), pp. 423-440.

Peirce, Charles Sanders (1931-58), *Collected Papers of Charles Sanders Peirce*, (CP), Vol. I-VIII, editors Hartshorne, C.; Weiss, P.; Burke, A. Harvard University Press.

Timpler, Clemens (1604). *Metaphysicae Systema methodicum*. Steinfurt.

Triche, S. & McKnight, D. (2004). The quest for method: the legacy of Peter Ramus, History of Education, January, 2004, Vol. 33, No. 1, 39–54

Øhrstrøm, P., Andersen, J., Schärfe, H. (2005). What Has Happened to Ontology. In F. Dau, M.-L. Mugnier & G. Stumme, G. (Eds.): ICCS 2005, LNAI 3596, pp. 425–438, 2005. Berlin, Heidelberg: Springer-Verlag 2005.