

IAA-01-IAA.9.2.11 ANALOGY AS A TOOL TO COMMUNICATE ABSTRACT CONCEPTS IN SETI

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ABSTRACT

The aim of my paper is to detect a suitable way to make our moral and religious concepts understandable to extraterrestrials in a hypothetical SETI communication. First of all, I am going to expose the reasons why I think that analogy, according to the insights of Middle Age philosophers, could be a good tool for this purpose. Then I'll try to show that this is possible only in the context of an integrated language, using both abstract symbols and pictures, that I have already suggested in some previous papers. Two possible practical examples of this will be sketched, too, and the results of their evaluation will be discussed, showing that, at least at first sight, it seems that they could work. Further studies will be required to determine whether this method could be extended to the higher-level abstract concepts in the other fields of our culture. Finally, I'll also argue that only *the inner logic* of such a language is really relevant in a SETI communication, while the symbolical apparatus is *not*: so, maybe the best we can do is just to use an already existent and well-tested one, that is our common alphabet.

INTRODUCTION

In the history of SETI (the *Search for Extra-Terrestrial Intelligence* with radiotelescopes) several languages have been proposed to communicate with extraterrestrials when (and if) SETI itself succeeds.⁶³ Despite their differences, they all belong to two main categories:

- a) formal languages (based on mathematics and logic);
- b) iconic languages (based on pictures).

From a general point of view, we can say that formal languages succeed in communicating many mathematical, logic and also scientific concepts, while iconic languages succeed in communicating the sensible features of our world. So, both approaches are in some way complementary to each other, and this is the reason why, in my opinion, the best we can do is to work out an integrated language, using both

mathematics and pictures, as I have already maintained in a previous paper.⁴³ In some way, this idea was present in the Arecibo message, too, but it was only a sketch, not a systematical construction, and then it has been no more carried out until the last few years, when Douglas Vakoch began to work on something similar with his 3-D digital "movies", using both human and geometrical figures.⁶⁵

I think that going on this way we should actually get the capability to give our hypothetical extraterrestrial partners a reasonable idea of how our world looks and what its inner constitution is. However, as Vakoch himself has pointed out, the main problem is how to communicate our high-level concepts, that is cultural ones, which are our own most original features, since science and mathematics should be the same everywhere in our universe.

So, the aim of my present paper is to detect a suitable way to make this kind of concepts understandable to ET in a hypothetical SETI communication.

OUR MIND'S "ENGINE": ANALOGY

At first sight the problem could appear insolvable: cultural concepts, indeed, are neither, in general, referred to sensible patterns nor to logical and mathematical relations, so how could we communicate them from such a starting point?

What we are forgetting, however, is that *we human beings, too*, have always started from there to elaborate those concepts, both in mankind's history and in our personal life: there is not, indeed, something like "Good and Evil" or like "God" in sensible nature, nor in mathematics, and, yet, we *were* able to get their concepts so well. So, how can it happen?

Very different answers have been given to this question in the history of philosophy. Some people, for example, have maintained that these ideas are *a priori* (e.g., Plato, Descartes, Kant); others, that they are seized by a direct insight of our mind (St. Anselmo, St. Bonaventura, Leibniz), or thanks to an illumination coming from God (St. Augustinus, Malebranche); there are also some (as Middle Age

Nominalists, Hume, Wiener Kreis Neopositivists) who say that these are empty and meaningless ideas (even though they are not able to explain how and why so many people believe to understand them perfectly). Should any of them be right, our task would be obviously hopeless. Anyway, I don't think so, because a more realistic and promising explanation is available, basing on *analogy*.

Analogy has been considered very little in SETI language up today. The main reason is, in my opinion, that it is very little considered in contemporary philosophy of language, which is still much influenced by a neopositivistic attitude. Wittgenstein said something important about this subject, speaking about his famous "family resemblances",⁶⁷ but he lacked a real theory of it.

Such a theory, however, has been worked out (in a very detailed and refined way) by the philosophers of the Middle Age, especially St. Thomas Aquinas.⁶⁰ According to him, the starting point of our knowledge is always sensible reality: "*nihil est in intellectu, quod prius non fuerit in sensu*", he said ("nothing is in our mind, without having been first in our senses"). So, there is no direct insight of any abstract concept, including God's one. All they are hence derived from sensible impressions thanks to an original faculty of our mind called "*intellectus agens*" (= active intellect), or, in modern terms, "intentionality",^{1 4 45 57} which is able to *universalize* them (that is, so to speak, to "look at" them from a universal point of view). Some of them (mainly the concepts of natural kind) are derived directly, the others indirectly, *via analogiae* (= in an analogical way), starting from the first ones. So, in this view the right way to get -and then to communicate- the higher-level (and more abstract) concepts is just to start from a lower-level one, related with any *sensible* feature of our material world, and then *to extend its meaning* by using analogy (the world-famous St. Thomas's "Five Ways to God", which are still the basis of Roman Church metaphysics and theology, are constructed just so).^{14 38 42 45 60}

I cannot discuss here and now the philosophical basis of this theory. In any case, it might be not even interesting for us. In my opinion, indeed, it would be much more useful to test it experimentally, by constructing a possible model basing on it and then asking whether it actually works. And this is just what I did.

HOW TO USE ANALOGY IN SETI

First of all, we must choose the concepts we want to communicate. For this first attempt I have preferred

to avoid esthetical ones, because they are the most subjective of all (even though I don't think they are *completely* subjective). Moral and religion, instead, certainly imply a personal experience, but have also a conspicuous objective content, that can be well expressed through abstract concepts. So, I'll focus on them as my present target.

Then, we must choose the lower-level concepts suitable as our starting point. Since moral concerns human behaviors, it seems obvious that we should use pictures of them, because we could hardly communicate the concept of a behavior without showing it. However, moral does not concern our actions materially considered, but their relations with something like a *law*, basing on which we can *judge* them. Thus, from this point of view mathematics is likely to work better, because it contents laws and judgement, easy to be shown through its formulas. So, once more, as I said above, an integrated language appears to be needed.

Third, obviously we have to make the assumption that extraterrestrials, too, use analogy in their reasoning. This could be seen as a too "anthropocentric" view: anyway, apart any philosophical consideration, we should notice that, as a matter of fact, also in working out our scientific concepts analogy plays a fundamental role,^{7 14 31 41} so we are allowed to suppose that ET able to build up radiotelescopes communicating with ours can do the same. However, in order to minimize any possibility of misunderstanding, we should be very careful in communicating the concept of analogy itself in a very sharp and precise way, and in specifying it explicitly any time we will use it.

TWO ANALOGY-BASED TEST MESSAGES FOR MORAL AND RELIGIOUS CONCEPTS IN SETI

After such methodological premises, now let me show you two little test messages I have sketched basing on them. What I want to communicate are some of the most fundamental concepts of our moral and religion, that is the concepts of "Right" and "Wrong" and the concept of the Christian God, Who is Creator, Infinite and Right.

a) A Message from the Disney Planet

@ bip @ bap @@
@ bip @@ bap @@@
@@ bip @@ bap @@@@

@ bip @ bap @@ bep A
@ bip @@ bap @@@ bep A

@@ bip @@ bap @@@@ bep A

@ bip @ bap @ bep B
 @ bip @@ bap @@@@ bep B
 @@ bip @@ bap @@ bep B

@ bip @ bop @
 @ bip @@ bop @@@@
 @@ bip @@ bop @@

O bap O
 I bop O

o bap O bep B
 o bop O bep B
 o bup O bep A



bep Y



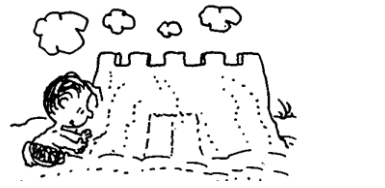
bep Z

Y bup A
 Z bup B

The first part of this message is not new: indeed, it is the same method imagined, e.g., by Carl Sagan in *Contact* to be used by the aliens to introduce, through very simple mathematical operations, the concepts of “plus” (here “bip”), “equal” (“bap”), “right” (“A”) and “wrong” (“B”).⁵⁶ What *is* new is the idea of introducing, in a very similar way, also the concept of “similar” (“bup”), defined as neither equal (“bap”) nor merely “diverse” (“bop”), and then of using it to communicate the fact that “Y” and “Z” are just “similar” (but not *identical*) to “A” and “B”, i.e. that their meaning is *analogous* to “right” and “wrong” in the mathematical sense. At first sight it may seem a useless complication, because it is very likely that if ET have just a little moral sense, they will understand as well even if we simply qualify our strips with “A” and “B”. This is true, but having different symbols to represent different concepts is fundamental for a *further* use of them in *other* contexts. In other words, it is fundamental to construct a real language, able to work without the necessity of continuously making reference to sensible images, just as it happens in *our*

terrestrial languages. So, the introduction of the concept of “similar” enables us to “transfer” certain concepts, unequivocally defined thanks to the sharpness of mathematics, in a different context, which, in turn, enables us to communicate the new way they must be understood. Finally, notice that I have also introduced the concept of “being” (“bep”), and just for the same reason: in the former context it was redundant, indeed, but in the *further* it *won't*, as we'll see immediately.

b) A Message from the Peanuts Planet



bep β



bep α



bep β

⌘ bep γ
 γ bup α

@@ ♣ @
 @@@ ♣ @
 @@@ ♣ @@

γ bup α
 γ ♣ α

|-----| bep X

----- bep W

§ bep δ

δ bup W

δ ♣ W

§ bep ε

ε bup Y

ε ♣ Y

Here the concept of “similar” enables us to communicate the idea of an Entity (“§”) which “builds up” (“φ”) the universe *analogously* to Linus with his sand castle, and then that this Entity is, therefore, the “Cause” (“γ”) of its “effect” (“β”) in a sense *analogous* (but, once more, not *identical*) to Linus’s one (“α”); while the concept of “greater” (“♣”), mathematically defined, allows us to specify that the difference is that such an Entity possesses those properties in a “greater” measure (or “in an eminent way”, as theologians say) than the material things starting from which we have defined them. And the same happens for the concepts of “Infinite” (“δ”), derived from the geometrical “infinite” (“W”) of a straight line, opposed to the “finite” (“X”) of a segment, and, finally, for the concept of “Right” (“ε”), defined as analogous to the “right” (“Y”) in the human moral sense. Now we can also fully understand how important it was to have defined a specific symbol to denote it. Indeed, in the case of God we have no more sensible images to use in order to specify the particular sense in which the concept must be understood, so if we had still one symbol (i.e. “A”) denoting the “right” in any sense, now we would be in troubles. Furthermore, here is also evident the importance to have introduced the concept of “being”, in order to help to distinguish the symbols denoting properties from the other ones denoting actions. Obviously, just for its importance in a more organic communication it would be necessary to define it many times and in different ways, following a strategy of redundancy,⁵⁸ in order to establish its meaning as sharply and unambiguously as possible. Last but not least, the “being” is also an important attribute of the Christian God, Who in classical theology is often called “the Pure Act of Being”,⁶⁰ and the fundamental concept of Western metaphysics: obviously, the complete explanation of such ideas would be a much more difficult and

complex task, anyway this may be a first step in this direction.

Discussion

Obviously, this is only a very simple sketch of what we should do in a real attempt of SETI communication. In such a case (apart from replacing Linus and Donald Duck with more realistic pictures), we should introduce, in my opinion, at least the basic concepts of mathematics and physics in a much more systematical way,^{13 20} thus establishing them as firmly as possible, in order to avoid as far as possible any misinterpretation, thus assuring a starting point surely common to both of us. Then, some basic information about our world and our human race should be provided, using both pictures and the former data. Finally, we could try to communicate something about our moral and religious beliefs in a way similar to that sketched above, but with a much wider and more solid set of concepts to be used. Anyway, the method in its essence could well be the same.

FINAL CONSIDERATIONS ABOUT SETI LANGUAGE

Finally, let me say something about what this experiment can teach us about what is needed (and what is *not*), in general terms, in order to build up a good language for SETI.

First of all, I think it has shown that analogy *can* be a good tool to communicate our abstract concepts to ET.

Second, I think also it has shown that analogy *should* be such a tool, because no other ways proposed up today have proved to work in a better or even in a similar way.

Third, the need of an integrated language in SETI (both mathematical and pictorial) has turned out once more.

Fourth, this experience has also shown, in my opinion, what is *not* needed in a good SETI language, that is a special, *ad hoc* constructed symbolic apparatus. In fact, I *didn't* it: I chose my symbols (intentionally) almost completely at random, or basing on esthetic, and even humorous, considerations, but nonetheless they *work*, just as Sagan’s ones and *any* others we can imagine. It’s *the inner logic* of the symbolic sequences (and *nothing* else), indeed, that makes their meaning understandable, not the symbols in themselves (which, *in themselves*, are always *entirely* conventional). They only *seem* to be relevant, because we cannot test our SETI messages but asking

some other *Terrestrials* to decode them:²⁴ consequently, we obviously cannot use symbols with a well known meaning, otherwise the test would be no more reliable. So, the symbolism we choose may make a great difference *for us*. But *for extraterrestrials* it is just the same (*precisely* the same) if we use the sign “bip”, the sign “+” or the sign “-” to indicate the concept of “plus”, or if we use “☩”, “gwrstk” or the English word “God” to indicate the concept of “God”. *For them*, indeed, they would be *all* unknown and mysterious symbols, so that both the procedures and the total amount of work needed to assign them the right meaning would be the same (*precisely* the same) in *any* case. But they *wouldn't* be the same *for us*: constructing a completely new symbolic apparatus for interstellar communications, indeed, as some authors, as Hans Freudenthal²⁹ or Yvan Dutil, have tried (or suggested to try), would be a very hard task, indeed, while, on the other side, if I am right, it would turn out to be completely useless. So, despite this common opinion, maybe the best we can do is just to use an already existent and well-tested one, i.e. one of our common alphabetical languages (likely the most largely widespread and grammatically simplest one, that is English). It is not by chance, after all, that we have adopted them, progressively neglecting pictographic and ideographic ones, but for the very good reason that they are much simpler and more efficient! So, why should we act in the opposite way just in SETI? On the contrary, *all* our efforts should be devoted to refine the method of *meaning attribution*, which is the *only* relevant issue in this matter.

THE “PRINCIPLE OF DIALECTIC NON-MEDIOCRITY” AND HEIDMANN’S “ENCYCLOPEDIA”

Fifth and last, a fact seems to emerge: if the best (or even the only) way to communicate our higher-level abstract concepts is to derive them by means of analogy from the lower-level ones, strictly entangled with material world, it turns out clearly that it is virtually impossible to perform this task without a widespread and systematic elaboration of the last, based on knowledge presumably shared by both us and them, i.e. sciences and mathematics (in my view, indeed, also mathematics is in some way a natural science and therefore concerned with the material world:⁴³ anyway, this is not so important). It follows that either we send a merely self-proclaiming message, or we must send a very, very huge one, because we should send a really enormous amount of scientific and mathematical information before

saying something new for aliens able to build radiotelescopes (the only ones we can contact, by definition, in SETI); while, on the other hand, something similar is required also as a basis to communicate our cultural concepts.

So, as well as in SETI we often speak about a “*Principle of Cosmic Mediocrity*”, meaning by this that: “The *existence* of other civilizations is *probable* if and only if Earth is not special, but in the cosmic average”, we may also speak, in a symmetrical way, about a “*Principle of Dialectic Non-Mediocrity*”, meaning by this that: “The *communication* with other civilizations is *possible* if and only if the information content of the message is special (i.e. highest or lowest), average messages being useless”.

So (let me finish with this homage to a great friend who is no longer among us today), Jean Heidmann’s idea to send them the *Encyclopedia Britannica*³² should not be regarded only as a provocation. On the contrary, it could be really the best possible SETI message at all, because there we have an almost complete, well organized *corpus* of our race’s knowledge. Since the symbolic apparatus is neutral, we could really send it as it is (maybe with only some syntactic simplifications, mainly in the conjugation of verbs). All we should do to make it feasible would be to attach a suitable “dictionary”, which could well be constructed according to the method suggested here. The real matter with this idea is its *size* (and, consequently, its cost). So, we could be forced to fall back upon a less ambitious project. Anyway, my present proposal wants to be a first step in this direction.

REFERENCES

1. Agazzi E. [1962], *Introduzione ai problemi dell'assiomatica*, Vita e Pensiero, Milano.
2. Agazzi E. [1978], *Le matematiche come teorie e come linguaggio*, in "Epistemologia", n. 3, Tilgher, Genova.
3. Agazzi E. [1985], *La questione del realismo scientifico*, in C. Mangione (ed.), *Scienza e filosofia. Saggi in onore di Ludovico Geymonat*, Garzanti, Milano.
4. Agazzi E. [1994], *On formalism*, in Fløistad G. (ed.), *Philosophical problems today*, vol. 1, Kluwer Academic Publishers.
5. Agazzi E., Darvas G. (eds.) [1997], *Philosophy of mathematics today*, Kluwert, Dordrecht.
6. Arbib M.A. [1979], *Minds and millennia: the psychology of interstellar communication*, in “Cosmic Search”, summer 1979, pp. 25, 47-48.
7. Arecchi F.T. [2000], *A critique of the scientific*

- reason: truth versus certitude*, in Arecchi F.T., Berti M. (eds.) *The scientific and philosophical challenge of complexity*, Fondazione RUI, Roma.
8. Arecchi F.T., Arecchi I. [1990], *I simboli e la realtà*, Jaca Book, Milano.
 9. Arecchi F.T., Basti G., Boccaletti S., Perrone A. [1994], *Adaptive recognition of a chaotic dynamics*, in "Europhysics Letters", 27.327 (1994).
 10. Arecchi F.T., Farini A. [1996], *Lexicon of complexity*, Studio Editoriale Fiorentino, Firenze.
 11. Aristotele [1], *Metaphysics*.
 12. Aristotele [2], *Organon*.
 13. Ascheri V. [2000], *A methodological approach to communication with extraterrestrials*, in Lemarchand G., Meech K. (eds.), *Bioastronomy '99. A New Era in Bioastronomy*, ASP Conference Series, vol. 213, 2000, pp. 603-607.
 14. Bertelè F., Olmi A., Salucci A., Strumia A. [1999], *Scienza, analogia, astrazione*, Il Poligrafo, Padova.
 15. Chaitin G.J. [1987], *Algorithmic Information Theory*, Cambridge University Press, Cambridge.
 16. Cocconi G., Morrison P. [1959], *Searching for interstellar communication*, in Cameron A.G.W. (ed.) [1963], *Interstellar communication. A collection of reprints and original contribution*, W.A. Benjamin Inc. New York.
 17. Contri G.B. [1989], *Leggi. Ambiti e ragione dell'inconscio*, Jaca Book, Milano.
 18. Contri G.B. [1990], *Dire, fare, baciare... Cinquanta pezzi facili di un laico psicoanalista, cristiano*, Lucchetti, Bergamo.
 19. Descartes R. *[1637], *Discours de la Méthode*, Leyda.
 20. Devito C.L., Oehlerle R.T. [1990], *A language based on the fundamental facts of science*, in "Journal of the British Interplanetary Society", vol. 43, pp. 561-568.
 21. Diederich J. [2000], *The convergence of intelligence*, in Lemarchand G., Meech K. (eds.), *Bioastronomy '99. A New Era in Bioastronomy*, ASP Conference Series, vol. 213, 2000, pp. 609-612.
 22. Diederich J., Wright S. [2000], *Symbol systems and pictorial representation*, in Lemarchand G., Meech K. (eds.), *Bioastronomy '99. A New Era in Bioastronomy*, ASP Conference Series, vol. 213, 2000, pp. 619-622.
 23. Doyle L., Hanser S.F., McCowan B. [2000], *Information theory as a comparative measure of animal communication complexity*, in Lemarchand G., Meech K. (eds.), *Bioastronomy '99. A New Era in Bioastronomy*, ASP Conference Series, vol. 213, 2000, pp. 613-617.
 24. Drake F., Sobel D. [1992], *Is anyone out there? The scientific search for extraterrestrial intelligence*, Delacorte Press.
 25. Drake F., Sagan C., Sagan L. [1972], *Report. A message from Earth*, in "Science" n. 175, pp. 881-884.
 26. Ebeling W., Nicolis G. [1992], *Word frequency and entropy of symbolic sequency: a dynamical perspective*, in "Chaos, Solitons and Fractals", vol. 2, pp. 635-650.
 27. Feyerabend P.K. [1975], *Against method. Outline of an anarchistic theory of knowledge*, New Left Books, London.
 28. Feyerabend P.K. [1987], *Farewell to Reason*, London-New York.
 29. Freudenthal H. [1960], *Lincos: design of a language for cosmic intercourse (Part I)*, North Holland, Amsterdam.
 30. Hahn H., Neurath O., Carnap R. [1929], *Wissenschaftliche Weltauffassung: Der Wiener Kreis*, Wien.
 31. Harré R. [1986], *Varieties of realism. A rationale for the natural sciences*, Blackwell, Oxford.
 32. Heidmann J. [1993], *A replay from Earth: just send them the Encyclopedia*, in "Acta Astronautica" n. 29, pp. 233-235.
 33. Hogben L. [1961], *Cosmical language*, in "Nature" n. 192, pp. 826-827.
 34. Hume D. [1739], *A treatise of human nature*, London.
 35. Kant I. [1781], *Kritik der reinen Vernunft*, Riga.
 36. Kuhn T.S. [1962], *The structure of scientific revolutions*, Chicago University Press, Chicago.
 37. Lakatos I., Musgrave A. [1970], *Criticism and the growth of knowledge*, Cambridge University Press, Cambridge.
 38. Maritain J. [1932], *Distinguer pour unir ou Les degrés du savoir*, Desclée de Brouwer, Paris.
 39. Minsky M. [1985], *Why intelligent aliens would be intelligible*, in Regis E. (ed.), *Extraterrestrials: science and alien intelligence*, Cambridge University Press, Cambridge.
 40. Morrison P. [1963], *Interstellar communication*, in Cameron A.G.W. (ed.) [1963], *Interstellar communication. A collection of reprints and original contribution*, W.A. Benjamin Inc. New York, pp. 249-271.
 41. Musso P. [1993], *Rom Harré e il problema del realismo scientifico*, Angeli, Milano.
 42. Musso P. [1997], *Filosofia del caos*, Angeli,

- Milano.
43. Musso P. [1999a], *The problem of SETI language. Is mathematics really universal?*, Poster Paper presented at *Bioastronomy 99. A New Era in the Search for Life in the Universe*, in www-radiotelescopio.bo.cnr.it
 44. Musso P. [1999b], *Dopo Bioastronomy 99. Teologia e filosofia di fronte alla ricerca della vita nel cosmo*, in "Studi storici e religiosi" n. 2/1999, pp. 223-231.
 45. Musso P. [2000], *Chaos and complexity: philosophical implications*, in Arecchi F.T, Berti M. (eds.), *The scientific and philosophical challenge of complexity*, Fondazione RUI, Roma.
 46. Musso P. [to be published], *On the last terms of Drake Equation: the problem of energy sources*, in the *Proceedings of the First Steps in the Origin of Life - Sixth Trieste Conference on Chemical Evolution*.
 47. Musso P. [to be published], *On the last terms of Drake Equation: the problem of energy sources and the "Rare Earth Hypothesis"*, in the *Proceedings of the ESA First European Workshop on Exo/Astrobiology*.
 48. Musso P., Ascheri V. [to be published], *Philosophical and theological issues risen by a SETI success*, in Wabbel T.D. (ed.).
 49. Nieman H., Nieman C.W. [1920], *What shall we say to Martians?*, in "Scientific American", vol. 122, March 20, 1920, pp. 298 and 312.
 50. Oliver B.M. [1963], *Interstellar communication*, in Cameron A.G.W. (ed.) [1963], *Interstellar communication. A collection of reprints and original contribution*, W.A. Benjamin Inc. New York, pp. 294-305.
 51. Oliver B.M. [1971], *Project Cyclops* (reprinted [1996], by SETI League & SETI Institute).
 52. Plato [1], *Dialogues*.
 53. Popper K.R. [1934], *Logik der Forschung*, Springer, Wien.
 54. Quine W.V.O. [1953], *Two dogmas of empiricism*, in *From a logical point of view*, Harvard University Press, Cambridge, Massachussets.
 55. Sagan C. [1971], *Communication with extraterrestrial intelligence (CETI)*, MIT Press, Cambridge, Massachussets.
 56. Sagan C. [1985], *Contact*.
 57. Searle J. 1992], *The rediscovery of the mind*, MIT Press, Cambridge, Massachussets.
 58. Shannon C.E. [1963], *The mathematical theory of communication*, University of Illinois Press, Urbana.
 59. Tennant N. [1993], *The decoding problem: do we need too search for extraterrestrial intelligence in order to search for extraterrestrial intelligence?*, in Kinsley S. (ed.), *SPIE Proceedings*, vol. 1867, pp. 1-9.
 60. Thomas Aquinas [1], *Summa Theologiae*.
 61. Vakoch D.A. [1998], *Constructing messages to extraterrestrials: an exosemiotic perspective*, in "Acta Astronautica", vol. 42, No. 10-12, 1998, pp. 697-704.
 62. Vakoch D.A. [1998], *The dialogical model: representing human diversity in messages to extraterrestrials*, in "Acta Astronautica", vol. 42, No. 10-12, 1998, pp. 705-710.
 63. Vakoch D.A. [1999], *The view from a distant star: challenges of interstellar message-making*, in "Mercury", March-April 1999, pp. 26-32.
 64. Vakoch D.A. [2000], *The conventionality of pictorial representation in interstellar messages*, in "Acta Astronautica", vol. 46, No. 10-12, 2000, pp. 733-736.
 65. Vakoch D.A. [2000], *Three-dimensional messages for interstellar communication*, in Lemarchand G., Meech K. (eds.), *Bioastronomy '99. A New Era in Bioastronomy*, ASP Conference Series, vol. 213, 2000, pp. 623-627.
 66. Wittgenstein L. [1921], *Tractatus Logico-philosophicus*, London
 67. Wittgenstein L. [1957], *Philosophische Untersuchungen*, Blackwell, Oxford.