SEMANTIC INFORMATION AND PROBLEM SOLVING ALGORITHMS

OCTAVIAN REPOLSCHI*

Abstract: The present paper aims to points toward a part of semantic information, the instructional information. A certain information map (Floridi 2011) is used for semantic information. Starting with some aspects concerning the Mathematical Theory of Communication (MTC) and Semantic Theories of Information (STI) the paper argues the importance of the algorithms in problem soving, as a representative part of instructional information. This aspect is first presented in MTC, then in a STI context. The large interest in factual information is then challenged by the instructional information, which is shown to be a necessary tool to reach for the factual information. We are arguing that this sort of information stands for a different type of knowledge than factual information, namely the *knowledge-how*, in completion to the *knowledge-that* which was connected with factual information. In the end we propose some completion traits to the information map suggested by Floridi.

Keywords: semantic information, factual information, instructional information, algorithm, knowledge.

1. ASPECTS OF MATHEMATICAL AND SEMANTICAL THEORIES OF INFORMATION

Starting with the seminal work of Shannon (1948), and followed by that of Weaver (1949) the field of information theory developed itself as one of the most promising areas of investigation not only for communication engineers, but for philosophers, linguists, computer scientists, and other researchers as well. The mathematical perspective on information advanced by Shannon advocates just the technical aspects of communication, asserting from the very start that "... semantic aspects of communication are irrelevant to the engineering problem" (Shannon 1948, 1). As Weaver also writes in his paper, information in mathematical theory of communication is "not to be confused with meaning" (Weaver 1949, 4). However, this mathematical perspective on information offers a useful tool to measure information, due to the definition of information proposed by Shannon and reiterated by Weaver (Weaver, 5): "The information is a measure of one freedom of choice when one selects a message". According to Shannon's theory (Shannon, 2), the person (or device) for whom the message is intended (informee, Floridi 2011) could pass through different epistemic states, ranging from E_1 (the epistemic state before the transmission of the message), to E_2 (the epistemic state after the transmission of the message). These epistemic states are relative to the communication situation. If the informer sends a series of messages selected from a

* Ph.D. Lecturer West University of Timişoara, Faculty of Political Sciences, Philosophy and Communication Sciences; e-mail: oreposter@gmail.com

- *If Claire is working, then Dan and Emily are working.*
- *If Fanny is working, then Dan is working.*
- *If Gina is working, then Dan is working and Anna is working.*

1. Which of the following is a complete list of people who could be working together?
(A) Anna, Bill, and Claire
(B) Gina, Dan, Anna, and Bill
(C) Emily, Anna, Claire, and Bill
(D) Gina, Dan, Anna, and Claire
(E) Fanny, Dan, Gina, and Emily

……………………………………………………………………………………

Let us follow the steps of the algorithm for answering the first question of the logic game.

1. The seven workers could be written as seven elements: A, B, C, D, E, F, G.
The activities of the workers are constrained by the following rules:
(a) $A \rightarrow B$
(b) $B \rightarrow \neg C$
(c) $C \rightarrow (D \,\&\, E)$
(d) $F \rightarrow D$
(e) $G \rightarrow (D \,\&\, A)$

2. Logic chains and inferences

• From (a) $A \rightarrow B$ and (b) $B \rightarrow \neg C$ we could infer that (g) $A \rightarrow \neg C$ (the rule of transitivity for implications)

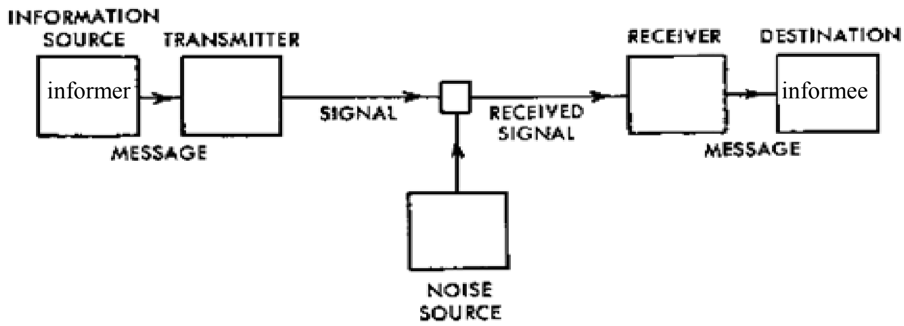
• From (e) $G \rightarrow (D \,\&\, A)$ we could infer that (h) $G \rightarrow D$ and (i) $G \rightarrow A$ (the rule of distributivity)

• From (c) $C \rightarrow (D \,\&\, E)$ we could infer that (j) $C \rightarrow D$ and (k) $C \rightarrow E$ (the rule of distributivity)

• From (i) $G \rightarrow A$ and (a) $A \rightarrow B$ we could infer that (l) $G \rightarrow B$ (the rule of transitivity for implications)

• From (l) $G \rightarrow B$ and (b) $B \rightarrow \neg C$ we could infer that (m) $G \rightarrow \neg C$ (the rule of transitivity for implications)

The logic chains that could therefore be formed according the relations written above are:
(I) $A \rightarrow B \rightarrow \neg C$, from (a), (b) and (g)
(II) $(C \rightarrow D) \,\&\, (C \rightarrow E)$
(III) $F \rightarrow D$
(IV) $(G \rightarrow D) \,\&\, (G \rightarrow A \rightarrow B \rightarrow \neg C)$, from (h), (a), (l), (m)



finite series of possible messages, then, according to Shannon and Weaver, the total amount of information sent, admitting that each message has a certain probability to be chosen by to source, can be calculated by following formula (Weaver, 8):

(1) $$H = -\sum_{i=1}^{N} Pi \log Pi$$

where H is the total amount of information (in bits), and Pi is the probability of a message i to be selected from the finite set of messages.

In the particular case of a selection of just one message out of a finite set of equally probable messages, the formula for measuring information would become:

$$I = -\log P$$

Further, P could be written as

$$P = 1/N$$

and the formula for the quantity of information becomes

$$I = \log N$$

where N is the number of total possible symbols that the source could select from.

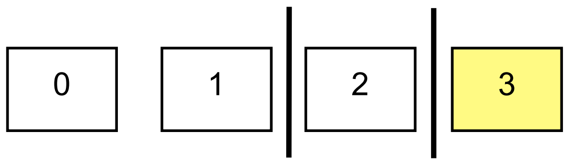
We could write the following general description of the epistemic states for the informee:

(2) $$E_1 = 0 \text{ bits}$$

(3) $$E_2 = H \text{ bits}$$

If the informee could have access to the entire set of messages, and could start a sort of questioning game with the source (informer – Floridi 2011), his lack of information could be gradually decreased. By following a certain algorithm of question/answer procedure, the informee could find out from the informer what the selected message was, and therefore, he reduces his ignorance from relatively maximum (–*H*) to 0, or he enhances his knowledge from relatively 0 to maximum (*H*). The algorithm is called the dichotomy algorithm. We will not dwell into the mathematics of this algorithm here, yet it perhaps important to say that this is an usual algorithm in artificial intelligence procedures for searching information. However, a short example would surely suffices to express the main idea of this algorithm.

Let us assume that the informer had hidden in one of the four boxes that he possesses a 100 $ bill, and that the informee does not know which one of the boxes got the money inside. Let us further assume that both of them agree to play the game of questioning and answering as the dichotomy algorithm is proposing: to each well formulated question of the informee, the informer must answer honestly with yes or no answers. If the sequence of questions and answers are those from bellow, then the informer gains with each answer an amount of information of exactly 1 bit, reducing thus his uncertainty in Shannon's formulation, until his uncertainty will reach to zero. Thus, his relative epistemic state could be characterised at the end of the game as being equal with the total amount of information that he acquired through this algorithm. And this amount of information is precisely the amount of information that characterise the informer free choice to hide the money in one of the boxes he possesses. (We assumed that there are no preferences for the informer concerning any of the boxes, and all of them are equally probable to be chosen).



If the box that contains the $100 bill is the box with the number three on it – as in the figure bellow –, or the forth box, in the case of representing the number on the box by x, the algorithm for searching the right box could be written as follows:

First step: Question 1: $x \geq 2$? – the first question always is addressed to the $N/2$ of the number of boxes

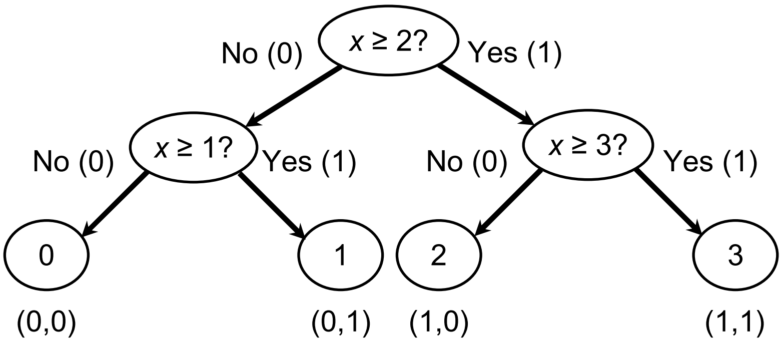
Answer 1: Yes (1) – this answer eliminates the boxes situated in the left side of the first division by two of the number of boxes available; the boxes that remain in discussion are the boxes 2 and 3.

Second step: Question 2: $x \geq 3$?

Answer 2: Yes (1)

Thus, the box that contain the money is certainly identified by logical deduction that is three. As an observation, by attributing to each 'yes' answer the number '1' in the base two, and for each 'no' answer the number '0' in the same base, reading the numbers from top to the bottom of the algorithm will give the exact number of the box written in base two.

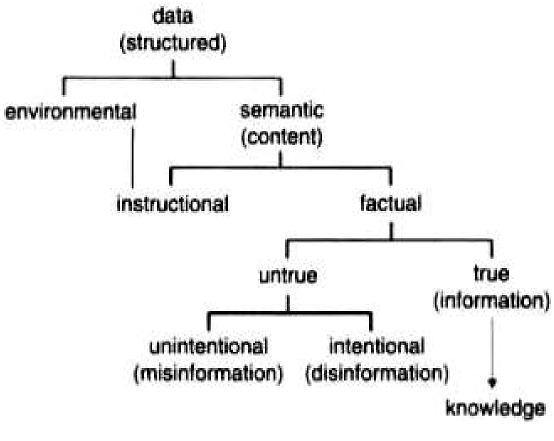
The tree representation of the algorithm is shown bellow:



Looking at the tree representation of the algorithm it is apparent that each box could be the box that contains the $100, and thus the fact that each of the boxes has equal probability to be chosen is preserved.

In the case of this informational exchange between the informer and the informee, the one that needs the information makes use of each answer that was offered to each of his questions. Therefore, each answer is substantially informative. I will call this kind of informative feature of the answers as being directly informative.

Let us go further to the semantic theories of information. From the mathematical or technical model of communication, the researchers had gone to different semantic interpretations of the information, given the fact that the mathematical theory is not directly preoccupied with the semantic or efficiency aspects of the communication (Weaver, 2). As Floridi remarks in many of his works on semantic information, this aspect of information involves at least two important varieties integrated in a structured map of information (Floridi 2011): factual and instructional information:



According to Floridi, factual information is mostly understood as true semantic content, and is directly connected with knowledge and rounds on the concept of truth. The question is if “some factual content qualify as information if it is true” (Floridi 2011). Some researchers support the idea that meaningful and well-formed data counts as information, regardless of its truth value. Others support the opposite idea, that “information and mis-information are not kinds of information” (Floridi 2011). We are not willing to enter into this complex debate here. However, following a logical-empiricist philosophical view, Carnap and Bar-Hillel (1953) argued that the semantic information of a statement can be calculated by the same formula proposed by Shannon (1948) with some difference in the meaning of the probability involved (Carnap and Bar-Hillel 1953, 151). Also, Carnap and Bar-Hillel (Carnap and Bar-Hillel, 149) define the empirical content of a statement as being “equal to the class of the negations of the statement descriptions”. In his paper Bar-Hillel (1964) advocates an identical formula for semantic information as it was proved by Shannon, with the similar remarks as in the above mentioned paper. Starting as an opponent to the logical-empiricist view developed by Carnap et al., Karl Popper’s perspective concerning the semantic aspects of information is grounded on deductive logic and a certain set of basic statements that are forbidden by a theory – falsifiers – (Popper 2002, 103):

I define the empirical content of a statement p as the class of its potential falsifiers. The logical content is defined, with the help of the concept of derivability, as the class of all non-tautological statements which are derivable from the statements in question.

However, the formula for semantic content of a message sent from one end to the other of the Shannon’s model supports the assertion that “the more probable a statement is, the less information it conveys (Burgin 2010, 320). The measure of information introduced by Carnap and Bar-Hillel (see Floridi 2011) in terms of probabilistic approach, define semantic content (cont) of a sentence p as being measured by the complement of the a priori probability of p, $P(p)$:

$$\text{cont}\,(p) = 1 - P(p)$$

It clearly follows from the above formula what was called by J. Hintikka ‘the scandal of deduction’ as long as the more probable a sentence is, the less informative it seems to be (in terms of it’s empirical content), taken informativeness (Inf) to be defined as Inf $(p) = -\log P(p)$. By these formulas, a tautology is non-informative, because its logical probability is 1. And more, the most informative sentences are the contradictions, because they have 0 logical probability. However, this complex problem will not be also addressed here. It is perhaps worth remembering that Hintikka developed a theory for differentiating between surface information and deep information of a sentence, and by this distinction he offers a solution to the problem of deduction in semantic theory (Pârvu 1974, 97–106). Still, this is also not to be explored in this paper.

For the questions involved in this article, what matters as factual information is already given and is true. Yet what appears to be of importance is that variety of semantic information that was called instructional information. As Floridi states in his article (Floridi 2011), "instructional information is a type of semantic content ... in the form of a recipe: first do this, then do that – or conditionally, in the form of some inferential procedure: if such and such is the case, do this, otherwise do that." (italics mine). What I will try to argue in the following lines will be the fact that critical thinking test aims at verifying the candidate ability to think critical by testing his instructional information, as defined by Floridi. More, this kind of information appear to be extremely important in solving certain logical puzzles, and could be understood as a particular kind of knowledge, different that the one that regards the knowledge that is characterised as being in the possession of *true information*, as it appears in the information map from above proposed by Floridi.

2. LOGIC GAMES

In the second part of this paper I will use an example of a critical thinking test as a model for investigating the sort of information that was called above instructional information. The particular case of the logic game test could still be easily expanded to the sort of investigations that could be called empirical. As will be clear by reading the passages bellow, the person that takes the test is in the case of empirical sciences the environment and the sort of answers that the environment could give are in fact of the sort of some measurement values. In investigating the nature, we are performing a sort of game of questions and answers, with the notable difference that the answers we receive are not that simple as those described above, or will be described bellow. In principle, still, the problem appears to be similar, or could be reduced to some similar approach.

If critical thinking is generally preoccupied with arguments: how to identify, analyse, and evaluate arguments advanced by a person that delivers a message, then according to Shannon's model of communication, the task of critically evaluating and comprehending the message belongs to the informee. As we already said, we will not dwell here into the complex controversies concerning truth, yet it is generally accepted that the purpose of critical thinking can be understood as that of evaluating the truth or approximate truth of some claim. In science, as it is well known, the truth (or approximate truth) of a statement must be either supported by evidence, or inferred from the empirical evidence. Thus, the situation that will be created by appealing to the example of this logic game could be, in some extent, similar to that of gathering information in empirical sciences.

Any logic game is intended to test a certain critical thinking ability, namely that of analytical reasoning. We have chosen this particular type of critical ability only for convenience. For the purpose of our argumentation other types of critical thinking abilities could be used as well. There are several aspects of this ability to think analytical, yet we will discuss here just one type of logic game, the formal logic game. Generally, formal logic games are composed by if-then statements, and the difficulty of the game is usually in direct connection with the number of if-then statements. The following logical relations could be found in such a game (Keenum 2008, 5):

1. $p \rightarrow q$ (if the event p occurs, then the event q occurs)
2. $\neg p \rightarrow q$ (if the event p does not occur, then the event q occurs)
3. $p \rightarrow \neg q$ (if the event p occurs, then the event q does not occur)
4. $\neg p \rightarrow \neg q$ (if the event p does not occur, then the event q does not occur)

The structure of any logic game is built on three axes. First of all there are the so called fact pattern, which typically concerns the true factual information that constitutes the basis for the logical inferences and the context of the logic game. The second axis is that of the logical constrains and which has the purpose to govern the fact pattern. The third axis is that of the questions based on the fact patterns and constraints. Each question has five possible answers, with only one correct answer. The game's aim is to test the person ability to remember and apply the numerous rules and sets of facts in a limited time. Correctly solving the game in a rapid manner is a matter of applying a set of *algorithmic steps*. There are some general and specific steps in the solving algorithm. Usually, the specific steps for formal logic games are (Curvebreakers 2009, 82):

a. Read and transcribe the fact patterns and the constrains of the game in the logical frame associated with the type of the game (in our case, in the formal logic game).

b. Add logic chains.

c. Form Contrapositives.

d. Finalize Chains and make Inferences.

e. Create a Hierarchy of Chains.

f. Answer the questions.

As it could be observed from the rules stated above, they could be easily completed with further *instructional* informations concerning the rules for transcribing, the rule for forming contrapositives, and so on. All these rules and their supplementary informations are structures of semantic information on the form of instructional information. In order to understand the importance of these instructional information for the solving this type of logical puzzle, we shortly present just a part of a logic game.

Let us start this example of formal logic game (McGraw-Hill 2009, 82) even if the game is presented only partially, because of the limited space of the article:

At the Ames town hall, a total of seven workers are employed.

These workers follow a daily schedule that is constrained by the following conditions:

- *If Anna is working, then Bill is also working.*
- *If Bill is working, then Claire is not working.*

3. The contrapositives are:
(2) $(A \to B) \leftrightarrow (\neg B \to \neg A)$
(3) $(B \to \neg C) \leftrightarrow (C \to \neg B)$
(4) $(C \to D) \leftrightarrow (\neg D \to \neg C)$
(5) $(C \to E) \leftrightarrow (\neg E \to \neg C)$
(6) $(F \to D) \leftrightarrow (\neg D \to \neg F)$
(7) $(G \to D) \leftrightarrow (\neg D \to \neg G)$
(8) $(G \to A) \leftrightarrow (\neg A \to \neg G)$
(9) $(A \to \neg C) \leftrightarrow (C \to \neg A)$
(10) $(C \to D) \leftrightarrow (\neg D \to \neg C)$
(11) $(C \to E) \leftrightarrow (\neg E \to \neg C)$
(12) $(G \to B) \leftrightarrow (\neg B \to \neg G)$
(13)$(G \to \neg C) \leftrightarrow (C \to \neg G)$

4. Finalize chains and inferences

(14) From (3) $(C \to \neg B)$, (2) $(\neg B \to \neg A)$, (8) $(\neg A \to \neg G)$ and (13) $(C \to \neg G)$ we could write that (15) $C \to \neg B \to \neg A \to \neg G$

(16) From (4) $(\neg D \to \neg C)$, (6) $(\neg D \to \neg F)$ and (7) $(\neg D \to \neg G)$ we could infer that (17) $\neg D \to (\neg C \,\&\, \neg F \,\&\, \neg G)$

(18) From (15) $C \to \neg B \to \neg A \to \neg G$, (k) $C \to E$ and (j) $C \to D$ we could write that (19) $C \to \neg B \to \neg A \to \neg G) \,\&\, (C \to E) \,\&\, (C \to D)$

(20) From $G \to A \to B \to \neg C$ and (h) $G \to D$ we could write (21) $(G \to A \to B \to \neg C) \,\&\, (G \to D)$

5. The hierarchy of chains
i) $F \to D$
ii) $\neg E \to \neg C$
iii) $\neg D \to (\neg C \,\&\, \neg F \,\&\, \neg G)$
iv) $(C \to \neg B \to \neg A \to \neg G) \,\&\, (C \to E) \,\&\, (C \to D)$
v) $(G \to A \to B \to \neg C) \,\&\, (G \to D)$

Now we can answer the questions equipped with all the necessary tools. In a complete logic game all the informations offered by the game and logically derived from them are necessary for correctly solving the game.

1. Which of the following is a complete list of people who could be working together?
(A) Anna, Bill, and Claire (could be written as A & B & C)
(B) Gina, Dan, Anna, and Bill (could be written as G & D & A & B)
(C) Emily, Anna, Claire, and Bill (could be written as E & A & C & B)
(D) Gina, Dan, Anna, and Claire (could be written as G & D & A & C)
(E) Fanny, Dan, Gina, and Emily (could be written as F & D & G & E)

The expressions “a complete list of people” and “could be working together” must be transcribed too in the same formal language as the fact pattern, constraints and answers in order to accurately choose the right answer from the five possibilities offered by the question. It appears immediately that “could be working together” refers to what we already called “chain”, and “a complete list of people” refers to the longest possible chain the game allows in the current conditions. The correct answer is given by the relation v) which presents the longest chain: $(G \rightarrow A \rightarrow B \rightarrow \neg C)$ & $(G \rightarrow D)$. Therefore, the correct answer is (B). (A) is incorrect because from the relation (I) if A works, then C does not work, and if B works, then C does not work. This relation could also be used to falsify the answers (C) and (D). The answer (E) is incorrect, because the relation 8) asserts that $\neg A \rightarrow \neg G$, and because in the answer (E) does not appear the worker A, and $\neg A$ being the case, then it certainly follows that G is not the case.

The entire game could be easily solved further in the same manner.

3. LOGIC GAME AND SEMANTIC INFORMATION

A couple of observations could be made in this particular context of the logic game.

Before discussing these observations, let us use Shannon’s model of communication (or the similar one proposed by Floridi) in order to clarify the communication situation. The person that delivers the test is in this case the *informer*. The person that takes the test is the *informee*. The test is the *informant* (Floridi). The answers given by the *informee* to the questions in the logic game are not informative in a direct way for the informer, because the one that delivers the test knows the correct answers to the questions in the game. Therefore those answers stand for something else. In this particular matter resides one of the main differences between this particular example and the way scientists gather information from environment, where any answer is informative. Still, there could be expected answers in certain types of experiment, and also unexpected answers. This particular type of critical thinking test seems to be similar to those types of experiments that are reproducing some well known scientific results, in which case the correct results are also of no surprise.

First, what is the amount of information that the informer delivers in this particular communication? We could try to shortly suggest a mathematical theory of communication approach on this. By looking at the first sentences sent in the fact patterns and constrains of the game we could infer that the “total of seven workers” that are employed could be in one of the following states: working or not working. This could be counted as a total amount of $2^7 = 128$ possible states in which all of the workers could be connected together by being in a state of working or in the opposite state of not working. As the maximum amount of information in Shannon’s theory is represented in the particular situation when all the possible messages are equally probable (maximum entropy), the constraints are just reducing the entropy and thus the amount of information. This particular game has seven questions, yet another question could arise in this particular situation of the logic game: how many reasonable questions could be asked starting from the particular fact patterns offered by the game? If we compare the amount of information involved in this game with the situation described in the algorithm of dichotomy, then it seems that the number of questions is equal with seven. Still, this situation seems different that that presented there, simply because of the fact that here we are not involved in finding a single and particular configuration of workers, but here the fact patterns and the constraints are offering an entire universe of possible states that could be investigated.

However, what is truly involved here is not the amount of information that the informer had sent to the informee, yet the other way around. This brings up the second question as we will discuss bellow. It is the *informer* that is interested to measure somehow the amount of information that the informee sends back to him by choosing the right answer. In the case of the algorithm of dichotomy, as we have seen, the yes/no answers to each well formed question count as a bit of information sent by the informer to the informee. In this particular case of the logic game it cannot be said that the informer does no know the answers to the questions in the game, and so he is not really informed by informee's message or answers in a *direct way*. On the contrary, *the best explanation* of choosing the correct answers for the informer would be that the informee knows how to solve the logic game and that he is in the possession of a certain type of knowledge or ability that accounts for this situation. However, in the case of dichotomy algorithm, the informee asks the questions and the informer provides him with the correct answers which are those that are *directly informative* for him. In the case of the logic game, it is the informer that asks the questions, yet the answers are only indirectly *informative* for the informer. In this case the informer is taking into consideration the fact that the total probability to correctly choose the right answer from a total of five proposed answer for each question and from an average of total number of seven questions for each logic game is $(\frac{1}{5})^7$. Therefore, the low probability calls for a better explanation that chance.

Thus, the second question that might arise in this situation concerns the measure of such amount of information. In this particular case, the logic game is grounded in deductive logic, which, at least as the semantic theory of information in Carnap and Bar-Hillel's formula, has no content at all, because they are tautologies. So, what could be the measure of this kind of information that refers to the kind of information that Floridi refers to as instructional information? Several answers have been proposed, and we will just mention them under the same conceptual name as *algorithmic information* (Burgin 2010). However, besides those measuring solutions, perhaps an indirect measure of the amount of information in this particular case could also be proposed, taking into consideration the number of wrong alternatives for each right answer for each question of the game. The adequacy of such a measure for instructional information, despite its context-dependency, should be a matter for further investigations. Comparing this logic game with the dichotomy algorithm, we can say that at least apparently each question of the game that offers five answers is a kind of game in which what was hidden in one of the 'boxes' denoted by the letters of the answers is the 'truth' of the answer. In such a situation, the dichotomy is of no use, because the answers are not equally probable. The right answer – the true answer that could be inferred from the factual information given by the game – has the logical probability equal with 1, and each other answer has the logical probability equal with 0. In this situation it seems that it would be a maximum surprise if any other answer except the one which is the certain one, would be chosen be the informee. In the economy of the game, in fact, no answer is non-informative, because each answer carries some different degrees of similarities with the right answer (they are called distractors).

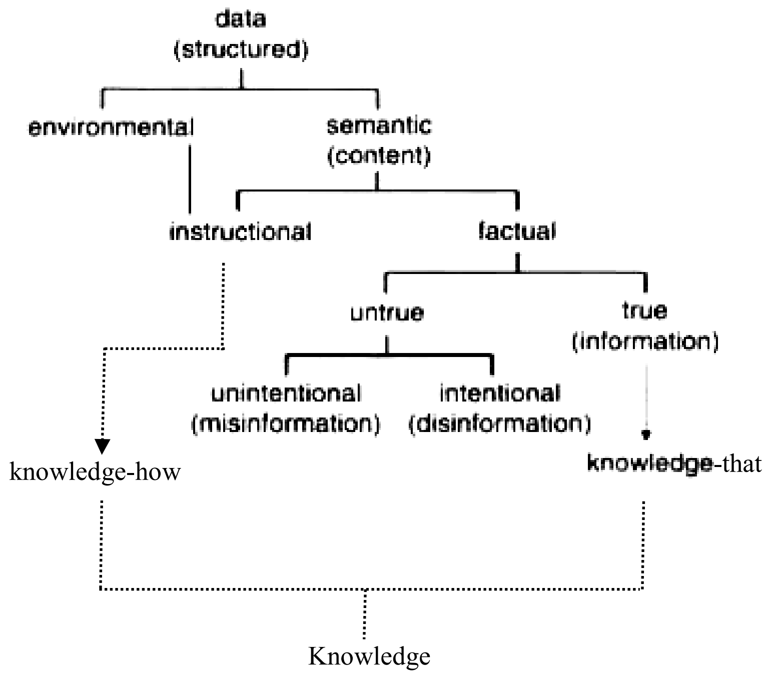
4. SEMANTIC INFORMATION AND PROBLEM-SOLVING ALGORITHMS

As we have shown above, the solving algorithm for formal logic games is an important part of the semantic instructional information that is involved in *processing* the factual semantic information of the game. Even that the fact patterns and constraints of the game are valued as true information, the path to the correct answer – the path toward true information – cannot be found in the absence of the *instructional* information. More, instructional information is not reduced to the sequence of steps that are recommendable to be taken in order to solve the game in the shortest possible time, but it also contains *important knowledge* of true logic laws and logic procedures that must also be considered informative, even though there are some tautologies involved. It is important to remember that, by syntactic or mathematical approach on communication, the amount of information of a tautology is 0 bits (Bremer 2003, 568), because "logical truths can be completely expected". Also, by Carnap's and Bar-Hillel's semantic approach it seems that logical truth carry no information at all (Bremer, 569), by the almost the same reasoning. Yet, in the case of the logic game above, the true answers to the questions are strictly depending of a sort of information that seems to count more than 0 bits. The solutions to this problem have been advanced, according to Bremer (2003), by the works of Barwise and Perry (1983), Devlin (1991), Hintikka (1970, 1973) and Chaitin (1997) and implies different aspects of information ranging from syntactic, and situational semantics (Barwise and Perry, Devlin), towards considerations concerning epistemic modal logic (Hintikka) and algorithmic information (Chaitin). For a synthesis of all this approaches see Burgin 2010.

Therefore, perhaps some questions concerning the pragmatic and/or algorithmic approaches to information are to be considered in this case and also some aspects of knowledge that not only emphasise the type of knowledge that could be described as the knowledge-that, but also to the particular aspect of knowledge, the knowledge-how – Ryle (1949) – that plays an important role in reaching for the truth in the case presented above.

As Floridi remarks in the end of his article about semantic information, the aspects concerning instructional, algorithmic and pragmatic information are to be subject to further investigations (Floridi 2011).

To summarize our position concerning the instructional information we are proposing some additional traits to the information map suggested by Floridi (our suggestions are added with dotted line):



This position seems to be supported not only by our example, but also by the ideas of Thomas Kuhn (1996). In his well known work, *The Structure of Scientific Revolutions*, Thomas Kuhn sees normal science as a puzzle-solving activity. And in problem-solving activity it is not the result produced that counts, yet it is the path toward the result (Kuhn 1996, 35–36):

Perhaps the most striking feature of the normal research problems we have just encountered is how little they aim to produce major novelties, conceptual of phenomenal.

………………………………………………………………………………………

Puzzles are, in the entirely standard meaning here employed, that special category or problems that can serve to test ingenuity or skill in solution. …It is no criterion of goodness in a puzzle that its outcome be intrinsically interesting or important.

More, Kuhn uses the expressions ‘puzzle’ and ‘puzzle-solver’ to indicate the specific scientific activity of an expert. In evaluating a person’s ability to think critical the accent lays on his knowledge to solve the logical puzzle presented by the critical thinking test. His success in solving the logic game stands for knowing how to deal with situations that require that sort of approach. In a similar way, an expert in the sense of Kuhn, uses his scientific training inside a particular paradigm in order to solve some scientific ‘puzzle’ with little interest in the result – because he already knows it –, but with great interest in the path that leads him to the particular result. And if this is his everyday work, than it appears that this sort of information concerning the path taken to solve the puzzle is one that should be taken into consideration in at least a similar weight as the factual information it produces.

REFERENCES

1. Bar-Hillel, Yehoshua. (1964). “*Language and Information”* Selected Essays on their Theory and Applications. Addison-Wesley Publishing Company.
2. Bar-Hillel, Yehoshua and Rudolf Carnap. (1953). “*Semantic Information”*. The British Journal for the Philosophy of Science, vol. 4. No. 14. (Aug., 1953), 147–157.
3. Bremer, E. Manuel. (2003). “*Do logical truths Carry Information?”* in Mind and Machines 13: 567–575. Kluwer Academic Publishers.
4. Burgin, Mark. (2010). *Theory of Information. Fundamentality, Diversity and Unification.* New Jersey, London, Singapore, Beijing, Shanghai, Hong Kong, Taipei, Chennai: World Scientific Publishing.
5. Curvebreakers, 2009. McGraw-Hill’s LSAT 2009 Edition. New York/Chicago/San Francisco/Lisbon/London/Madrid/Mexico City/Milan/New Delhi/San Juan/Seul/Singapore/Sydney/Toronto: McGraw-Hill.
6. Floridi, Luciano, “Semantic Conceptions of Information”, The Stanford Encyclopedia of Philosophy (Spring 2011 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/spr2011/entries/information-semantic/>. accessed: 10.08.2011.
7. Keenum, Chris. (ed.). (2008). Conquering LSAT Logic games. Second edition. New York/ Chicago/ San Francisco/Lisbon/London/ Madrid/Mexico City/Milan/New Delhi/San Juan/Seul/Singapore/ Sydney/ Toronto: McGraw-Hill.
8. Kuhn, S. Thomas. (1996). *The Structure of Scientific Revolutions*. Third Edition. Chicago and London: The Chicago University Press.
9. Pârvu, Ilie. (1974). Logica ştiinţei. Bucureşti, Editura Ştiinţifică.
10. Popper, R. Karl. (2002). The Logic of Scientific Discovery. London and New York: Routledge.
11. Ryle, Gilbert. (1949). The Concept of Mind. New York, Melbourne, Sydney, Cape Town: Hutchinson House.
12. Shannon, Claude. (1948). The Mathematical Theory of Communication. url: http://cm.bell-labs.com/cm/ms/what/shannonday /shannon1948.pdf; accessed: 10.08.2011.
13. Weaver, Warren. (1949). Recent Contributions to The Mathematical Theory of Communication. url: http://www.designingasociety.org/evergreen/wp-content/uploads/2010/05/ weaver.pdf; accessed: 10.08.2011.