Reasoning from Paradigms and Negative Evidence

Argument from ignorance has been analyzed in the contemporary philosophical literature as a defeasible argument, one which can be fallacious when used to shift the burden of proof to the other party (Walton, 1999). Consider this example: "Bob has been at home yesterday: his friends did not see him at the pub, and he did not go out for dinner". In this case, considering that Bob usually dines out or goes to the pub, this lack of positive evidence tentatively supports the conclusion that he was at home. However, the following argument would hardly be acceptable: "There is no proof that Bob did not eat the chocolates. Therefore he ate them". While in the first case a set of possibilities is outlined and the most plausible alternatives are proven to be wrong, in the second case the set of proofs of the contrary cannot be even produced, as it would be extremely difficult, if not impossible, to prove that an action was not committed. In this paper, we show that evaluating cases of reasoning from negative evidence is based on the possibility of providing evidence in the case, and presupposes a possible set of alternatives that need to be negated to support a conclusion. We show that when such possibilities cannot be provided, the reasoning itself risks being unreasonable. By investigating the deep logic of reasoning from negative evidence, we show how a set of alternatives, which we call a paradigm, is related to negation and is the foundation of the reasoning used to derive a positive conclusion from negative evidence. We use pragmatic principles of paradigm and implicature to analyze how argumentation from negative reasoning works by excluding alternatives to arrive at a best explanation of the data given (and not given) in a case.

1. Negative Evidence and Arguments from Ignorance

In the kind of argumentation associated with what is called *negative evidence* in scientific research, an expected outcome is tested for, and not found, and then a conclusion is drawn about the significance of this failure to find. Traditionally in logic, this form of argumentation is called the *argumentum ad ignorantiam,* which has the following form: it is not known (proved) that a proposition *A* is true (false), therefore *A* is false (true). The argument from ignorance has traditionally been portrayed as a fallacious form of argument in the logic textbooks, although it is sometimes recognized that it can be reasonable in some instances.

Argument from ignorance, also called inference from lack of knowledge, represents a form of reasoning that is fundamentally knowledge-based reasoning of a kind widely used in computing, for example in expert systems. Suppose an expert system on coffee production in South America is asked whether Guyana is a major coffee producer and a search finds that 'Guyana is a major coffee producer' is not in its knowledge base. The questioner can infer, using argument from ignorance, that Guyana is not a major coffee producer. Hence when used in the right evidential circumstances, the argument from ignorance can a reasonable kind of defeasible argument that shifts a weight of presumption in a balance of considerations. Argument from ignorance, often named by other labels, like reasoning from negative evidence, has become more widely accepted than it once was. Also in the logical tradition, such a pattern of reasoning has been

described as having some non-fallacious instances, which can be drawn from medical and scientific research (Copi & Cohen, 1990, p. 94):

Case 1

> In some circumstances, of course, the fact that certain evidence or results have not been got, after they have been actively sought in ways calculated to reveal them, may have substantial argumentative force. New drugs being tested for safety, for example, are commonly given to mice or other rodents for prolonged periods; the absence of any toxic effect upon the rodents is taken to be evidence (although not conclusive evidence) that the drug is probably not toxic to humans. Consumer protection often relies upon evidence of this kind.

This remark suggests that use of negative evidence is commonplace and essential in scientific and medical research. However, the classification of the *argumentum ad ignorantiam* as a fallacy suggests a downgrading in logic of arguments based on negative evidence. Curiously, this strong preference for argumentation based on positive over negative evidence is mirrored in practices of publishing scientific research.

2. The Underlying Logic of Negative Evidence

Is this preference for positive over negative evidence based on the underlying logic of the two types of reasoning, indicating that arguments based on negative evidence are somehow less reliable than arguments based on positive evidence? Or as Smithson (1988, p. 1) put it, is it simply a reflection of the dominant positivistic traditions of the past, that saw scientific research as a cumulative buildup of positive, verified propositions, leading to the truth step by incremental step , transforming these propositions into knowledge? However, the model advanced by the classic model of purely deductive logic, leading to absolutely true conclusions, has been recognized as unable to deal with many types of arguments used in law, politics, and scientific domains such as medicine and physics. In such fields, contingent proofs are needed, and not absolute conclusions are required. The classic model of formal logic was first attacked by Leibniz, who developed the Principle of Sufficient Reason to account for contingent reasoning. He noticed how in law presumptions work as defaultive patterns of reasoning; for instance, the presumption of innocence states that in absence of contrary evidence or should the burden of persuasion not be fulfilled, the defendant shall be considered as innocent. Such reasoning is not conclusive without assumptions, as the conclusion is reached only under some conditions (Dascal, 2001).

The logic of defeasible arguments and the acceptability of arguments from ignorance have been recently defended in scientific reasoning. Smets (1991) has shown how establishing well-founded theories in science rests on the use of arguments from ignorance. Witte, Kerwin and Witte (1991) have championed the use of arguments from ignorance in medical education and research. Dohnal (1992) maintains that arguments from ignorance are common and useful in reliability reasoning used for testing microelectronic circuits. The example cited in section 1 has already shown that the lack-of-knowledge inference is a commonly used type of default reasoning used in drawing conclusions from the search of a knowledge base.

Arguments from ignorance were shown in Walton (1996, p. 258-260) to have a non-explicit premise which gives information on how thorough or complete the searching process has been to the point at which the argument from ignorance is being used. This premise is a conditional of the form: If *A* were true, then *A* would be known to be true. Thus such arguments are partly based on ignorance, but also partly on what is known at a given stage of an inquiry. Negative and positive evidence are combined in a functional way in this structure of reasoning. The argument from negative evidence can be modeled as a form of inference with two premises and a conclusion in the argumentation scheme below (Walton, 1996, p. 254).

Argumentation Scheme: Argument from Negative Evidence

Major Premise: If *A* were true, *A* would be known to be true.
Minor Premise: *A* is not known to be true.
Conclusion: *A* is false.

Such pattern of reasoning has been analyzed in computing as a relativistic form of deductive reasoning called autoepistemic reasoning. On Moore's view (1985, p. 273) inferences of the kind

Tweety is a bird. Most birds can fly. Therefore Tweety can fly

can be analyzed considering the premise "Most birds can fly" as a consistency clause, providing that "the only bird s than cannot fly are the ones that are asserted not to fly" (see also McDermott & Doyle, 1981). Since Tweety is not asserted to be fall within the group of birds that cannot fly, Tweety can fly. Therefore, the conclusion that "Tweety can fly" is not drawn absolutely (it is an ontological fact that birds fly, and if something does not fly it is not a bird), but relative to a theory, or shared knowledge. Such a pattern of reasoning can be formalized as follows (Moore, 1985, p. 275):

1. If $P_1,..., P_n$ are in T, and $P_1,..., P_n \vdash Q$, then Q is in T (where " $\vdash$ " means ordinary tautological consequence).
2. If P is in T, then LP is in T.
3. If P is not in T, then ~LP is in T.

The second and third clauses provide that if a proposition is (is not) in the theory, or domain of knowledge, such a proposition is (is not) believed (indicated by the logical operator 'L') to be in such theory.

This pattern of reasoning is often used in everyday argumentation. If we do not find our dog in our car, we infer that the dog is not in the car. The strength of such inference, however, depends on several factors. First, it is necessary to establish our theory, about what "not known to be true" means. Lack of knowledge of a fact may be the result of a test, a thorough investigation, or absence of specific perception under ordinary conditions. In law such a distinction is extremely important. For instance, in witness testimony, the absence of positive knowledge of a fact needs to be supported by proofs that the witness was actually able to perceive such fact or event under the given conditions (see Tigar, 2003, p. 357; Kassin *et al.*, 2001). In cross-examination, doubts may be cast on the witness's ability to perceive or report (Mueller, C. & L. Kirkpatrick,

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1999, § 6.5), while in examination-in-chief the counsel needs to support the testimony with proofs of the witness's perception. See for instance, the following dialogue (Romano, 2006):

Case 2

> Q. Did you have any hearing problems?
> A. No.
> Q. Any vision problems?
> A. Not really. Had my glasses on.
> Q. During the entire period of time you were out there at the scene, that forty five minutes or so, did you see any citrus trucks and big rigs like that go by in either direction on the highway?
> A. None.
> Q. Are you sure?
> A. Yes, sir.
> Q. Did you hear anything else that sounded like one of those rigs?

The second crucial aspect of argument from ignorance is the relation between absence of perception and absence of a sign. Even though an event or an object has not been perceived under ordinary circumstances, it might have happened or exist anyways, such as in the following case from the O.J. Simpson trial (cross-examination: 3/14/95 AM. at 0040):

Case 3

> Q. Wouldn't you think the first four trips would have been enough to blot out any footprints of the perpetrator, if there were any?
> A. I did not see any.
> Q. You wouldn't see footsteps in leaves, that takes an expert?

In this case, the witness's testimony of absence of evidence is rebutted by the attack to ordinary perception. In some cases, the counsel argues, footprints cannot be seen by the naked eye, but only detected by infrared or other instruments.

The last critical point of argument from negative evidence is the relation between absence of a sign and absence of a fact, that is, the causal relationship between an event or a fact and the tracks or signs it leaves. For instance let's consider the following argument (*United States v. Phillips*, 575 F.2d 97 (6th Cir. 1978)):

Case 4

> It was the purpose of this cross examination to infer that, **if no fingerprints of the appellant were found, he could not have been the third participant of the robbery**. The gist of the testimony of the expert was that **there are many factors which are determinative of whether one leaves a fingerprint upon touching something**. The body chemistry, the secretion or non-secretion of body fluids is a factor. Some individuals do not secrete fluids in a normal fashion and, as a consequence, would not leave prints upon touching something. Such persons are known as non-secretors (emphasis added).

In this case, the causal link between the sign and its cause is undermined. Since the causal correlation between someone's touching an object and his or her leaving a fingerprint is

not extremely strong, the reasoning from sign to effect based on it cannot be very reliable.

Therefore, the argument from negative evidence can be treated as a deductively valid form of argument in very few cases, as perception can rarely be considered as complete knowledge, and the causal relationship cannot in many instances be taken to be strong or necessary. Argument from negative evidence is therefore a defeasible form of argument, but even so it plays a crucial role in evidential reasoning. It holds tentatively during the process of an investigation, and provides a tentative weight of evidence holding until stronger contrary evidence is provided. It is used more frequently to fulfill the burden of supporting a conclusion in order to shift the burden of proof on the other party, than to prove it conclusively and beyond all doubt.

The purpose of negative evidence in the cases mentioned above is not to prove that there were no other vehicles passing by when the homicide occurred, or that no people passed by the crime scene, or that the appellant was not present at the robbery. Its role is as an instrument of evidential argumentation that can be used to shift the burden of producing evidence onto the other party, who needs to provide additional evidence or stronger contrary arguments to rebut it.

3. Proving Negative Findings

Positive evidence is, from a logical point of view, distinctively different from evidence of absence. Knowledge of a fact requires a proof that the fact has happened, and the positive testimony of witnessing a fact is a clear proof that the fact has happened. In order to rebut such a proof we need to show that the knowledge was in fact not knowledge (for instance the witness's perception was impaired, or he is lying, or his memory of the fact is poor). However, when evidence of absence of a fact or object is advanced, its strength depends on the completeness of negative knowledge. For instance, knowledge of footprints on the ground is considered complete knowledge; however, the absence of footprints needs to be assessed considering whether all the ground has been examined, how it has been examined, with what instruments it has been analyzed, and by whom. Negative evidence depends on the completeness of what has been negated.

The difficulty of proving that a fact has not occurred or that an entity does not exist depends on how wide the paradigm of instances to be negated is. In other words, the complexity and strength of such arguments hinges on the completeness of the information provided, which in turn depends on how wide the paradigm of entities considered is. For instance, in order to prove that oil contamination in the Santa Barbara Channel oil spill had no effects on the population of elephant seals, it is necessary to examine a limited number of individuals, namely the elephant seals living nearby, in a limited number of months after the event (Le Boeuf, 1971). In this case, the number of individuals is restricted and the type of damage to be found is quite specific. However, if we wish to establish that oil spills have no negative effects on sea life, the number of factors and individuals to be taken into consideration would make this conclusion extremely hard to prove.

We can conceive the number of factors to be considered as a paradigm made of the possible instances of a relation between an entity and a property. For instance, if we consider a possible relation "x causes P", such as the negative effects of a drug on the

human body, we need to considered all possible instances of such relation, namely "x causes P_1, P_2, P_3, P_4,…", such as "Drug x has negative effects on the stomach; Drug x has negative effects on the kidneys; etc." As argued in (Hahn, Oaksford & Bayindir, 2005) and (Hahn & Oaksford, 2007), the number of factors to be considered make negative arguments weaker than positive ones (see also Walton, 1996, p. 66). For instance, while the positive argument "Drug A is toxic because a toxic effect was observed" can be only rebutted by undermining the premise "a toxic effect was observed", the negative argument "Drug A is not toxic because no toxic effects were observed" is only presumptive: even if the premise is true, there might always be future toxic effects in the future, or some factors may always be overlooked in the tests. Such an argument is only probable, and the strength of such probability depends on the strength of some tests conducted (Hahn & Oaksford, 2007, p. 52).

Negative arguments depend on the completeness of the negated paradigm. In medicine or history such paradigm can be hardly considered as complete, and therefore reasoning from ignorance can only provide a certain degree of probability. However, when the relation considered has only a closed number of instances (for instance, a relation "x is P" having only four instances "x is P_1; x is P_2; x is P_3; x is P_4"), from the negation of all instances follows the negation of the relation. For instance, if we want to establish whether a child, Bob, is in the classroom, we need to prove that every child in the classroom is not Bob. Once we have found that all children in the classroom are not Bob, we have proved that Bob is not in the classroom. Such pattern of reasoning is possible only when the search is complete, namely it is applied to a closed database. In computing, such principle has been developed under the name of the Closed World Assumption, setting forth that "if a ground atom A is not a logical consequence of a program P, than it is possible to infer $\sim A$" (see Reiter, 1978). This rule has been developed by Clark into the principle called "Negation as Failure" (1978, p. 114), stating that "To show that P is false, we do an exhaustive search for a proof of P. If every possible proof fails, $\sim P$ is 'inferred'". Such pattern of reasoning can be formalized as follows (Clark, 1978, p. 114):

$$\vdash \sim \; \vdash P \text{ infer } \vdash \sim P$$

If an entity A is within the failure set of a program (namely the program can detect whether such entity is in the database or not), then it is possible to infer $\sim A$ with respect to such program. What is extremely important in computing is how the database (the kids) world and the query (such as, for instance, "to be in the classroom") are circumscribed (see McCarthy, 1980; Reiter, 1991; Reiter, 2001). In order to "close" the world considered, it is necessary to redefine the predicate "to be in the classroom", excluding the cases in which a child is in the wall of the classroom, or under the floor, or hidden somewhere in the room. Similarly, the concept of "child" needs to be specified, excluding cases such as a child imagined by other children, or mentioned by a book, or painted on a wall.

4. Argument from Ignorance and Reasoning from Paradigms

Arguments from ignorance are based on a reasoning of a kind essentially opposite to the logic of the other types of argument. Arguments from cause to effect (*x* causes *y*; *x*; therefore *y*), from definition (*x* means *y*; *A* is *x*; therefore *A* is *y*), or from authority (if *Expert* says *p*, *p* is plausibly true; *Expert* says *p*; therefore *p* is plausibly true) lead from some factual premises to a conclusion; they proceed from positive evidence, even if weak or not certain, to a unaccepted or controversial conclusion. Reasoning from ignorance is not grounded on positive evidence, but simply on absence of evidence. Consider the following examples:

Case 5

1. Substance X has been found to cause dyspepsia. Therefore it is hazardous.
2. Substance X has not been found to cause negative effects on humans. Therefore it is not hazardous.

The first argument is based on a fact: substance X causes a disease. In the logic of this argument, any possible diseases could be relevant to support a conclusion about the safety or hazardousness of the substance. However, the other possible diseases are not necessary, nor are they needed to support the conclusion. The affirmation of one fact argumentatively excludes all other possibilities. The second argument follows a different structure of reasoning. The ground supporting the conclusion consists in absence of positive evidence, and is not constituted by positive findings. This type of argument is based on two basic reasoning steps: a passage from absence of information, or absence of knowledge, to negative evidence, and a step from the negation of a premise to the negation of the conclusion. The second passage can be represented in formal logic by the logical inference rule of *modus tollens* and disjunctive syllogism:

Modus Tollens	Disjunctive Syllogism
If A, then B.	Either A or B.
Not B.	Not A.
Therefore, not A.	Therefore B.

When applied to natural language, the abstract structure of these two axioms needs to be adapted to the problem of semantic paradigms and negation. In natural language, we can express negation in different ways, but in particular by denying a predicate representing a category (This animal is not a feline), and denying all species of a category (This animal is not a tiger, a cat, a panther...). This latter type of reasoning was described in the ancient works on dialectics and argumentation as a particular type of argument from definition, in which the genus, a more generic predicate (such as 'to be a feline'), was denied by denying all the more specific predicates which can be characterized by the generic predicate. For instance, 'tiger', 'cat', 'panther' can be all described as 'felines'; and the predicate 'feline' can be attributed to an entity only if the entity falls within one of its more specific attributions. Aristotle in his *Topics* (*Topics* IV, 1) described this pattern of reasoning treating the nature of the genus, which cannot predicated of an entity unless one of its species is predicated of it too. Later, Cicero applied this kind of reasoning to law, providing the following example (Ciceronis *Topica* III)

Case 6

> If a slave has not been declared free either by the censor, or by the praetor's rod, or by the will of his master, he is not free: but none of those things is the case: therefore he is not free.

In the argument above, the general predicate of 'be free' is indirectly denied of the subject 'a slave'; instead of denying the predicate, all the more specific predicates constituting its possible subdivisions are denied. Cicero describes the reasoning as a particular form of reasoning from definition, in which from the negation of the species follows the negation of the generic predicate the specific predicates belong to. As 'to be set free' can be specified only in three categories, 'be declared free by the censor, by the praetor, by the master', the negation of all the species implies the negation of the generic predicate. Aristotle expressed the semantic ground of this axiom of reasoning as follows (Aristotle *Topics* IV, 2):

> For of necessity what partakes of the genus partakes also of one of the species produced by the first division of the genus.

In linguistic terms, we can describe this pattern of reasoning using the categories of paradigm and paradigmatic elements. For instance, when characterizing a person's eyes, a paradigm of possible colors is opened. The eyes, and more specifically the eye iris, may be blue, black, green, blue, but not white or pink or red. These colors constitute the paradigm of eye color (see Gobber, 1999). Other generic predicates include only two elements, such as 'condition of existence for living creatures' which includes only 'dead' and 'alive'. Both open and binary paradigms can be conceived as general predicates specified in a list of elements, and the negation of all possible specifications implies the negation of their genus. For instance, if an entity is neither dead nor alive, it cannot exist as a sentient being; if an eye is not black, green, blue, etc., it has no color. This pattern of reasoning is grounded on a semantic system much wider than the one used in formal axioms. It includes not only the definitions of the logical connectors and quantifiers (et, aut…; all, some…) but also of the elements or symbols connected (A; p…). The relationship between premises and conclusion is not only based on relationships between connectives and quantifiers (x is Q; All Q's are P; therefore x is P), but also on the meaning of the predicates attributed. Such type of reasoning is only defeasible, as while some paradigms are commonly accepted, such as the paradigm 'dead-alive', others can be challenged or are unshared and controversial. Depending on the acceptance of the paradigm, the pattern of reasoning from negation of the species provides a greater or weaker support to the conclusion. The acceptability of the conclusion depends on whether the majority of native speakers of the language consider the paradigm the indirect negation is grounded on to be complete.

Going back to Case 5, we can notice that an implicit argument from negation of the species has applied. The only way to deny the predicate 'to have no negative effects' was to prove that the substance did not cause any possible negative consequences to humans. We can represent the pattern of reasoning as shown in figure 1.

Implicit reasoning	Paradigm of 'To have negative effects' (humans)
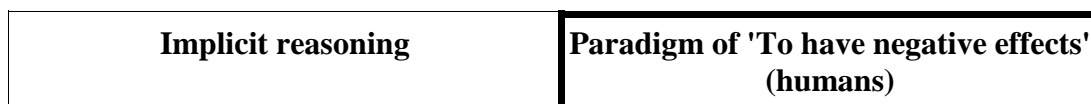
Substance X has not been found	To cause headache
Substance X has not been found	To cause dyspepsia
Substance X has not been found	To cause infections
Substance X has not been found	To cause cancer
Substance X has not been found	To cause vomiting
Substance X has not been found	To cause disease Y, Z...
....	....
Hence substance X has not been found	**To cause negative effects on humans**
Therefore it is **not hazardous**	

Figure 1: Denying the Predicate of No Negative Effects

The acceptability of the conclusion depends on how complete the implicit paradigm of the negative effects a substance may have on human beings is. This pattern of reasoning is not simply a classification, as it does not merely proceed from a definition to the *definiendum*. Instead, it is based on the paradigm characterizing the genus of the *definiendum*. This pattern of reasoning can be represented by the following argumentation scheme (see also Walton & Macagno, 2010, p. 46):

Argumentation Scheme: Classification under lack of knowledge

> PREMISE: If *A* were *X*, *Y*, *Z*, then *A* would be known to be *X*, *Y*, *Z*.
> PREMISE: It is not the case that *A* is known to be *X*, *Y*, *Z*
> PREMISE: A can be either *X*, *Y*, *Z*, or *K*. Other possibilities are not known.
> CONCLUSION: Therefore *A* is *K*.

In the example above, an entity is not known to 'cause diseases X, Y, Z…', namely 'to be hazardous'. As a substance is either hazardous or not hazardous, the conclusion to be drawn is that it is not hazardous.

The probative force of reasoning from lack of evidence ideally depends on two criteria: the definition of the general concept under which the specific concepts are classified, and the negation of the species. In the first case, depending on how we define 'negative effect', different possible illnesses are classified as such. For instance, can migraine be included as a negative effect of a substance? The other criterion is how 'absence of an effect' is defined. In science, the assessment of negative results depends on statistical standards. For example, the absence of the effect of a substance is calculated based on the increase in frequency of a disease (Hansson, 1997, p. 227). Not considering the controversies about detection levels, another logical and epistemological problem arises in reasoning from lack of evidence. In everyday reasoning, if we take for granted that presence of fire usually implies presence of smoke, the absence of smoke provides strong evidence for the conclusion that there is no fire (Caminada, 2008). However, the logical axiom of *modus tollens*, when applied to default reasoning, does not apply when we only do not perceive the presence of smoke (Sharma, 2004). The negation of

'presence of smoke' is simply the best explanation of a finding, which constitutes a distinct pattern of reasoning in its own right, described as follows (Walton, 2002, p. 44):

Argumentation Scheme: Explanation under lack of knowledge	
▪ *F* is a finding or given set of facts. ▪ *E* is a satisfactory explanation of *F*. ▪ <u>No alternative explanation *E'* is as satisfactory as *E*.</u> ▪ Therefore, *E* is plausible, as a hypothesis.	▪ No smoke is observed ▪ There is no smoke ▪ <u>The other possible explanations (the smoke cannot be seen because of the distance; the smoke has been covered...) are not as satisfactory as the absence of smoke.</u> ▪ Therefore there is no smoke

Clear examples of the defeasibility of this species of reasoning can be drawn from medicine and geology. The absence of symptoms of an illness in a limited period of time does not exclude the absence of negative effects of a substance on humans; some types of disease, such as cancer, may appear later in life. In evolutionary sciences (see Heyning *et al.*, 1999), the absence of a fossil trace of an organism within a stratigraphic horizon does not preclude the possibility that the organism did in fact exist during that time interval. Another equally satisfactory explanation might be the loss of such traces.

Lack of evidence is therefore a defeasible pattern of reasoning, grounded on two different types of argument: classification from lack of evidence and reasoning from the best explanation. Both patterns are based on a particular type of presupposition (or premise taken for granted), namely the paradigm of possible alternatives. In reasoning from classification from lack of evidence the paradigm is constituted by the possible alternative classifications. In reasoning from the best explanation, the potential set of alternative choices is composed of all other satisfactory explanations. The two patterns are closely related, as the classification, grounded on the negation of the alternatives, is often an explanation of a lack of a positive finding.

This double weakness does not mean that reasoning from lack of evidence is an unscientific method or unreliable. On the contrary, it can be an extremely powerful reasoning pattern, especially when the paradigm of the possibilities is shared between the interlocutors, or fixed. The evaluation of an argument from lack of evidence as stronger or weaker depends on the completeness of the paradigm, or rather on its closure. A clear example can be drawn from reasoning from sign. We can consider the relation between the grass being wet and the possible causes of such event. If it rains, or someone waters it, or the ground has been flooded, or the sprinkler is on, grass will be wet. The negation of the consequent in such case can be only considered as a sign of absence of rain, as other possible causes are possible. However, if we exclude all the other possibilities, the abduction becomes an MT deduction (see Console, Dupré & Torasso, 1991). Similarly, the negation of the antecedent can be a reasonable pattern of abduction: from the negation of a fact the best explanation is concluded, which corresponds to the negation of its more plausible consequence or relation. However, if we limit the paradigm, or database, such inference becomes deductive.

In computing, the limitation of the database turns a plausible reasoning into a deduction. If we need to find out whether Bob is in the classroom, we will analyze the

data that we have, namely the children in the classroom. The absence of the child, however, can be explained by several factors: the child can be hiding somewhere, or another child is pretending to be Bob. However, if we define our database, and the meaning of the predicates "to be a child" and "to be in the classroom", we can limit our search to the "children who can be seen inside this classroom" and to entities that "look like Bob". So reconfigured, our query may be written as a premise of this kind.

> If Bob is in the classroom, then he will look like a kid that can be seen in the classroom.

The negation of the consequent, in a world in which the concepts of correspondence and presence are redefined in the aforementioned fashion, deductively implies the negation of the antecedent. If we redefine the meaning of words, an instance of abductive reasoning from paradigms can become a deductive inference.

5. Reasoning from lack of evidence and burdens of proof

From a dialectical point of view, reasoning from lack of evidence cannot be considered as a conclusive proof; however, it can meet the burden of proof needed to support a conclusion up to a suitable proof standard. In law there is a proof discrepancy between the litigating parties. One party (the claimant) has to persuade the judge or the jury of the truth or falsity of a proposition to the appropriate standard of proof, while the other party needs only to provide evidence contrary to some facts or elements in the claimant's argument. For instance, in criminal proceedings the prosecution needs to prove beyond reasonable doubt that the defendant committed the crime he is charged with. In civil law the plaintiff needs to persuade the judge by providing clear and convincing evidence, or preponderance of evidence. The general rule setting the burden of proof can be expressed as follows (*Schaffer ex rel. Schaffer v. Weast*, 546 U.S. 49 (2005)):

> The burdens of pleading and proof with regard to most facts have been and should be assigned to the plaintiff who generally seeks to change the present state of affairs and who therefore naturally should be expected to bear the risk of failure of proof or persuasion.

The party who seeks to change the present state of affairs bears the risk of failure of proof or persuasion (Strong, 1999 § 337, p. 412). If the claimant or the prosecution does not prove the essential elements (all or most of them, depending on the type of trial), the defendant is acquitted.

Burden of proof is a dialectical device closely related to presumption. As seen above, a presumption is an inference which can be drawn in conditions of lack of knowledge. For instance, a person is presumed to be innocent unless the prosecution proves the contrary. If a defendant has *not* been *proven* guilty, it is possible to infer that the defendant is innocent, without an actual conclusion of guilt having been established (Rescher, 1977, p. 26). Presumption and burden of proof apply both to the general setting of the dialogue and the specific sub-issues coming up during the discussion (for the notion of burden of proof, see Tillers, 1989; Anderson, Schum & Twining, 2005; for its

application to dialogue theory, see Prakken & Sartor, 2009; Gordon & Walton, 2009; Prakken, 2005). For instance, we can consider a legal discussion in which the defendant is accused of murder. The general issue, namely his innocence, is governed by the presumption of innocence. In order to rebut such presumption, the prosecution needs to support the contrary conclusion with arguments of a specific kind and force, fulfilling a standard of strength (beyond reasonable doubt, in case of criminal law). Several factors need to be established by the prosecution to support a conclusion. For instance, the defendant needs to be proven to have had a weapon with him, to have hit the victim, etc. If the prosecution provides evidence supporting such sub-issues, a *prima facie* case is established, and the defendant needs to provide contrary evidence, otherwise the case stands or falls only by this evidence. The burden of persuading the judge is not shifted, but a different burden is placed onto the defendant: the burden of production.

Presumptions may affect in different ways the production of evidence. For instance, let's consider the classic presumption that a person who has been absent for 7 years is presumed to be dead. When a person is missing or is not heard of for years, it is hard or impossible to establish whether he is dead or alive. It would be extremely hard to prove both; however, if it is necessary to make a decision based on his living conditions, it is reasonable to conclude that he is dead. Similarly, it would be long and hard to establish that a person is under the influence of alcohol while driving; however, if the alcohol level in his or her blood exceeds a specific threshold, he is presumed to be intoxicated. Presumptions work in conditions of lack of evidence, and lead the other party to provide the missing information. Obviously, presumptions need to be grounded on a rational connection, namely the presumed fact needs to be more likely than not to flow from the proved fact supporting it (see *Leary v. United States*, 395 U.S. 6, 36 (1969)). For instance, the possession of marijuana was not considered as a fact from which knowledge of its illegal importation could be presumed, as a good amount of such substance was produced domestically (see *The Constitution of the United States of America*, p. 1765).

This legal concept can be applied, in a modified form, to scientific discussions (Purchase, 1997, p. 230). Just as the court acts as holding the assumption that claimant's proposition is false and allocates the burden of disproving such presumption on the claimant himself, so in science the proponent of a new theory, contradicting the existing ones or yet unproven, has the burden of proof (Hansson, 1997, p. 225). The crucial problem is to assess what is the shared knowledge about a theory or a hypothesis (what constitutes evidence), as the allocation burden of proof depends on what is considered to be commonly accepted, or acceptable as evidence. For instance, natural food, containing natural chemicals, is assumed not to be hazardous until it is proven to be toxic. On the contrary, "for the introduction of new pharmaceuticals, food additives and pesticides, there is a mandatory requirement for certain tests, for example, for carcinogenicity." (Purchase, 1997, p. 230).

Chemicals are considered to be hazardous unless proven to be safe. The difference lies in what is commonly accepted by the majority, or simply in what can be reasonably presumed safer or more convenient. Everyone presumes food is not toxic, until it is proven dangerous for human health, while it would be too risky to presume additives or chemicals safe until someone is seriously harmed. The rationale for setting the burden of persuasion in science is not grounded on principles of justice, but on the more pragmatic criterion of avoiding retraction of a claim supposedly proved, or other harmful negative

consequences that may threaten safety. Moreover, the type of burden of proof may be different depending on the purpose of a substance or scientific hypothesis. For instance, in cases of chemicals used to treat a life-threatening disease the burden of proof will be lighter than, or simply different from, the burden for chemicals used to treat trivial diseases or used as food additives (Purchase, 1997, p. 230).

The types of reasoning underlying the propositions to be proved in such cases may be noticeably different. While the potential hazard of a substance can more easily be proved and quantified, the absence of hazard is highly difficult to prove. Negative evidence can be considered as a further argumentative step relative to positive findings. If we consider positive findings as atomic elements, they hold independently of the amount of knowledge considered, whereas a negative conclusion it is in itself an implicit argument whose strength depends on the amount of knowledge, or theory. If we consider positive findings the conclusion of an argument, such as from sign or appearance (if x causes effect K, x is hazardous), negative evidence is always a further argument, which adds to the defeasibility of such type of reasoning the uncertainty deriving from the theory taken into consideration.

Reasoning from ignorance can only support a reasonably acceptable assumption that can be taken to hold in default of contrary evidence. Or it may be used to rebut theories grounded on positive finding by providing evidence to the contrary (see Li, Han & Wu, 2005). In particular, in case of a hypothesis grounded on lack of contrary evidence, if its opponents fail to fulfill the appropriate burden of production, the hypothesis can be taken to be acceptable as a tentative way to move forward.

Burden of proof requires specific standards to be fulfilled that are appropriate for the case and the type of investigation in which the evidence is to be assessed. A negative proof needs to be based on a certain amount of data (a threshold), and such data must provide enough evidence to meet the appropriate standard of proof (Gordon and Walton, 2009). Even when the standard has been met, reasoning from lack of evidence is somehow always an incomplete proof that may later have to be retracted. The burden of providing evidence is unevenly allocated on the proponents of positive or negative conclusions, and in many cases such burden cannot be reversed only to make the proving procedure simpler. Reasoning from lack of evidence is an instrument of defeasible argumentation that provides a prima facie case, and shifts a burden of production onto one's opponents to come up with a better argument. If the other party cannot provide positive evidence to rebut, or an explanation for the negative findings other than the proponent's hypothesis, the conclusion can justifiably be held to be acceptable for the time being.

6. The pragmatic consequences of dialectics: maxims and reasoning

In the sections above, we analyzed reasoning from negative evidence from a logical, semantic, and dialectical point of view. Reasoning from negative evidence is not merely an abductive type of reasoning, providing a possible explanation for a finding. Negative evidence already presupposes a set of alternatives, in which the negation of one or more elements leads to a plausible conclusion. Such alternatives sometimes are part of our semantic system: if a person is not dead, he must be alive; if a door is neither open nor ajar, it must be closed. Some paradigms are constituted by two elements, others by

several, others are not even clearly defined, as there is always the possibility of implementing them. For instance, the paradigm of the colors of the eyes is multiple, and it is necessary to deny all the alternatives to come to a judgment. If we consider value judgments, the paradigms are even more complex, as the elements here are ordered on a scale of intensity, such as in the case below (see Ducrot, 1980):
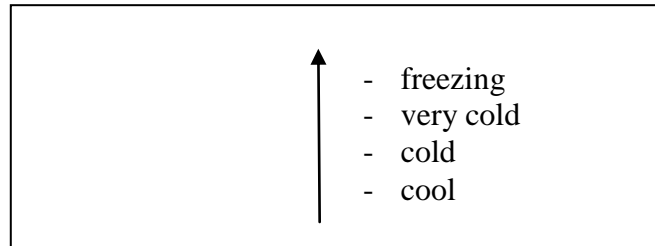

Figure 3: A scale of intensity

Finally, paradigms may be sets of possible explanations of an event. For instance, we can consider the well-known case cited by Grice (1989, p. 33):

Case 7

> *Y* is writing a testimonial about a pupil who is a candidate for a philosophy job, and his letter reads as follows: 'Dear Sir, Mr. *X*'s command of English is excellent, and his attendance at tutorials has been regular. Yours, etc.

In this case, the reader of the letter of recommendation expects an answer to the question: *How good is the student as a philosophy teacher (or researcher)?* No answers to this question have been provided in the letter; therefore the reader needs to find an explanation in the reply among the possible reasons he can think of, such as the following:

- He is unable to answer, because he does not know.
- He does not want to answer the question.
- He has not understood the purpose of the letter.
- There are no other qualities that are more suitable to answer the question.

Among such possible explanations, only the last one is plausible in such a context. The professor must know the qualities of his pupils, and must know what a letter of recommendation is all about. Moreover, if he had not wanted to write the letter of reference, he could reply that he was not in a position to do so. Therefore the only explanation is that the pupil does not have the qualities required to be a good candidate for the job (see also Walton, 1999, p. 64).

Reasoning from negation of paradigmatic alternatives is frequently a complex procedure, in which the agent needs to begin by assessing all the alternatives and end by excluding all except one. When paradigms are closed, such as 'dead-alive', the inference is straightforward. However, when paradigms are multiple or open-ended, or when explanations are involved, a shortcut is frequently needed. An example of how such reasoning shortcuts are used can be found in law. In *Gardner v. Wilcox* (370 F.2d 492, 494 (9th Cir.1966)), the appellant's husband disappeared for 13 years. There might be

several explanations for such fact, and it would be extremely long and difficult in a discussion to show that all the possible alternatives to death are to be excluded, or less likely. The law for this reason provides a principle of inference which supports a conclusion without any need to resort to a more complex pattern of reasoning (*Gardner v. Wilcox* 370 F.2d 492, 494 (9th Cir.1966)):

> It was there held that when the facts show that a person has been absent from his residence and unheard of for a period of seven years, a presumption arises that he is dead. The burden of explanation then shifts to the Secretary, and the presumption can be dissipated "by proof of facts that rationally explain the anomaly of the disappearance in a manner consistent with continued life."

The presumption of death can be interpreted as a heuristic shortcut based on reasoning to the best explanation. The plaintiff needs not provide negative evidence by rebutting all the possible alternatives explanations (the missing person is hiding somewhere; he has left the country…). The highest plausibility of the conclusion is established by a rule of presumption, shifting the burden of proof to the other party who now has to bear the burden of proving that one alternative is more reasonable.

Presumptions in reasoning from negative evidence work as instruments to determine which alternative in a paradigm is the most suitable or plausible. Every negation, or failure to provide a positive answer, opens a set of positive alternatives or explanations (see Gatti, 2000). For instance, if we state that 'This suit is not blue' we do not determine a quality, but a paradigm. The suit can be red, black, grey, etc. The negation does not specify one element, but provides a range of choices among which the interlocutor may choose. However, sometimes the set of possibilities is not informative, or not conversationally useful. For instance, the sentence 'Bob is not dressed in black today' would be only marginally relevant in a context in which Bob is used to wearing different colors every day. Therefore negation, or non-compliance with the conversational rules, often triggers reasoning from best explanation, in which a positive answer or choice is selected by exclusion of the less plausible options. In the sentence above, reasoning from best explanation would have normally provided the interpretation that Bob has exceptionally changed his dressing code. Such a relation between negation, paradigm and reasoning is simplified by conversational presumptions, which can be accounted for by pragmatics.

In everyday conversation we often use conversational implicatures to draw a conclusion from some data (Atlas, 2005). Grice identified four maxims (quality, quantity, manner and relation), establishing what the communicative expectations are. For instance, consider the following case:

Case 8

> A. How did you like the guest speaker?
> B. His suit was really nice.

In this case, Grice would have explained B's answer showing that he flouted the maxim of quantity, namely "Make your contribution as informative as is required for the current purposes of the exchange". This maxim can be interpreted as a principle from which a presumption can be derived, establishing that "No data more informative than the

information provided are presumed to be available to the speaker". This principle would lead to conclude from B's answer that the only thing that can be said of the speaker is that he was well dressed; therefore it cannot be said that he was a good or decent speaker, which would have been a more informative answer. This presumption operates on two paradigms: it avoids the reasoning from best explanation applied to all the possible explanations for B's answer, and it opens the paradigm of all the possible more informative answers B could have given. The conclusion is therefore the whole negated paradigm of positive judgments that could have been made on the speaker's performance. We can represent this kind of reasoning as shown in figure 4.
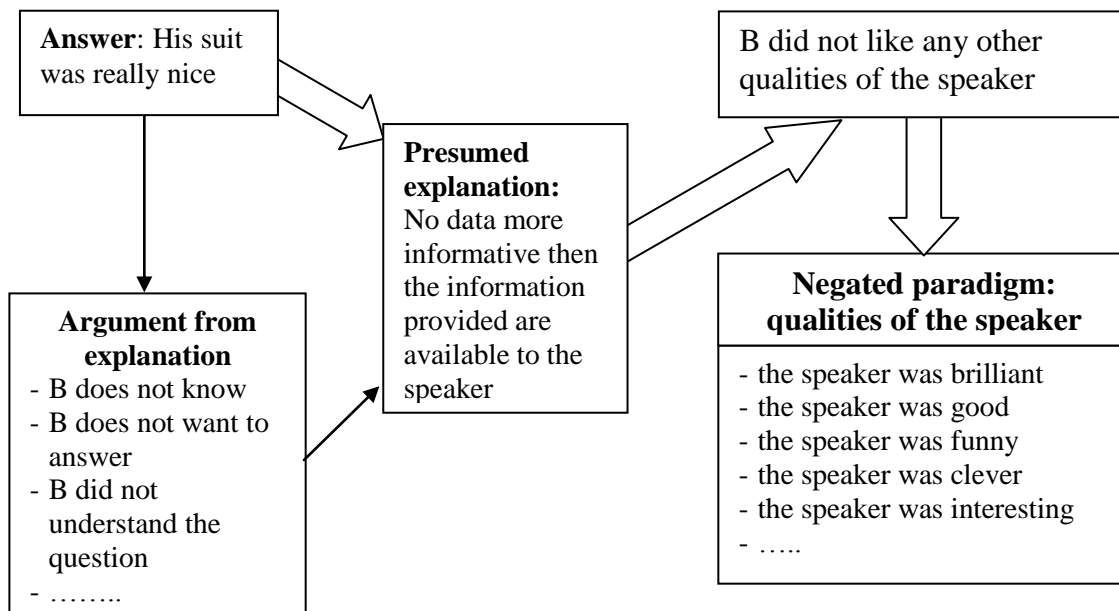
Figure 4: A presumption opening a paradigm

The same principle applies in case 7, where the same presumption of quantity leads to a conclusion that represents the negation of all the other possible teaching qualities of the student.

The relation between presumption and paradigms can help explain a particular case of pragmatic implicatures. Scalar paradigms elicit particular types of implicatures when one extreme is negated. For instance, the negation of 'freezing' in the sentence 'it is not freezing today' implies that the temperature is cold, but not too much. By denying 'cold', the conclusion 'It is mild today' can be drawn. Ducrot (1980) explained this phenomenon by using scalar predicates, as may be illustrated in figure 5.
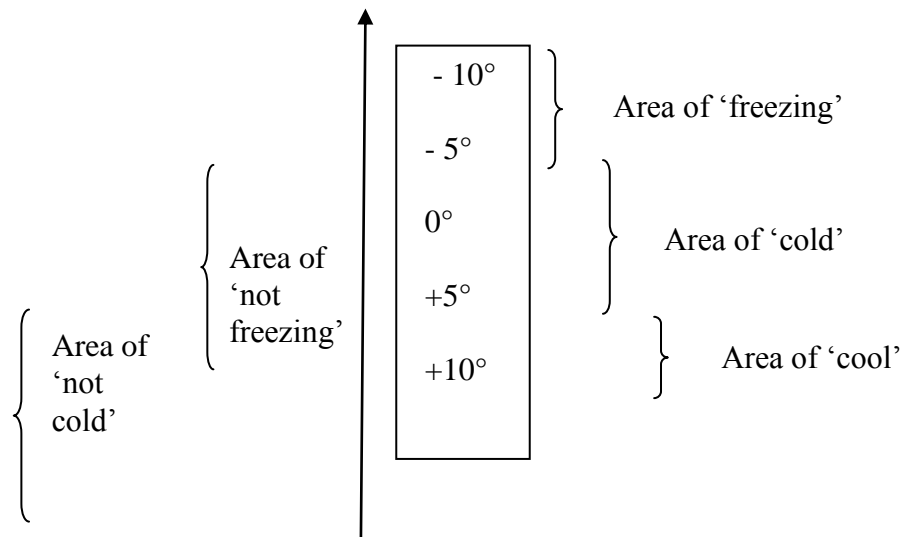
Figure 5: A scalar paradigm eliciting an implicature

Scalar predicates, such as 'cold' or 'beautiful', are lower-bound when negated; the negation implicates the affirmation of a paradigm of elements ranked on the scale just below the negated item. For instance, 'not freezing' implicates that it is cold or even cool (even though it rarely implicates that it is mild or warm), while 'not cold' usually implicates that it is cool or mild. On our analysis, the negation of an element opens a paradigm of possible explanations. For instance, 'not freezing' can be explained in different fashions: it is not freezing because it is hot, or cold, or mild, or warm, etc.

However, a whole paradigm is not conversationally informative, especially when the speaker could have used a positive statement to express the atmospheric condition more precisely. Therefore, an explanation for such a failure to be informative needs to be found. If we analyze the sentence 'It is not freezing (or cold) today' we notice that it is usually positively evaluated, as the predicates 'freezing' or 'cold' are commonly considered as negative. The inference 'What a pity: it is not cold today.' would be reasonable only in some specific contexts in which the values commonly associated to 'cold' and 'mild' are inverted. What 'not freezing' or 'not cold' usually implicate is that the temperature is 'cold' or 'cool or mild', but such a use of 'cold' or 'mild' is to be considered as positive, instead of negative or neutral. 'Not freezing' therefore is not simply 'cold'; it would be simpler and more informative just to use 'cold' instead. 'Not freezing' needs to be explained finding the only meaning no other predicates can express, namely 'It is positive that it is less than freezing'. This chain of reasoning is shown in figure 6.
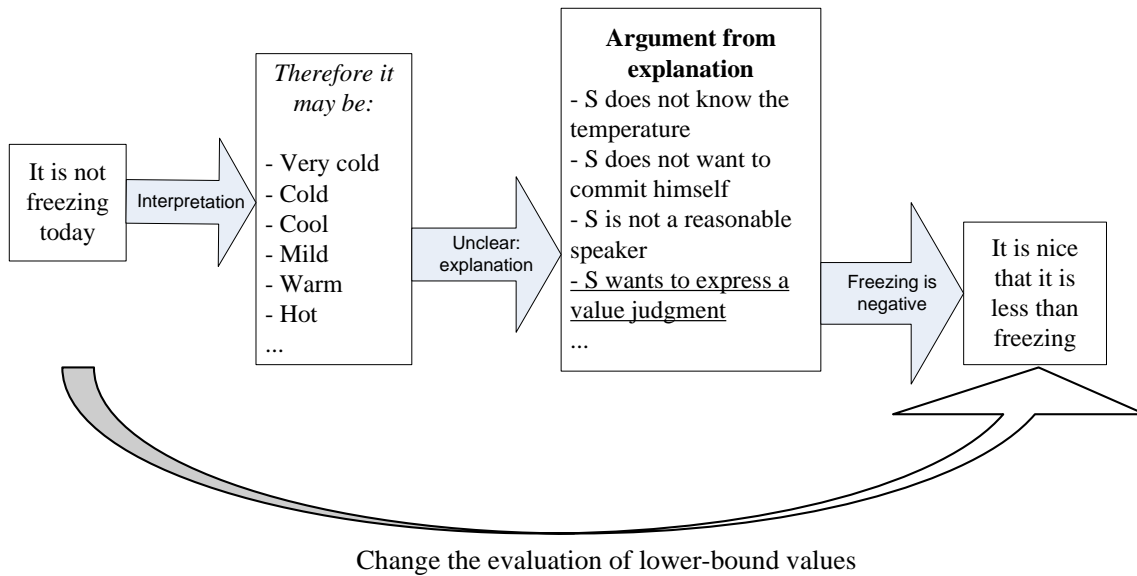
Figure 6: Reasoning by finding a failure to be informative

Also in this case, the negation triggers a pattern of reasoning from explanation, which is simplified by a presumption establishing that the negation of a scalar predicate subject to an evaluation is presumed to change the value judgment of a lower-bound predicate similarly evaluated. Such a presumption bypasses a long chain of reasoning from negative evidence, in which all alternatives are compared and evaluated.

7. Conclusions

We have proved eight conclusions about reasoning from negative evidence using these case studies. The first is that argumentation from negative evidence is an inherently defeasible type of argumentation. The second is that it needs to be evaluated on a basis of burden of proof in an investigation. The third is that reasoning from lack of evidence needs to be analyzed and evaluated by bringing the concepts of paradigm and negation to bear. The fourth is that during the evaluation process every element needs to be conceived as within a paradigm of alternative choices fulfilling the same function. The fifth is that in this process, the choice of an element results in the negation of the other alternatives of the paradigm, while the negation of an element opens up the paradigm.

The sixth conclusion we demonstrated is that the strength of the negation of all possible alternatives depends on the completeness of the "world", or rather paradigm, considered. For instance, if we want to conclude from the fact that Bob has not been sent go to the pub or a restaurant that he is at home, the world, or paradigm of possibilities considered is incomplete and open, unless such two actions are the only two possible outdoor actions he can perform. Our seventh conclusion is that the strength of the inference depends on how the arguer defines his conclusion and what he considers to be in the paradigm of negated alternatives. For example, let's suppose that, "going out" means "to take part in social life outside the home", and therefore includes visiting friends, going to the theatre, etc. If we negate only two of the several possible alternatives, even if they are the most probable, the conclusion will be weak. However, if

we deny all possible alternatives, such reasoning will be strong and in some cases deductively valid. The most significant aspect of reasoning from alternatives is its dependence on how we define the genus, or generic property, of the paradigm. Our eighth conclusion is that this aspect is part of the method required to evaluate arguments based on negative evidence. As we showed, modifying the definition of the property leads to re-evaluating the strength of the inference.

The linguistic elements of genus, definition and paradigm were therefore shown to be important parts of the method we used to understand the structure of the argumentation mechanism of reasoning from lack of evidence. Understanding this structure of reasoning sheds light on the linguistic analysis of pragmatic implicatures deriving from the negation of a predicate, such as from "it is not freezing cold today". In such cases, the implicatures can be seen as reasoning processes that depend on a prior process of interpretation in which there is a dialogue interchange explaining ambiguous and unclear sentences.

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