Chapter 1

Argumentation and Abduction in Dialogical Logic

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Abstract

This paper advocates for a reconciliation of argumentation theory and formal logic in an agent-centered theory of reasoning; that is, a theory in which inferences are studied as human activities. First, arguments in favor of a divorce between the two fields are presented. Those arguments are not so controversial. However, rather than forcing a radical separation, they urge logicians to rethink the object of their studies. Arguments

cannot be analyzed as objects independent from human activity, whether it is dealt with deductive or non-deductive reasoning. The present analysis naturally takes place in the context of dialogical logic in which the proof process and the semantics are conceived in terms of argumentative games, which involve the agents, their commitments and their actions. The present work focuses first on deductive reasoning and then takes abduction as a case of non-deductive reasoning. By relying on some relevant ideas of the Gabbay-Woods (GW) schema of abduction and Aliseda's approach, a new dialogical explanation of abduction in terms of *concession-problem* is proposed. This notion of *concession-problem* will be defined thereafter. With respect to the topics of the model-based sciences, the question of the specificity of the speech act by means of which a hypothesis is conjectured is set more specifically.

1.1 Reasoning as a Human Activity

In this paper, it is argued against the radical dissociation of formal logic and argumentation advocated by Toulmin [1] and Perelmann and Olbrechts-Tyteca [2]. It is proposed to bring formal logic and argumentation together in the field of dialectical interaction in which the *human being* and the *action* of the agent are given a central role. In this contribution, it is thus advocated a unified theory of reasoning, the key concept of which is not something as a "universal logic" but rather the notion of *commitment*; that is, what a speaker is ready to defend on uttering a sentence or in making use of a particular argument. Indeed, from the perspective of dialectical interactions, the crucial question is: "What are we committed to when we utter a sentence in a dialectical interaction?" In other words, when an agent perfoms a claim, it is never for free, and further justifications may be demanded for by the speaker's argumentative partners. The commitment to providing further justifications precisely constitutes the ground in order to distinguish between various kinds of speech acts relevant for the specification of different forms of reasonings. The present study takes place within the dialogical framework in which the proof is conceived in terms of a dialectical process. The specificity of deductive and abductive reasonings is clarified by identifying different kinds of speech acts specific to each of these forms of reasoning. The aim is to show that abductive dialogues involve specific speech acts, namely certain conjectural claims that differ from usual assertions and questions of deductive dialogues. A more exhaustive study of commitment and its role in the definition of different kinds of speech acts in dialogical interaction can also be found in Walton and Krabbe [3]. However, the present study focuses here on some aspects of commitment related to assertions and questions in deductive dialogues and considers how to extend the picture to abductive dialogues. The context of this study is first explained. In order to defend a practical logic to study the fallacies, Woods [4] identifies what he calls *third-way reasoning*, which operates beyond the usual standards of deduction and induction. According to Woods, logicians have missed the target concerning the study of fallacies because they have failed to invoke the right standards of reasoning. The mistake is linked to an ostracism with respect to the human being when the task should be to describe reasoning. Indeed, in most logical studies of reasoning, the human being has simply been left out of the story! In Woods' own words, "there are no people in the models of mainstream mathematical logic" ([4], p. 12).

Toulmin [1] also reports that logicians left out the human being while they were modeling reasoning. As a solution, he urges for the divorce between logic and argumentation by claiming that logic was too narrow to study argumentation. Toulmin was right in thinking that formal logicians had forgotten the human being. He was wrong in thinking that the solution was to dissociate logic and argumentation. Independently of how some logicians might have led their investigations, the point of view endorsed in this paper is that an agent-centered logic (that is, a logic built around human activity) is possible. Logic and argumentation should again be brought together. Human beings play a fundamental role in third-way reasoning as well as in deductive reasoning.

A study centered on the role of the agent constitutes the condition of possibility of a unified theory of reasoning, that is, a theory in which logic and argumentation are analyzed together. What is to be considered is not a mere relation of consequence-having but a relation of consequence-drawing. As stressed by Woods [4], while the former is a mere relation between propositions, the latter is to be linked with agent-based inferences, that is, actions by means of which an agent draws conclusions. The latter is the basis of what has been called an "agent-centered logic". The position defended in this chapter, which is perhaps stronger than that of Woods, is that focusing on a consequence-having relation is also a mistake with respect to deductive reasoning. Reasoning in general must be studied in a general framework in which particular attention is paid to the action of the agents and their commitments.

More precisely, it is argued that deductive as well as non-deductive reasoning should be understood within argumentative practices, taking into account the interaction between agents. This can be achieved by means of dialogical logic, a semantics based on argumentative practices and presented as a game between a proponent of a thesis and an opponent to this thesis. More precisely, dialogical logic is grounded on speech acts and commitments related to these speech acts. That is, a dialogue is a sequence of speech acts, questions and assertions, in order to justify or challenge an initial thesis. Moreover, utterances are not free of further justifications: when we utter something, we are committed to providing justification of what we are saying. This is the basis of the rules which say how to challenge and how to defend an utterance. Deductive validity is thus conceived in terms of strategy by means of which a proponent of a thesis defends her initial claim against every attack of her opponent.

However, this is just deduction! Is it possible to generalize the picture to non-deductive reasoning? To answer this question, abductive reasoning will be considered as a case of non-deductive reasoning. A relevant conceptual question is therefore the following: What is the difference and the specificity of abduction with respect to other inference kinds? If it makes sense to talk about abduction as a third kind of inference, it is because it is neither a deductive nor an inductive inference.

According to Gabbay and Woods ([5], p. 192), "[w]hereas deduction is truth-preserving and induction is probability-enhancing, abduction is ignorance-preserving". An abduction is triggered by an ignorance-problem that arises when a fact cannot be explained by the current knowledge of an agent. The inability to solve an ignorance-problem is a cause of discomfort, which Gabbay and Woods ([5], p. 190) call a "cognitive-irritant". Such an unpleasant situation is sometimes overcome by conjecturing a hypothesis on the basis of which further actions are made possible. Even if such a conjecture allows the agent to overcome the irritant situation, it does not constitute a solution to the ignorance-problem: it is only a defeasible hypothesis. This precisely grasps the specificity of abduction.

Rather than an explanation in terms of "ignorance-problem", the specificity of abduction is set from a dialogical perspective in terms of *concession-problem*. A *concession-problem* is overcome by a conjecture on the basis of which the dialogue is continued. In contrast with the usual deductive dialogues, such a conjecture is settled in a new kind of move allowed by an additional rule. The difficulty is thus to specify which kind of speech act is at stake while performing such conjectural moves. Indeed, under the view endorsed in this paper, conjectural moves are performed by means of speech acts which are neither assertions nor questions of usual deductive dialogues.

Reasons why Toulmin argues in favor of a radical separation between formal logic and argumentation are given in the first section. Although it is true that some aspects of argumentation such as the role of the agent, the dynamic of the contexts, and the defeasibility are to be taken into account, it is not a reason to conclude that formal logic and argumentation should be studied separately. First, it is not true that those aspects are completely missing in formal logic. It is shown in the rest of this section that numerous formal logics deal with these aspects, although they have yet to be brought all together. Second, in the present contribution, it is thought that even deduction is to be understood within argumentative practices. Hence the dialogical framework is introduced in the third section, where it is come back to the key concept of commitment. It is also shown how dialogical logic enables to grasp the central role of the agent as well as the dynamics of the contexts in terms of a pluralist attitude. After having presented abductive reasoning in the fourth section, the scene for a dialogical understanding of abduction is set in the fifth section. All the details of dialogical pluralism, dynamics of contexts and dialogical defeasibility cannot be given here. However, the relevant related works on each of these points will be systematically mentioned.

1.2 Logic and Argumentation: the Divorce

Heavy criticism against the fomal logic approach to natural human reasoning has been raised by theoreticians of argumentation who have stressed the importance of the context, the plausibility and the defeasibility of arguments, the commitments and the actions of the agents, and so on. Some of the most virulent of these theoreticians were perhaps Toulmin [1] (see also [6] for recent studies about Toulmin Model) and Perelmann and Olbrechts-Tyteca [2]. The present chapter focuses on Toulmin, who defined a model of argumentation based on the analysis of micro-arguments. This model will be called the “Toulmin Model” of argumentation whose general idea is that some data leads to the claim (or conclusion). The data is supported by a warrant. The whole process is qualified by an adverb such as "plausibly", "probably", or "necessarily", that may be rebutted. An important insight of Toulmin's work was to emphasize the role of the agent and the persuasive feature of argument. Arguments are used to persuade someone to believe something. An agent puts forward an argument in order to defend a thesis and the inferences are defeasible, that is, they might be rebutted when new information is encountered. Schematically, the Toulmin Model may be represented as in Figure 1.1.

This schema represents the process that consists in defending a claim against a challenger. First, the agent asserts a *Claim* (C) and then defends this claim by appealing to relevant available facts, the so-called *Data* (D). Next, the challenger may ask for the bearing of the data and this is exactly what is called the *Warrant* (W). The warrant influences the degree of force on the conclusion it justifies and this is signaled by the qualifying of the conclusion with the *Qualifier* (Q): "necessarily", "probably", or "presumably". The qualifier "presumably" renders the argument defeasible, and the condition of *Rebuttal* (R) should be specified. The process ends in a question that consists in asking what is thought about the general acceptability of the argument: what Toulmin calls *Backing* (B). In different fields, warrant and backing might be of different kinds.

According to the Toulmin Model, an argument is assumed to be used by a practical agent. Inferences are not conceived in terms of the relationship between propositions independant from any act. And the act of inferring is linked with the agent who expresses a claim, by means of which a commitment to a thesis is in fact expressed. The underlying methodological thesis is that the study of reasoning must be related to real-life reasoning. This kind of reasoning is never perfect (as in an ideal model of formal logic) because we have never all the information needed to defend a claim and we might always find a rebuttal that changes it. Hence, the right standard of a good argument cannot be the deductive standard of validity. An argument succeeds or fails only in relation to an agent's target. Toulmin's schema enriches the traditional premises-conclusion relationship of the deductive reasoning model of arguments by distinguishing additional elements, such as warrant, backing and rebuttal. It is an interesting fact that the Toulmin Model and argumentation theory call up not only the matter of the burden of proof, but also the matter of the burden of questioning, which is of importance for the beginning of the process. A consequence of this action- and agent-centered analysis is that an account of the defeasibility of reasoning is now required. The fact that none of these features appeared in formal logic constituted the core of Toulmin's criticism, that led him to consider argumentation theory and formal logic as radically different disciplines.

There is nothing really controversial in Toulmin's critics of formal logic or in his model of argumentation. Nevertheless,following van Benthem [7], in this paper, it is believed him to be wrong in pronouncing the divorce of argumentation theory and formal logic. Indeed, it might be true that classical formal logic is insufficient to deal with reasoning as a human activity. Classical formal logic is not the only way to do logic, however. Although Toulmin's work has the virtue of emphasizing the role of human being, the defeasible feature of everyday life reasoning, and the dynamic of argumentative contexts, it is worth noting that those features were not completely lacking in formal logic. With respect to the agent, intuitionism initiated by the Dutch mathematician Brouwer [8] is motivated by the need of taking the importance of the agent into account. More recently, agent-centered dialogical logic initiated by Lorenzen [9, 10] conceives the notion of proof itself in terms of interactions between agents. It remains true that further efforts are still required to deal with non-deductive reasoning. Before pronouncing the divorce between logic and argumentation theory, it should be recognized that many logicians had already widened the range of argumentative schemas in formal logic, by adding the agent, thinking otherwise the premises-conclusion relation, and defining several kinds of consequence relations.

Certain cognate aspects of reasoning must be grasped. For example, inference is a process which involves a flow of information, changes of belief, knowledge or even desires. Logicians have to take the "Dynamic Turn", in the words of Gochet [11]. That is why the agent has sometimes been introduced explicitly in the object language in order to express intentional relations by means of specific operators. The enterprise does not always head in the same direction as an agent-centered analysis (in fact it almost never goes in that direction) but the enterprise does provide new tools on how to implement the agent in the study of reasoning. Hintikka's explicit epistemic logic [12], and more recently Priest's intentional logic [13], among others, define useful tools to describe the intentional states of an agent. In addition, dynamic approaches, such as the AGM-Belief Revision Theory ([14] and see introductory chapter of this section), are meant to give an account of how to incorporate new pieces of beliefs into an agent's belief set, conceived as a set of sentences. In the same spirit, dynamic studies coming from natural language semantics [15, 16, 17, 18] and dynamic epistemic logic [19, 17, 18] add operators to deal with the flow of information and the transmission of information between groups of agents. The study of dynamic inferences is not restricted to model theory and to the change in information. From a pluralistic point of view, a change of logic might occur with respect to a given context of argumentation. For example, dialogical logic is a pluralist enterprise in which the context of argumentation is defined by means of rules governing the general organization of a dialectical game (more precision on this point below). Although this fails to provide Toulmin with an answer to each critic he addresses on formal logic, it does reveal how formal studies are sufficiently rich to consider the possibility of a more practical logic in which reasoning is conceived as a human activity.

Another aspect of argumentation stressed by

Toulmin is the imperfect feature of human reasoning, which he deals with by means of the notion of "rebuttal". Thinking of reasoning as defeasible means that an agent never draws conclusions definitively, that is, whatever she infers from a given base of information might be revised when faced with new information. In other words, the conclusions drawn by an agent might be defeated. It is worth noting that defeasibility does not need to be studied in the context of non-monotonic logics. If non-monontonic reasoning is defeasible, the converse does not hold. Interesting ways of defeasible cases come from the context [20]. What characterizes defeasible resoning is the possibility to defeat, or to change a previously drawn consequence. Again, this feature cannot be claimed to be completely missing in formal logic. Indeed, defeasible reasoning has been studied from various perspectives [21]. As already mentioned, one well-known approach is the epistemic approach such as that in the context of Belief Revision Theory. The formal epistemology of Pollock [22], who differentiates between fundamental knowledge and inferred knowledges, provides another example. In this theory, inferred knowledge is precisely a knowledge which might be defeated. Another approach is centered on the notion of logical consequence, that is, dealing with defeasibility in the context of non-monotonic logics (see introductory chapter of this section). Some of the most important proposals are Default Logic by Reiter [23] and Circumscription by McCarthy [24]. In both of these frameworks, the conclusion follows defeasibly or non-monotonically from a set of premises, just in the case that it will hold in almost all models that verify the premises. (For a relevant survey, see for example [25, 26, 27]. See also the third-way reasoning in [4].) It is also important to mention Batens' adaptive logic [28], a formal logic in which the application of inference rules may be subject to conditions with respect to the context of the proof (for example in the context of contradictory premises, disjunctive syllogism might be rejected).

The three main aspects of the Toulmin Model of argumentation that have been highlighted are the central role of the agent, the dynamics related to the action and changes of contexts, and defeasibility. In what follows, it will be argued for a reconciliation of formal logic and argumentation, and deduction will be also defined in argumentative practices. Notice that it is not the purpose of this paper to deal exhaustively with all the relevant aspects of argumentation. Indeed, every facet of the dialogical pluralism (although the general principles are explained and relevant related works are mentioned) or defeasible reasoning cannot be presented here. The designation "Defeasible Reasoning" gathers together aspects of default logic, non-monotonic logics, truth maintenance systems, defeasible inheritance logics, autoepistemic logics, circumscription logics, logic programming systems, preferential reasoning logics, abductive logics, theory revision logics, belief change logics, and so on. In fact, all of this relates to what is called by Woods the *third-way reasoning* [4]. Various systematic approaches to defeasible argumentation that make use of formal tools originating from computational sciences and artificial intelligence can be found in [29].

The main thesis of this contribution is that a unified study of reasoning may be achieved by focusing on the key notion of commitment in argumentative interaction. Indeed, this notion forms the basis for a distinction between various kinds of speech acts that are significant for the specification of different kinds of reasonings, such as deduction and abduction.

1.3 Logic and Argumentation: A Reconciliation

It is true that a study of logic that is not centered on human activity is not sufficient to deal with reasoning in general. However, it is a mistake to conclude that the divorce between argumentation and logic is to be pronounced. Logic and argumentation must be brought together within a general framework in which a consequence-drawing relation, conceived as a human practice, is taken into account, and not a consequence-having relation conceived as a mere calculus between propositions. In the rest of this section, deduction is modeled inside an argumentation theory and the standard (deductive) dialogical logic is defined by giving the rules for the propositional level.

1.3.1 What is Dialogical Logic?

The dialogical logic referred to in this paper has its roots in the works of Lorenzen and Lorenz [10], and more recently in Rahman [30] and his collaborators (see for example Rahman and Keiff [31], Fontaine and Redmond [32], and Clerbout [33]). Different works on dialogical logic have also been developed by Elsa Barth and Eric Krabbe [34, 35], among others, and by the Pragma-dialecticians from an informal point of view [36, 37].

Dialogical logic is considered to be an alternative semantics, that is neither a model-theoretic semantics nor a proof-theoretic semantics, and is grounded in the argumentative practices. It is a semantics based on the "meaning is use" of Wittgenstein ([38], p.43) and the description of specific language games governed by the rules defined below. Although it was first developed to deal with intuitionist logic, it has since taken a pluralist turn. Indeed, different kinds of rules enable a sharp distinction between different semantic levels and this enables the definition of a wider range of logics in a unified framework.

Roughly speaking, dialogical logic is a framework in which the proof process is conceived as a dialectical game between two players: the *Proponent* of a thesis and the *Opponent*. The Proponent utters an initial thesis and tries to defend it against challenges performed by the Opponent, who criticizes the thesis. The two players make moves alternately. Those moves consist of specific speech acts by means of which they perform challenges and defences. A thesis is valid if and only if the Proponent is able to defend it against every attack of the Opponent. In order to criticize an assertion of her argumentation partner, a move in which a formula has been uttered has to be challenged with respect to its main connective. Such sequences of utterances, challenges and defences are regulated by the particle rules by means of which the local meaning of the logical constant is given. In addition, structural rules give the general organization of the dialogue and determine the global level of semantics. In fact, these structural rules dictate how the particle rules may be applied and allow to define different games for different contexts of argumentation, for different underlying logics. In the following sections, the particle rules are given, then the structural rules, and finally, the notion of winning-strategy which is necessary for the definition of the dialogical notion of validity is presented.

1.3.2 Particle rules

In a dialogical games, moves are of two different kinds: challenges and defences (plus the utterance of the initial thesis as a special move), and are performed by means of two kinds of speech acts: assertive utterances and interrogative utterances. Notice that challenges are not necessarily performed by means of interrogative utterances (as shown later below). An utterance is challenged with respect to its main connective. How to challenge and how to defend an utterance is prescribed by the particle rules, which therefore give the local meaning of logical constants. More precisely, particle rules are abstract descriptions of how an assertion may be challenged and defended with respect to its main connective. They are abstract because they are not related to any specific context of argumentation and are defined independently of the identity of **P** and **O** (hence they are defined making use of player variables **X** and **Y**). It is fundamental that when agents perform utterances, they are committed to justify their claims. This commitment is essential in the characterization of different kinds of speech acts and in giving the meaning of what is said.

The language used to define the rules of dialogical logic is defined as follows. Let L be the language of standard propositional logic:

- Two labels, **O** and **P**, stand for the players of the game: the Opponent and the Proponent, respectively.
- To define particle rules, variables **X** and **Y** are required, with $\mathbf{X} \neq \mathbf{Y}$, that hold for players (regardless of their identity with **O** or **P**).
- Force symbols, ! and ?, are used to specify the kind of speech act at stake: ! for declarative utterances, and ? for interrogative utterances.
- The conjunction can be indexed yielding $\wedge_i$, where $i \in \{1, 2\}$, such that $\wedge_1$ stands for the first conjunct, and $\wedge_2$ the second.
- $r := n$ indicates the rank chosen by the player at the begining of a dialogue, as pointed out by the rule **[SR0]**. For example, $n := 1$ means that the rank is 1. (The notion of rank is explained and defined in the next subsection of this paper.)

A *move* is an expression of the form X- f -e where **X** is a player variable, f a force symbol and e is either a well-formed formula of L or a question of the form $?\vee$ or $?\wedge_i$. Notice that the dash "$-$" has no meaning, it is used only in order to distinguish in a clear way the element of a dialogical expression. A sequence of such moves will be called a *play*, and a sequence of plays a (dialogical) *game*.

Particle rules (See Figure 1.2) are abstract descriptions that consist of sequences of moves such that the first member of the sequence is an assertive utterance, the second says how to challenge that utterance with respect to its main connective, and the third says how to answer the challenge.

Rules are *abstract descriptions* that are formulated by making use of variables **X** and **Y** (and not **O** and **P**). They are independent of any specific context of argumentation. They are the same no matter the presupposed logic and are applied in the same way by both players. The formulation of particle rules is symmetric.

Symmetry is an essential feature of dialogical particle rules and this is the reason why dialogical logic is immune to trivializing connectives such as Prior's tonk [39], even if there is no reference to any model or to any truth-condition. Rahman, Clerbout and Keiff [40] and Rahman [41] show that defining a rule for a tonk operator would lead to a formulation of particle rule which is not symmetric. This would involve player-dependent rules, which is not possible in dialogical logic because, at the local level, the identity of the players has not been yet defined. As rightly stressed by Clerbout [33], it does not even make sense to talk of Opponent and Proponent at the local level. Indeed, the identity of the players is defined at the level of structural rules, when it is said, for example, that the Proponent is the player who utters the initial thesis.

Notice how commitment is essential to the meaning of an assertion. An agent, on uttering a conjunction, is committed to give a justification for both of the conjuncts. Hence the challenger has the choice of which subformula to defend. That is, if **X** utters $\varphi \wedge \psi$, **Y** challenges this move by asking either $?\wedge_1$ (the first conjunct) or $?\wedge_2$ (the second conjunct). In the case of a disjunction, it is the defender (**X**) who chooses. Indeed, an agent uttering a disjunction is committed to give a justification for (at least) one of the disjuncts, that is, **Y** asks $?\vee$ and **X** chooses to answer either φ or ψ.

Notice that a challenge on a negation cannot be answered. The challenge consists in a switch in the burden of the proof: if a player **X** utters a formula $\neg\varphi$, a player **Y** challenges that formula uttering φ and has to defend it thereafter. For the conditional, **Y** takes the burden of the proof of the antecedent. It might be said that when an agent **X** utters a conditional $\varphi \rightarrow \psi$, then **X** is committed to justifyng ψ with the proviso that the argumentation partner **Y** concedes φ.

1.3.3 Structural rules

Now structural rules are neded in order to define the general organization of a dialogue by explaining how to apply the particle rules, that is, how to start a dialogue, who has to play, when, who wins, and so on. The global level of meaning is defined by these rules, that is, a level of meaning that arises from the application of the particle rules in specific contexts of argumentation.

[SR0][Starting Rule] Let φ be a complex formula. Every dialogical game $D(\varphi)$ starts with the assertion of φ by **P** (φ is called the *initial thesis*). **O** and **P** then choose a positive integer called *repetition rank*.

[SR1-c][Classical Gameplay Rule] After the ranks have been chosen, moves are alternately performed by **O** and **P** and every move is either a challenge or a defence. Let n be the repetition rank of a player X: When it is X's turn to play, X can challenge a preceding utterance or defend herself against a preceding challenge at most n times by the application of particle rules.

[SR1-i][Intuitionistic Gameplay Rule] After the ranks have been chosen, moves are alternately performed by **O** and **P** and every move is either a challenge or a defence. Let n be the repetition rank of a player X: When it is X's turn to play, X can challenge a preceding utterance or defend herself against *the last challenge which has not yet been defended*, at most n times by the application of particle rules.

[SR2][Formal Rule] **P** is not allowed to utter an atomic formula unless **O** uttered the same atomic formula before. Atomic formulae cannot be challenged.

[SR3][Winning Rule] A player **X** wins the game if and only if the game is finished and **X** made the last move. It is said that a game is finished if and only if there are no more moves allowed according to the particle rules.

The first rule **[SR0]** sets the identity of the players by claiming that the Proponent is the one who utters the initial thesis and introduces asymmetry. Once the initial thesis is uttered, the players have to choose a rank of repetition. That rank of repetition prevents them from infinitely repeating the same moves. In fact, they indicate how many times a player can challenge or defend a formula. For example, if a player choses rank 1, then this player is allowed to challenge a formula at most once. Ranks are used to ensure that every game ends after a finite number of moves. Rules **[SR1-c]** and **[SR1-i]** regulate the gameplay and distinguish classical from intuitionistic games. Notice that a game is never played with both of them. The classical rule **[SR1-c]** does not impose any restriction with respect to the defences. While playing with the intuitionistic rule **[SR1-i]**, it is forbidden to defend the same move twice or to give a defence against a challenge that is not the last one. This is related to the intuitionistic requirement of having a direct justification for the uttered formula.

The formal rule, **[SR2]**, might be understood as a rule that prevents the Proponent from making any supposition which might be used to win. Without that rule, dialogues would be trivial and the Proponent would always be in a situation to win. Finally, the winning rule, **[SR3]**, gives the conditions of victory.

1.3.4 Winning-Strategy and Validity

Hitherto, nothing has been said about the notion of validity. In dialogical logic, validity is not defined in terms of truth-preservation but rather in terms of winning-strategy. It is said that a player has a winning-strategy if and only if she is able to win regardless of the moves and the choices made by her argumentation partners. This leads to the strategic level which is not involved at the level of particle and structural rules. Indeed, nothing in those rules indicate how to play strategically and in no way do they indicate how to win; neither do they prevent anybody from playing badly. Notice then that it is not one play of the game which is to be taken into account to determinate the validity of a formula: The validity of a formula is determined by the existence of a winning-strategy.

Now, it is reasonable to ask whether a generally "good" strategy exists. First a comment about the choice of rank. As explained by Clerbout [42, 33], it is sufficient to consider the case in which the Opponent chooses rank 1 and the Proponent rank 2 in order to obtain a significant range of winning strategies to deal with deductive validity. Second, trained dialogicians know in fact that the best way to play is always to let the Opponent choose first when it is possible and thereafter to repeat the same choices. This is the well-known "copy-cat" strategy based on a clever use of the formal rule.

An illustration of a dialogue is given in Figure 1.3 by taking the elimination of double negation principle $\neg\neg p \rightarrow p$ as an example. In the table below, the moves of the players are written down in the column **O** for the **O**-moves, and in the column **P** for the **P**-moves. The number of a move is indicated in the outer column whereas those of the challenges moves are indicated in the inner columns. The game runs by applying the classical rule **[SR1-c]**.

At move 0, **P** states the initial thesis. At move 1, **O** chooses rank 1 and **P** chooses rank 2. At move 3, **O** challenges the initial thesis uttering the antecedent of the conditional, namely $\neg\neg p$. **P** cannot answer immediately by giving the consequent p because **P** cannot utter an atomic formula. Therefore, at move 4, **P** challenges the double negation $\neg\neg p$ by uttering $\neg p$. No defence is allowed and **O** has to counter-attack by uttering p. **P** uses that concession to answer to the attack 3 at move 6. Again, **P** wins. However, this game has been played with classical rule **[SR1-c]**. If it had been played with the intuitionistic rule **[SR1-i]**, **P** would have lost. **P** could not have performed move 6 because the last challenge of **O** is 5, not 3 (see **[SR2]**). Thus the dialogue would have ended at move 5 with a victory by **O**.

These two different possible gameplays illustrate the difference between classical and intuitionistic negation. Quine's claim "change of logic, change of subject" ([43], pp. 80-94) must be thought otherwise. Indeed, the dialogical setting displays that negation has the same local meaning in every logic, and its global meaning is changing according to its use in different contexts of argumentation. Both of the semantic levels are significant in fully defining the meaning of an expression.

Beyond the classical and intuitionistic logics, the sharp distinction between the particle rules and the structural rules allows a development of dialogical logic as a pluralistic tool. The pluralistic aspect of dialogical logic allows to deal with various kinds of argumentation contexts and their dynamics, the importance of which has been stressed by argumentation theoreticians. Indeed, more expressive languages may be introduced by means of the introduction of new symbols, the (local) meaning of which will be given by a particle rule. A language may be used in different contexts of argumentation, with various underlying logics. Dialogically, this means that a language may be used in different kinds of games distinguished by their structural rules.

As stated before, it is not the purpose of this contribution to present all the varieties of dialogical logics which nevertheless should be taken into account in order to deal with the contextual aspect of argumentation. More details on first-order dialogical logic are to be found in Clerbout [42]. With different structural rules it is also possible to define a dialogical free logics as in Rahman et al. [44], Fontaine and Redmond's paper in [45] and an application to the logic of fiction is to be found in Fontaine [46]. For the introduction of modal operators (and explicit contexts of argumentation) and their use in different modal frames, see [47] and [31].

1.4 Beyond Deductive Inference: Abduction

Within dialogical logic, an analysis of the relation of consequence-drawing in terms of argumentative games in which the action of the agents and their interactions are taken into account has been proposed. Until now, it has been focused on deductive reasoning. However, if the aim is to bring together logic and argumentation, it is necessary to extend the dialogical approach to non-deductive reasoning. This is performed by taking abduction as a case of non-deductive reasoning. After having defined the conception of abduction that will be defended here, the basis for abductive dialogues will be described. While relying on existing proposals in this field, the aim is to offer a new and different understanding of abduction in the context of a dialogical interaction.

As explained by Magnani [48], the "knowledge assimilation theory" of Kowalski [49], in which the assimilation of new information into a knowledge-base is described, might explain the role of the agent in abdudction in terms of the generation of hypotheses. Aliseda also explores an epistemic study of abduction in which a more important role would be given to the agent. She defines abduction in terms of epistemic changes in the context of Belief Revision Theory ([50], 179ff., see also introductory chapter of this section). The role of the agents might be strengthened by developing that approach in the context of dialogical logic, and more precisely in the context of the dialogical approach to belief revision of Fiutek [51]. In a similar way, Nepomuceno et al. ([52], see also chapter by Nepomuceno et al. in this section) define abduction in the context of dynamic epistemic logic and its public announcement operator. This might be dialogically understood on the basis of Magnier [53]. However, this is not the path followed in this contribution, because the agent would be introduced into the language and abduction would still be understood in terms of consequence-having relation, despite some kind of interaction in a dialogical reconstruction. Moreover, an epistemic understanding of abduction would lead to consider hypothetical *abductive solutions* as new pieces of knowledge; something that is not defended in this chapter, as clarified in the following.

Essentially, the challenge consists in explaining what is specific to abduction in a dialogue. As shown below, while studying abduction, the concepts of *abductive problem* and *abductive solution* are fundamental (see introductory chapter of this section). In order to define dialogues based on these concepts, a new kind of move performed by means of a specific type of speech act is needed. Therefore, the problem is to clarify this type of speech act and the rules which govern it. Again, the key question is related to commitment: What are we committed to when we state an *abductive problem* or an *abductive solution*? The purpose is to understand abduction in terms of consequence-drawing and to study the key step of such an inference in terms of interactions in relation to the question of commitment. Therefore, although there exists different approaches to abduction, in this chapter, the GW schema (following Gabbay and Woods [5]), in which a central role is given to the agent, constitutes a landmark. This contribution will also rely on Aliseda's insights [50] when a dialogical reconstruction of abduction is proposed, thereby benefitting from her clear and formal systematization of this kind of inference.

The GW model of abduction

What is characteristic to abduction and is not characteristic to other reasoning kinds, such as deduction and induction? When is an abduction triggered? Why does an agent begin an abductive process? How does an agent draw abductive conclusions and what is the (cognitive or epistemic) status of those conclusions? According to Gabbay and Woods [54, 5], and more recently Woods [4], abduction is first to be understood as an inference triggered by an ignorance-problem and, second, the relation between the premises and the conclusion is to be understood as an ignorance-preserving relation.

Abduction is an inference triggered in response to an ignorance-problem, in particular, there is an ignorance-problem when, with respect to a (surprising) fact or state of affairs, there is a question (a problem), Q, we cannot answer with our present knowledge. We assume that there is a sentence α such that if we knew it, it would help us to answer Q. With respect to such a Q, three situations are possible:

- Subduance, i.e. new knowledge removes ignorance (for example by discovering an empirical explanation);
- Surrender, i.e. we give up and do not look for an answer;
- Abduction, i.e. we set a hypothesis as a basis of new actions.

Abduction is thus an inference by means of which we do not solve the ignorance-problem, but we overcome it in a certain way by setting a hypothesis. This hypothesis can then be released in further reasoning, something which allows for specific kinds of actions. In Woods' words, abduction "is a response that offers the agent a reasoned basis for new action in the presence of that ignorance" ([4], p. 368). Therefore, what must be grasped here is that the conclusion of an abduction is not (necessarily) a true sentence or a new piece of knowledge; it is a hypothesis that can be used in further reasoning. The ignorance contained at the level of the premises is inherited by the conclusion. What is specific in the relation between premises and conclusions here is not a gain of knowledge, but rather an ignorance-preserving relation.

For reasons of clarity, the GW schema is formally presented following Woods' latest version in ([4], p. 369). Let T be an agent's epistemic state at a specific time, K the agent's knowledge-base at that time, $K*$ an immediate successor-base of K, R an attainment relation for T (that is, $R(K, T)$ means that the knowledge-base K

is sufficient to reach the target T), $\rightsquigarrow$ a symbol denoting the subjunctive conditional connective, for which no particular formal interpretation is assumed, and $K(H)$ the revision of K upon the addition of H. $C(H)$ denotes the conjecture of H and H^c its activation. Let $T!Q(\alpha)$ denote the setting of T as an epistemic target with respect to an unanswered question Q to which, if known, α would be the answer. According to the GW schema, the general structure of abduction is as follows:

1. $T!Q(\alpha)$
2. $\neg(R(K,T))$ [fact]
3. $\neg(R(K*,T))$ [fact]
4. $H \notin K$ [fact]
5. $H \notin K*$ [fact]
6. $\neg R(H,T)$ [fact]
7. $\neg R(K(H),T)$ [fact]
8. $H \rightsquigarrow R(K(H),T)$ [fact]
9. H meets further conditions $S_1, ..., S_n$ [fact]
10. Therefore, $C(H)$ [sub-conclusion, 1-7]
11. Therefore, H^c [conclusion,1-8]

The aim, here, is to characterize what is specific to abductive inference, by taking into account what triggers such an inference, and to describe the subsequent process. At the beginning, a cognitive target $T!Q(\alpha)$ is set (1): something we aim to reach in response to an ignorance-problem. The ignorance-problem triggers an abduction because it is a cognitive irritant; that is, it places us in an unpleasant situation of lack of knowledge which can be overcome by action and reasoning.

Step (2) $\neg(R(K,T))$ says that the current knowledge is insufficient to attain the cognitive target. This is essential if we face an ignorance-problem. Step (3), $\neg(R(K*,T))$, says that there is no immediate successor of K by means of which the target would be attained. This is a crucial step. If there were such a $K*$, we would just extend our knowledge by adding new information and would refrain from triggering anything such as an abduction. This would be subduance, that is, new knowledge would remove the initial ignorance.

If there is no K or $K*$ relating to the cognitive target, a hypothesis H is sought by the agent in order to set a plausible solution to the ignorance-problem. Such a hypothesis is not knowledge, it is a hypothesis. This is represented in steps (4) and (5). Since it is only a hypothesis, it cannot relate to the cognitive target either, because it is not a solution. Even combined with the knowledge-set, the cognitive-target is not attained. This is expressed in steps (6) and (7).

What is the purpose of the hypothesis H if it does not solve the problem? In step (8), it is settled as a hypothesis that *subjunctively* relates to the cognitive-target in combination with our knowledge-base. What does this mean that it *subjunctively* relates to the cognitive-target? This is how Gabbay and Woods understand Peirce's "hence" in the schema laid down by Peirce ([55], 5.189, see also introductory chapter of this section for the original formulation). It means that it is not a true sentence, it is not a piece of knowledge either, but if it were, it would give an acceptable solution to the cognitive problem. As in step (9), some additional conditions should be added for the acceptability of H.

Having set hypothesis H as a *subjunctive* solution of the cognitive problem, abduction first consists in concluding that we are right in conjecturing that hypothesis. This is the first subconclusion at step (10). $C(H)$ means that the hypothesis H is conjectured. It is important to notice here that abduction does not end at step (10). Indeed, by taking seriously the fact that abduction is triggered by a cognitive problem, we trigger an abduction not to conjecture a hypothesis, but in order to find a possibility of further actions despite the lack of knowledge. Therefore, the abduction should not end before step (11), that is, when the conjecture is released and when the hypothesis is used in further reasoning as a basis for new action. H^C represents the hypothesis released in a further reasoning; that is, in a reasoning in which we act on the hypothesis H and the superscript ^{C} indicates the conjectural origin of the hypothesis. Following Woods ([4], p.371) an inference that ends at step (10) will be called a *partial abduction*, and an inference continuing with step (11) a *full abduction*.

For the purpose of clarity, in step (10) we face two possibilities. First, we do not test the hypothesis but we use it in a further reasoning (as in step (11)). This is precisely what is called "full abduction". Second, we test the hypothesis, by empirical methods, for example. This presents us with three possibilities. First, the hypothesis is confirmed and we obtain a new piece of knowledge; this would lead to a situation similar to the $K*$ situation above. In this case, no full abduction is triggered; that is, we do not act on the hypothesis in an ignorance-preserving way. In fact, we would end with new knowledge and this is subduance, or hypothetico-deductive reasoning, induction or even a mix, but this is not abduction. Second, we do not have confirmation and give up on the hypothesis: again this would end in a partial abduction. Third, we do not have confirmation but we continue with the hypothesis and perform a full abduction.

This is what leads Woods [4] to claim that abduction should not be understood as an inference to the best explanation (that would consist of the first part of the abduction schema, with respect to certain aspects), but rather as an inference *from* the best explanation. That is, we opt for a hypothesis and make an inference by activating that hypothesis. The following example of daily reasoning illustrates this point :

Shahid and Ángel are in Mexico City at the *Barranca del Muerto* underground station (see figure 1.4). They want to go to a conference near *Universidad*. On their map, the new line (dotted line on the map) between *Mixcoac* and *Zapata* is missing. They do not know the existence of this line and decide to travel first to *Tacubaya*. During the trip to *Tacubaya*, they see a workmate disembarking the train at *Mixcoac*. They think their workmate will be late and they proceed to change in *Tacubaya*. There, they board another train to *Centro Médico* where they will change again to go to *Universidad*. When they arrive at the conference they are surprised to see their workmate already there. The fact to be disclosed is now that there is a faster way to go to *Universidad* which cannot be explained on the basis of the information contained on the incomplete map.

With respect to the previously detailed GW schema, step (1) $T!Q(\alpha)$ is such that Q is the question of knowing how their workmate might have arrived so early. The cognitive target T would be a situation in which an α is known such that α would be the answer to that question. With respect to step (2), their knowledge base is insufficient to answer the question because their map does not show any another way to reach *Universidad* $(\neg(R(K,T))$. In step (3), they receive no further knowledge (e.g. an updated map) to answer the question $(\neg(R(K*,T))$. There are three possibilities: First, they do not care and follow the same trip as the day before (surrender). Second, they search for more information and obtain an updated map in which the line between *Mixcoac* and *Universidad* appears (subduence). Notice that in this last case, no abduction is triggered, a new piece of information is added to the knowledge-base (such that the new knowledge-base $K*$ explains why the workmate went faster the day before - $R(K*,T)$). Third, they perform an abduction. That is, they conjecture the existence of the line and, therefore, they can leave half an hour later the following day. The existence of such a line is a hypothesis, H, and is such that $H \notin K$ (step (4)) and $H \notin K*$ (step (5)), and is not part of any knowledge-set. Therefore, step (6) holds because H is not an established fact and does not relate to the target $(\neg R(H,T))$. Moreover, step (7) also holds because even combined with their knowledge-base K, it does not relate to the cognitive target $(\neg R(K(H),T))$. Step (8) is crucial because H only subjunctively relates to the cognitive target; that is, the effective existence of another line might be such that, when added to the knowledge-base K, it would allow the cognitive target T to be reached. However, H is only a hypothesis and without further information, it does not constitute an α answer to Q that would relate to the cognitive target T. If H meets further conditions $(S_1, ..., S_n)$ it might be considered as a good or plausible explanation, perhaps the "best" one, as expressed in step (9), and that hypothesis would conjectured as in step (10) $(C(H))$. The following day, Sahid and Ángel stop at *Mixcoac* as if they knew the existence of this line, but in fact they do not. That is, step (11), they release the conjectured hypothesis (H^C) and act upon it despite their persisting ignorance with respect to the genuine explanation of the initial problem.

The fact that an epistemic view of the abductive inference thus described would not grasp the specificity of abduction has to be emphasized. Indeed, the new hypothesis is not to be considered as a new piece of knowledge or belief. It might be accepted as an abductive conclusion and as *a* good explanation without being believed or accepted as *the* good explanation. What is characteristic of an abduction is the conjectural aspect of its conclusion and the activation of the hypothesis in further reasoning. What is essential to an abduction is that the cognitive-target is not attained by a definitive solution of the initial problem at the level of the conclusion.

1.5 Abduction in Dialogical Logic

It is time to propose a dialogical understanding of abduction and its basic concepts. In previous work, Keiff ([56], 200ff.) defines *abductive problems* in the context of substructural dialogues, namely dialogues in which optimal rules to defend a thesis are sought. Roughly speaking, in the context of substructural dialogue for modal logic for example, the Proponent is allowed to conjecture the accessibility relations that are needed for the defence of her thesis, while this kind of move is forbidden in modal dialogical logic. The framework now outlined is rather different and more general, even if some basic problems remain similar.

Although some given explanations have their roots in the GW model and Aliseda's characterization of abduction, the aim is not to give a faithful dialogical formalization of these approaches. The point is rather to identify the general features of abductive dialogues following these three main questions:

- How can a surprising fact, an *abductive problem* and (or) an ignorance-problem be characterized?
- How can the guessing step, in which a hypothetical explanation is conjectured, be characterized?
- How can the ignorance-preserving feature of abduction be characterized?

The first question relates to the conditions under which an *abductive problem* may be stated in a game; that is, the *triggering* of an abductive dialogue must be described. The second question relates to the possibility of conjecturing an explicative hypothesis during the dialogue; that is, the act of *guessing* specific to an abductive dialogue must be described. The third question relates to the conjectural status of the explicative hypothesis in a dialogue; that is, the question of the *commitment* must be asked. Indeed, "what are we committed to when we conjecture a hypothesis?" This last question is more complicated and involves in-depth considerations about the defeasible aspect of conjectures. In this chapter, this difficulty will be explained in terms of *not-conceded preservation*; that is, a hypothesis that has not been conceded by the Opponent, remains not conceded at the end of an abductive dialogue even if the Proponent has conjectured it. In fact, it is the general point of this contribution to propose a dialogical explanation of abduction in terms of what is called a *concession-problem*.

The leading idea is to allow the Proponent to claim "I am facing an *abductive problem*" when this agent has no winning strategy for a thesis Φ given some shared knowledge or an accepted theory Θ. As explained below, the theory Θ is represented as a set of initial concessions of the Opponent. Φ is the thesis that the Proponent cannot explain on the basis of the initial concessions; that is, Φ holds for a "surprising" fact. If the Proponent is able to justify which kind of *abductive problem* she is being faced, then she triggers a subdialogue in which she is allowed to conjecture a hypothetical explanation α.

The Proponent then has to show that this conjecture is such that if it had been conceded, it would have enabled her to explain the surprising fact expressed by Φ. However, the hypothetical explanation α remains not-conceded at the end of the dialogue and the Proponent only *subjunctively* and *defeasibly* wins. To parallel the explanation to the GW model, let the target T of the Proponent be the situation in which she wins the dialogue, the question Q be a set of challenges she is unable to answer, and α that which would enable her to defend herself against those challenges. When the Proponent conjectures a hypothesis α, the target is only subjunctively attained. In other words, the Proponent is in a situation, such that "if α had been conceded, she would have explained Φ". The explicative feature of the conjectured α may be thus interpreted in the spirit of the "subjunctive attainment relation" ($\rightsquigarrow$) of the GW model of abduction. The situation also parallels the $\neg R(H,T)$ and $\neg R(K(H),T)$ of the GW model because the Proponent does not actually reach the target. Notice that this process, which will be described in this section, is simply partial abduction. In order to attain a characterization of full abduction, it should be explained how to release the conjectured hypothesis in a further dialogue and how to act upon it. This requires in-depth considerations about the specificity of the speech act by means of which such a hypothesis is conjectured. This issue will be dealt with in the last section of this paper.

1.5.1 Triggering

The triggering of an abductive dialogue is characterized within what is called by Rahman and Keiff [31] and Rahman and Tulenheimo [57] "material dialogues"; that is, dialogues with the standard rules plus initial concessions of the Opponent. For example, let Θ be a theory or a knowledge-base consisting of several sentences, and Φ be the initial thesis. A material dialogue begins with **O** conceding all the formulae contained in Θ and with the initial thesis uttered by **P**. The dialogue then runs as usual. The following example, with $\Theta = \{A \to B, B \to (C \wedge \neg E), D \to (C \wedge \neg E)\}$ and $\Phi = C \wedge \neg E$, is given in Figure 1.5.

In Dialogue 2 (see Figure 1.5), **O** concedes the formulae of Θ numbered Θ_1, ..., Θ_n. **P** states the initial thesis $C \wedge \neg E$. Both choose a rank. At move 3, **O** challenges the initial thesis by asking for the first conjunct. **P** cannot answer because the required C is an atomic formula. There is no winning strategy for **P** for Φ, given the initial concessions Θ_1, ..., Θ_n. If Θ_1, ..., Θ_n is interpreted as the shared (assumed) knowledge and Φ as holding for a fact, then it might be said that Φ represents a surprising fact which cannot be explained by the current knowledge. The idea is now that in such a situation, **P** has to be allowed to claim that she is facing an *abductive problem.* In fact, as it is clear in the dialogue (figure 1.5), an *abductive problem* is triggered by a *concession-problem*: **P** cannot explain her thesis on the basis of the concessions.

The notion of *abductive problem* is dialogically defined following Aliseda's ([50], p. 47) definitions of abductive novelty and abductive anomaly (see also the introductory chapter of this section): **P** will now be allowed to claim "I am facing an abductive novelty" or "I am facing an abductive anomaly", as in the rules **[SR-AN]** and **[SR-AA]** below. In the first case, **P** is committed to show that neither Φ nor $\neg\Phi$ is entailed by Θ. In other words, **P** has no winning strategy for Φ nor for $\neg\Phi$, given Θ. In the second case, **P** is committed to show that Φ is not entailed by Θ while $\neg\Phi$ is. That is, **P** has a winning strategy for $\neg\Phi$ but not for Φ given Θ. Here, the technical difficulty is that the Proponent would need a "losing strategy" in order to justify she is facing an abductive novelty or an abductive anomaly. How strange such a game would be!

The difficulty is easily overcome by making use of the "attackability" operator $\mathcal{F}$ introduced by Rahman and Rückert [58] in their dialogical connexive logic. This $\mathcal{F}-operator$ allows the Proponent to claim that under some conditions, the formula in the scope of that operator cannot be defended. Here a subscript is used in order to apply this operator in material dialogues. That is, if **X** says $\mathcal{F}_\Theta\Phi$, then she is claiming that Φ may be attacked given the premises Θ. The rule is stated in Figure 1.6.

Notice that the rule is formulated with an indication for what is called "section of a dialogue", i.e. main dialogue (d_1) and subdialogue ($d_{1.i}$), in accordance with the following definitions:

[D2][Main Dialogue d_1] The first section of a game in which **P** defends an initial thesis is called *main dialogue* d_1.

[D3][Subdialogue] The subdialogue triggered by the challenge of an $\mathcal{F}-operator$ in a section d_1 or the subdialogue triggered by an $AS-challenge$ is called *subdialogue* $d_{1.i}$. Notice that this rule allows subdialogues of subdialogues (that is, a subdialogue $d_{1.i.i}$ triggered in a subdialogue $d_{1.i}$, for example in the case of an $AS-challenge$, as defined in the next section).

The main idea is that **X** justifies $\mathcal{F}_\Theta\Phi$ by showing that Φ cannot be justified, given Θ. This supposes a device that allows switches of the burden of proof, in addition to the particle rule for the $\mathcal{F}-operator$. This presupposes a generalization of the formal rule by means of a structural rule which says that the player who plays formally (i.e. the player who cannot introduce atomic formula) is the player who challenges an

$\mathcal{F}-operator$ (or the player who defends an $AS-move$). In other words, the argumentation partner who challenges a formula such as $\mathcal{F}_{\Theta}\Phi$ will have to take the burden of the proof by defending Φ under the formal restriction.

[SR2.1][Formal Restriction] Let d_n be a section of a dialogue (main dialogue or subsection): If **X** *plays under formal restriction* in d_n, then **X** is not allowed to utter an atomic formula unless **Y** uttered the same atomic formula before in the same section d_n.

The rule governing the application of the formal restriction is now defined as follows:

[SR2.2][Application of the Formal Restriction] The application of the formal restriction is regulated by the following conditions:

1. In the main dialogue d_1, if $\mathbf{X} = \mathbf{P}$, then **X** plays formally.
2. If **X** opens a subdialogue $d_{1.i}$ by challenging an $\mathcal{F}$-operator, then **X** plays formally.
3. If **X** opens a subdialogue $d_{1.i}$ by challenging an $AS - move$, then **Y** plays formally.

Now, structural rules that allow the Proponent to claim she is facing an *abductive problem* are added. She has the choice between the two kinds of *abductive problems* previously defined:

[SR-AN][Utterance of Abductive Novelty] When **P** loses a game playing deductively (i.e. with the standard rules of dialogical logic), then **P** is allowed to claim that she is facing an abductive novelty by saying $\mathcal{F}_{\Theta}\Phi \wedge \mathcal{F}_{\Theta}\neg\Phi$.

In the same way, the *Proponent* is allowed to choose between the claim that she is facing an abductive novelty or an abductive anomaly. The following rule is therefore added:

[SR-AA][Utterance of Abductive Anomaly] When **P** loses a game playing deductively

> (i.e. with the standard rules of dialogical logic), then **P** is allowed to claim that she is facing an abductive novelty by saying $\mathcal{F}_{\Theta}\Phi \wedge \neg\Phi$. Notice here that the second conjunct does not trigger any subdialogue $d_{i.i}$ and that $\neg\Phi$ has to be defended in the same context as the initial thesis, namely when the concesion of Θ is given by **O**.

Without going into excessive details, this point is explained with an example based on Dialogue 2, (Figure 1.5).

In Dialogue 2.1 (Figure 1.7), **P** loses and now claims she is facing an abductive novelty at move 4. **O** challenges that move at move 5, **P** answers by giving the first conjunct. **O** then challenges the $\mathcal{F}-operator$ at move 7 by opening a subdialogue in which she now plays formally. **P** answers by saying $\neg(\Theta \rightarrow (C \wedge \neg E))$, where Θ is the same set of initial concessions as before, and the dialogue runs as usual. It is easy to verify that **O** will lose (for the same reasons **P** lost in Dialogue 2, Figure 1.5). In the same way, **O** will lose even if she challenges the second conjunct in move 4, and **P** will have justified that she was facing an abductive novelty.

1.5.2 Guessing

After having shown she was facing an *abductive problem*, the Proponent has to guess what is missing in order to solve it. The Proponent has to be allowed to conjecture a hypothetical *abductive solution*. Such a conjecture is made by means of a subjunctive speech act; that is, a speech act that does not rely on the concessions of the Opponent. In fact, such a move should be rendered as a defeasible move. Notice that it will not be explained how an *abductive solution* is generated or chosen. Instead, the present proposal will be to describe the conditions under which such a conjectural move is performed.

This contribution relies again on Aliseda [50] who proposes a calculus for abduction, based on the semantic trees of deductive logic, but with some nuances with respect to the status of the abductive explanation. Roughly speaking, the idea is to construct the tree for $\Theta \rightarrow \Phi$ and identify its open branches together with such formulae that may close those branches (in a consistent way). Several formulae may do the job. These formulae are called by Aliseda "abductive solutions" to *abductive problem* consisting of the pair Θ, Φ. Therefore, an abduction consists in guessing (or discovering) what the possible *abductive solutions* are. To put it in Aliseda's own words, consistent abductions are those formulae which "if they had been in the theory before, they would have closed those branches that remain open after $\neg\Phi$ is incorporated into the tableau" ([50], p. 110).

Even if, from a dialogical viewpoint, it is not looked for any "true" formula, what is an *abductive solution* may be defined following a similar process. Indeed, after having shown that she was facing an *abductive problem*, the Proponent should be allowed to put forward a hypothesis. What the Proponent has to look for is a formula, not conceded by the Opponent, that enables her to win the dialogue previously lost. Therefore, a rule that allows the Proponent to conjecture the hypothesis of an explanation called *abductive solution* is added:

[SR-SA][Abductive Solution Rule] When the Proponent has won the subdialogue triggered by the challenge of the $\mathcal{F}-operator$, whether it be novelty or anomaly, the Opponent is allowed to ask her $?AS$ (i.e. she claims "do you have an *abductive solution* to propose?"). If so, the Proponent answers $AS : \alpha$ (i.e. she claims "α is my *abductive solution*").

What does it mean that α is an *abductive solution* for the Proponent, and why is that *abductive solution* the conjecture of a hypothesis? In fact, this move consists in claiming that there is a plausible explanation to the surprising fact Φ given Θ. This specific move, $AS : \alpha$, is the move that forces to reconsider dialogical games to fit in with abductive reasoning. Indeed, it may consist of the utterance by the Proponent of an atomic formula not previously conceded by the Opponent. Nevertheless, the introduction of this new piece of information is to be understood as a subjunctive explanation. That is, the Proponent introduces α as she would say "if you had conceded me α, I would have been able to explain Φ". In no way is α introduced as an **O**-concession to be incorporated into Θ or into a Θ', a successor of Θ containing the initial concessions and the other concessions made during the dialogue. α is a new formula that may be used in further reasoning, but only temporarily, and that temporarily nature requires further justification. Indeed, as a hypothesis, α is defeasible; that is, it is a conclusion *faute de mieux* guessed by the Proponent. If it is shown later that this is not a good explanation or if a counter-example is encountered, then α will be defeated and removed. Its conditions of use are not the same as the usual assertions of the standard dialogical logic because it is subject to further justfication, no matter whether it is an atomic or a complex formula: would it be a new kind of utterance?

1.5.3 Committing

The dialogues defined here only describe a partial abduction; that is, an *abductive problem* is set and a plausible answer is guessed. However, in order to characterize a full abduction, it should be explained how the conjecture might be released in a further dialogue and how the players might act upon it. As already explaind, Gabbay and Woods characterize abduction as an ignorance-preserving inference. It has been shown that abductive dialogues are not-conceded-preserving: the explicative conjecture remains not-conceded and the Proponent only gives a subjunctive explanation for the surprising fact. The difficulty at this point involves the clarification of the commitment carried by such conjectural moves, which are rather different from the usual assertions.

Even if the question of the commitment of the conjectural move is very complex (it might even vary according to the argumentation contexts), a rule to deal with the consequence requirement of the type of abduction called "plain abduction" by Aliseda ([50], III) can be defined. In a dialogue, this consists in adding the possibility of a challenge on the $AS - move$, called an $AS - challenge$. The Opponent makes the request to justify that it is sufficient to consider the conjunction of Θ and α to derive Φ by means of the rule in Figure 1.8.

Under this rule, the challenger opens a subdialogue in which the defender will have to defend the condition $(\Theta \wedge \alpha) \rightarrow \Phi$. The act of Y opening a subdialogue means that X will play under formal restriction. The formal restriction is applied in accordance with the rules **[SR2.1]** and **[SR2.2]** above. More kinds of such challenges should be defined to complete the picture. Adding the explanatory character of α might also be required. Thus, the possibility to chose another attack against an $AS - move$ is offered to Y (see Figure 1.9).

Other requirements, such as consistency $(\Theta, \alpha \nvDash \bot)$, minimality and so on (see introductory chapter of this section), might be added in the same way. It would also be possible to rely on these rules in order to deal with the defeasibility of $AS - moves$. Indeed, if a player is not able to answer the $AS - challenges$ performed by her argumentation partner, then her conjectural move should be removed and considered as null. In the same way, if some counter-examples or a better explanation are found, the $AS - moves$ should also be cancelled. However, defeasibility is a very wide topic and cannot be dealt with in detail in this paper. A non-monotonic account of abduction that makes use of adaptive logic is given by Meheus and Batens [59] and Beirlaen and Aliseda [60] (see also chapter by Gauderis in this section). For a dialogical study of defeasible reasoning, see the work of Nzokou [61]. For a non-monotonic treatment of inconsistencies in the context of an adaptive dialogical logic, see Rahman and Van Bendegem [62] .

What has been characterized in this section is only partial abduction. In order to attain a full abduction, the framework over which dialogues are obtained and in which the hypothesis α is released in the defence of another thesis "as if" it had been conceded, should be developed. Indeed, full abductive dialogue should be not-conceded-preserving; that is, the agents act upon the hypothesis although it has not been conceded by the Opponent. This is the dialogical understanding of ignorance-preservation in the GW model of abduction defended in this contribution. In the GW schema, it was said that neither $R(K(H), T)$ nor $R(K * (H), T)$ were the case. Here, this parallels the fact that **P** does not actually attain the target. **P** only encounters something similar to a subjunctive winning strategy, a strategy which would lead to the victory if **O** had conceded α; similarly in the GW model, it is only a subjunctive attainment relation expressed by $H \rightsquigarrow R(K(H), T)$. Now, the challenge faced in order to complete the picture and to define the conditions of use of a hypothetical explanation α in a full abduction, consists in providing an in-depth analysis of the commitment carried by such a conjecture. This relates to the following question: What kind of speech act is at stake when a hypothesis is conjectured? Without a precise answer to this question, no precise rule of victory for abductive dialogues can be yet formulated.

1.6 Hypothesis: What Kind of Speech Act?

In the previous section, a new kind of move specific to abductive dialogues, the so-called $AS - move$, by means of which a hypothetical *abductive solution* is conjectured, has been introduced. Such a move is considered as a subjunctive move, that is, a move stated hypothetically with an assumption such as "if you had conceded me α, I would have been able to justify Φ". The conditions under which it is possible to conjecture an *abductive solution* and how such a hypothetical *abductive solution* might be challenged have been clarified. However, by means of what kind of speech act is an $AS - move$ performed? What kind of speech act is the conjecture of a hypothetical *abductive solution* if α can be used in the defence of another thesis (in a full abduction)?

An epistemic explanation might have seemed attractive, relying for example on the notion of subjunctive knowledge defined by Rückert [63]. Subjunctive knowledge is defined in a modal frame as the knowledge people of another world would have about the actual world. Abduction might thus be thought of in terms of subjunctive epistemic change, namely if some people of another world had the knowledge of what is expressed by the hypothesis, they would be able to explain a surprising fact in the actual world. This would smartly explain the subjunctive status of the explanatory relation conjectured in a hypothetical *abductive solution*. However, it would have ended up in an account explicitly involving the epistemic states of the agents instead of taking into account their actions. Moreover, such an account would yield an excessively strong commitment on the part of the agent with respect to the belief or the knowledge of the truth of the hypothetical *abductive solution*. However, as explained earlier, this is not necessary. An *abductive solution* can be conjectured as being plausible without any commitment to the belief of the truth of what is expressed.

This last point brings back the problem of the status of an $AS - move$. Is it an assertive speech act? How could it be? An assertive speech act is usually characterized by the commitment (of the speaker) to its truth. In his theory of speech acts, Searle ([64], p. 12) defines the class of assertive speech act as follows: "The point or purpose of the members of the assertive class is to commit the speaker (in varing degrees) to something being the case, to the truth of the expressed proposition". Although, in dialogical logic, the commitment to the truth is irrelevant in the characterization of an assertion, assertion can be thought of in terms of commitment to justify what is said (by defending it against further challenges or by relying on the concessions of the Opponent). What about the $AS - move$? It is conjectured and might be released in another dialogue without being conceded by the Opponent or fully justified by the Proponent. Therefore, is the conjecture of a hypothesis an assertive utterance in the dialogical sense of the term? In Searle's terms, is conjecturing an assertive act? It seems that it cannot be. Answering these questions is crucial if the aim is to succeed in introducing the $AS - move$ defeasibly and to release the conjectures in further reasoning in the same way as in the GW schema of abduction in a dialogical framework.

If the speech act, by means of which a hypothetical *abductive solution* is conjectured, is not an assertion, would it be a commissive speech act? Beyond the question of the commitment to the truth or to belief, or even to the acceptance of what is uttered, an *abductive solution* commits the speaker to a subsequent series of actions. First, the speaker is committed to answer the $AS - challenges$. Second, the use of the hypothesis in a full abduction without knowing whether it is true or not, might be seen as a peculiar kind of commitment. Does such a peculiar commitment relate to what Searle has called the commissive speech acts? More precisely, Searle defines the commissives as "those illocutionary acts whose point is to commit the speaker (again in varing degree) to some future course of action" ([64], p. 14). In the dialogical approach, which has been outlined in the previous section, the underlying idea is that the Proponent conjectures a hypothetical *abductive solution* which is such that, if it had been conceded, it would have explained the surprising fact. However, this should not be the end of the story because the aim would be to release the hypothesis in a further reasoning: in another dialogue in which the Proponent defends another thesis by acting on the hypothesis at stake. That is why the commitment carried out by the speech act, by means of which an $AS - move$ is performed, indicates that it could be understood in terms of a commissive speech act. In addition to further justification, it also commits the agent to further dialectical actions. Nevertheless the commissives are usually speech acts in which the agents commit themselves to an action over which they have full control. That is to say, the commissive speech act commits to something that depends only on the agents, as it happens in the case of promises and oaths. However, the agent who performs an abduction does not have full control of the explanatory force of an *abductive solution*. Indeed, while in the first case the failure of the promise is dependent upon the agent herself, the failure of an abductive explanation includes a wider range of factors which do not exclusively depend on agent activity. So, it does not seem that the speech act by means of which an $AS - move$ is performed, is a commissive speech act.

If it consists in neither an assertive nor a commissive act, would a conjectural move be a fictional speech act? Indeed, according to Searle [65], fictional discourse is not composed of genuine assertions but instead of pretended-assertions. The point is that in fiction, even if the author is not committed to the truth of what she says, she does not have the intention to lie. Therefore, the author does not tell the truth but neither is the author lying. The author tells a story doing *as if* she were asserting. When a player performs an $AS - move$ and uses it in a further reasoning, she does *as if* it were conceded. She does not have to believe what she says but neither is she trying to mislead the interlocutor. However, beyond the fact that Searle's theory of fictionality is not share by this contribution, it is thought that abduction has a practical dimension, which is not necessary to the fictional discourse. Hence, in this paper, it is not believed that the hypothetical speech act should be explained in terms of fictional discourse. Moreover, what is to be explained while studying fiction is its double aspect, the fact that while we know it is not true we react to such a discourse without experiencing any kind of cognitive dissonance. And there is no such tension to be explained in the conjecture of a hypothetical *abductive solution*. (For more details on these points, see [66, 67] and [68].)

An alternative, though tentative solution, would be to reconsider the taxonomy of speech acts. For example, Bach and Harnish [69] define the wider category of constatative, which the conjecturing act would be part of. Other inspirations might be found in the work of Barés Gómez [70] who distinguishes between different kinds of assertions in natural language (asseverative paradigm, negative paradigm and evidentiality) by making use of Dynamic Epistemic Logic and by focusing on the transmission of information. These different kinds of assertions might also be understood as different types (talking thus about hypothetical judgement); see the recent work of Rahman and Clerbout [71] on Constructive Type Theory in the context of dialogical logic follows in this respect. The question is left as a challenge for further investigations. Is a hypothetical speech act a particular kind of assertive or commissive act? Is it a mix of both? Is it a completely new kind of speech act?

1.7 Conclusions

In this paper, it is first advocated for a reconciliation of argumentation theory and formal logic in an agent-centered theory of reasoning; that is, a theory in which inferences are studied in terms of human activities. More precisely, the dialogical approach to logic, in which reasoning is studied through a dialectical interaction between the Proponent of a thesis and the Opponent of it, is defended. In this context, the necessity of taking into account, not only the actions of the agents, but also the importance of the notion of commitment is stressed. Beginning with deductive dialogues, the picture has been extended to abduction, which is considered as a case of non-deductive reasoning.

The starting point to deal with abduction is the agent-centered analysis of the GW model. While Gabbay and Woods identify abduction as an ignorance-preserving inference triggered by an ignorance-problem, abductive dialogues have been defined here as not-conceded-preserving dialogues triggered by a *concession-problem*. The specificity of abductive dialogues has been identified at the level of the so-called $AS-moves$ by means of which hypothetical *abductive solutions* are conjectured. To allow such moves, new rules have been put forward. The challenge for dialogicians now consists in exploring the release of such hypotheses in further dialogues in which they remain not-conceded. However, the difficulty of defining the nature of such a hypothetical speech act is being faced, which leads to the key question of commitment. What are we committed to when we conjecture a hypothetical explanation of a surprising fact and when we release such a hypothesis in further reasoning? A definite answer to this question is let for further investigations.

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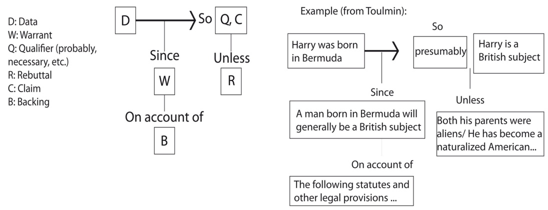

Figure 1.1: Toulmin Model

Assertion	Challenge	Defence
$X\!-\!!-\varphi\wedge\psi$	$Y\!-\!?-\wedge_1$ or $Y\!-\!?-\wedge_2$,	$X\!-\!!-\varphi$ or $X\!-\!!-\psi$ respectively
$X\!-\!!-\varphi\vee\psi$	$Y\!-\!?\!-\!?\vee$	$X\!-\!!-\varphi$ or $X\!-\!!-\psi$
$X\!-\!!-\neg\varphi$	$Y\!-\!!-\varphi$	No defence
$X\!-\!!-\varphi\to\psi$	$Y\!-\!!-\varphi$	$X\!-\!!-\psi$

Figure 1.2: Particle Rules

[66] J. Woods: Fictions and their Logics. In: *Handbook of Philosophy of Science*, Vol. 5, ed. by D. Gabbay, P. Thagard, J. Woods (Elsevier 2007) pp. 1061 – 1126

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Dialogue 1					
	O			P	
				$\neg\neg p \to p$	0
1	$r := 1$			$r := 2$	2
3	$\neg\neg p$	0		p	6
	$---$		3	$\neg p$	4
5	p	4		$---$	

Figure 1.3: Dialogue 1

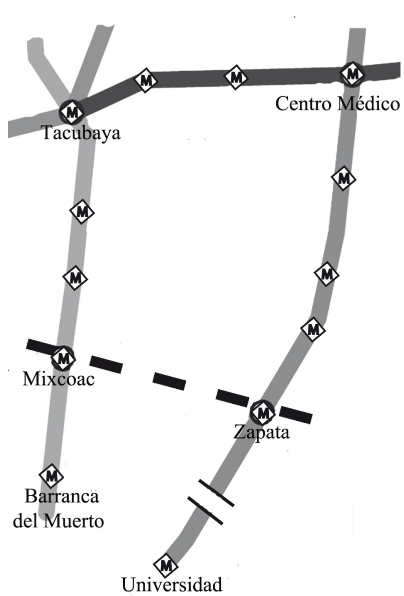

Figure 1.4: México City Metro

Dialogue 2					
	O			P	
Θ_1	$A \to B$				0
Θ_2	$B \to (C \wedge \neg E)$			$C \wedge \neg E$	
Θ_3	$D \to (C \wedge \neg E)$				
1	$m := 1$			$n := 2$	2
3	$?\wedge_1$				

Figure 1.5: Dialogue 2

Assertion	*Challenge*	*Defence*
$X\text{–}! - \mathcal{F}_\Theta\Phi - d_1$	$Y\text{–}?\mathcal{F}_\Theta - d_{1.i}$	$X\text{–}! - \neg(\Theta \to \Phi) - d_{1.i}$
	Y opens a subdialogue $d_{1.i}$.	

Figure 1.6: Particle Rule for F Operator

Dialogue 2.1					
	O			P	
d_1					
...	...	...	...	...	...
3	$?\wedge_1$				
				$\mathcal{F}_\Theta(C \wedge \neg E) \wedge \mathcal{F}_\Theta\neg(C \wedge \neg E)$	4
5	$?\wedge_1$	4		$\mathcal{F}_\Theta(C \wedge \neg E)$	6
$d_{1.1}$					
7	$?\mathcal{F}_\Theta$	6		$\neg(\Theta \to (C \wedge \neg E))$	8
9	$\Theta \to (C \wedge \neg E)$	8		$- - -$	
11	$C \wedge \neg E$		9	Θ	10
...	...	...	...	...	...

Figure 1.7: Dialogue 2.1

Utterance	*Challenge*	*Defence*
$X\text{–}! - SA : \alpha - d_{1.i}$	$Y\text{–}?\text{–}?Plain_{AS} - d_{1.i.i}$	$X\text{–}! - (\Theta \wedge \alpha) \to \Phi - d_{1.i.i}$
	Y opens a subdialogue $d_{1.i.i}$	

Figure 1.8: AS-challenge 1

Utterance	*Challenge*	*Defence*
$X\text{–}! - SA : \alpha - d_{i.i}$	$Y\text{–}?\text{–}?Explanatory_{SA} - d_{i.i.i}$	$X\text{–}! - ((\Theta \wedge \alpha) \to \Phi)$ $\wedge(\neg(\Theta \to \Phi) \vee (\alpha \to \Phi) - d_{i.i.i}$
	Y opens a subdialogue $d_{1.i.i}$	

Figure 1.9: AS-challenge 2