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The Diversity of Cognitive Processes in a Dialogue

Abstract The aim of the paper is to propose a unified formal account of dialogical cognitive processes so that it allows the analysis of similarities and differences between those processes. Formal dialogue systems constitute two basic categories or paradigms of modelling communication depending on what cognitive process is described by a given system. The first paradigm consists of designing a set of dialogue rules in a similar manner to Lorenzen's dialogue logic (1978), and according to which players jointly aim to prove (argue) the validity of a formula. In such cases we will say that the system describes formal dialogues and the formal cognitive process of proving the validity of a formula. The second paradigm focuses on building a system similar to Hamblin's formal dialectics (1970), which "simulates" the real-life communication practice. In the type of dialogues described by those systems, players perform "good" argumentation, i.e. argumentation which fulfils certain requirements of rationality such as e.g. the requirement of not committing a fallacy of circular reasoning (begging the question). In such a case we will be speaking of a natural dialogue and a natural cognitive process of argumentation.

Keywords formal dialogue systems, formal dialectics, dialogical logic, dialogical cognitive processes, cognitive process of argumentation, cognitive process of proof

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Introduction

The aim of the paper is to formulate a proposition for unifying the description of cognitive processes, argumentation and proving in particular occurrences in dialogues. The present study fits into the research line on the relations occurring between dialogue structures expressed in a language (for example, with the discourse symbols such as: i says p; then j asks why p; then i says q), and the cognitive processes represented by these symbols (such as inference: p since q) (Budzyńska, Reed 2016). The main motivation for undertaking the analyses is the fact that the current researchers in the phenomena of argumentation, dialogue and persuasion, do not devote sufficient attention to the relations between the structure of an utterance containing the discourse symbols and the cognitive correlates of these utterances. The starting point for the direction of our study is the hypothesis suggesting that the analysis of the discourse symbols in terms of syntax, semantics and pragmatics is an indispensable condition of a thorough analysis of cognitive processes typical for the dialogue.

In the present paper, we are interested solely in these cognitive processes, which are described by formal dialogue systems, that is, the systems that treat dialogue as a governed form of play between two parties of a dialogue. The formal dialogue systems are divided into two basic classes, or paradigms of communication modelling, depending on which type of cognitive process is the subject of description within the framework of a given system. The first paradigm consists in constructing a set of dialogical rules, modelled on Lorenzen's (1978) dialogical logic, according to which the players attempt to prove (argue) that a formula is a tautology, and their aim is to verify the correct rule of inference. In this case, we say that the system describes formal dialogues, and the formal cognitive process, consisting in proving that a formula is tautological. In the framework of the second paradigm, one attempts to create a system modelled on Hamblin's (1970) formal dialectics, where actual communication practice is "simulated". In dialogues described by these systems, the players carry out a proper argumentation, that is, the argumentation that fulfils certain postulates of rationality, for instance, not committing a circular reasoning in its justification. The aim of holding such dialogues is to give reasons why a sentence is true. In this case, we will be talking about a natural dialogue and natural cognitive process of argumentation (more on the dialectical and rhetorical aspects of cognitive processes can be found in: Budzyńska, Reed 2016; Budzyńska 2013).

Both paradigms define the cognitive processes in a dialogue in essentially

diverse ways, which prevents the identification of the actual similarities and differences in the dynamics of both of the cognitive processes. For example, in dialogical logic, players can attack and defend certain language structures, for instance, they can attack a conjunction by asking whether one of its propositions is true. On the other hand, in formal dialectics, players do not have attacks and defences at their disposal in the set of their moves; however, they can perform locutions (locutionary acts or speech acts) such as: Statement S, Question S, Resolve S. Does the distinctness of the sets of the permitted moves in both of the systems mean that formal dialogues must be realised differently from natural dialogues? In other words, must the cognising party behave differently in a formal cognitive process if they performed a natural process of argumentation? It seems that these types of differences are purely superficial, and the identification of a significant number of distinct properties will solely be the consequence of a lack of uniformity of the languages of description adapted in these paradigms. On the other hand, the actual similarities and differences between the two types of cognitive processes in a dialogue will be impossible to identify, overshadowed by the incomparability of the languages. For instance, it will be impossible to answer the following question: in that case, what are the moves which can be performed in both formal and natural cognitive process in dialogue, and what are the ones which can be performed only in one of these processes?

In the present paper we shall undertake the performance of the first step in an attempt to answer these questions. We propose a uniform descriptive language for two pioneering systems in both of the indicated paradigms of communication modelling. What is more, we indicate the basic similarities and differences between these types of cognitive processes in dialogue. We have adapted Prakken's (2006) general framework as the methodological base of this study. In this framework, dialogue systems are described by three rules: (1) the locution rules, (2) the protocol rules, specifying which speech acts can be performed at a given point of the game, and (3) the effect rules, specifying the effects of speech acts on the player's commitment store (the set of publicly declared convictions). We reconstruct Lorenzen's and Hamblin's systems according to this description, that is, both of these systems will be expressed with the use of the abovementioned rules. In effect the reconstruction of what becomes possible is a unified description of both types of cognitive processes in dialogue, as well as the identification of their actual similarities and differences. Similar general frameworks for dialogue games involving model communication can be found in literature. However,

unified descriptions are proposed solely for systems within the framework of a single paradigm (e.g., Prakken 2006 for systems modelling natural dialogues or Rahman, Keiff 2004 for systems describing formal dialogues).

The present paper consists of four parts. The first part discusses the original formulations of pioneer systems for both paradigms of communication modelling: Lorenzen's dialogical logic and Hamblin's formal dialectics. The second part is devoted to the description of systems of cognitive processes of argumentation and proving based on the example of the course of dialogue games on the grounds of the systems we will discuss. The third part proposes a reconstruction of both of the systems, which allows for a description of them in a single, unified language of the main elements of dialogue systems, as proposed by Prakken. The reconstruction enables the comparison of dialogical logic and formal dialectics for the player's communication-cognitive processes. The basic differences and similarities are discussed in the final part of the present paper.

I. Two Paradigms for Dialogue Processes

Two basic dialogue paradigms of formal systems are discussed in the present chapter: for natural cognitive processes (pt. 1) and for formal processes (pt. 2). Both of the paradigms are illustrated by the examples of novel dialogue systems for these paradigms.

1. System for Natural Dialogues

The first paradigm of modelling cognitive processes in dialogue consists in a formal description of communication typical for natural contexts. The aim of holding such a dialogue is to justify that a sentence is true. Hamblin's formal dialectics (1970) is a pioneering system, which was developed within the framework of this paradigm. The system is also called system H. The system includes a set of *players* and a set of *moves*, which the players can perform. Two players participate in one game (conventionally called Black and White), and perform moves in turns. The players can have two roles: the proponent (the responding party) and the opponent (the challenging party). The aim of the proponent is to defend the truth of a sentence. The aim of the opponent is to bring reasons against the sentence. These roles may shift during the game.

System H can be described by three rules: the locution rules, the structural rules and the commitment rules (a set of commitments publicly declared

by the player). The locution rules define the moves (speech acts), which the player can make during a dialogue. The player's language can be a language of any propositional calculus with a finite number of atomic sentences. Let $S, T, \ldots, X$ be sentence variables. Thus, system H permits the following moves:

Locution rules[4]:

(D1) "Statement S", in some special cases: "Statement S, T";

(D2) "Retract $S, T, \ldots, X$", for any number of sentences $S, T, \ldots, X$ (one or more);

(D3) "Question $S, T, \ldots, X$", for any number of sentences $S, T, \ldots, X$ (one or more);

(D4) "Why S?" for all S, except for axioms;

(D5) "Resolve S".

In formal dialectics, according to rule **(D1)**, a sentence or sentences can be said to be true by making the move "Statement S" or "Statement S, T". According to **(D2)**, the player can resign from committing to state that one or more sentences are true by making the "Retract $S, T, \ldots, X$" locution. In Hamblin's game, the *ad ignorantiam* rule is in operation, which states that the lack of commitment to S does not implicate commitment to $\neg S$ (Hamblin 1970: 264). In system H, two types of questions are permitted: "Question $S, T, \ldots, X$", meaning to ask the opponent to express their sentence on the validity of one or more sentences **(D3)**; and "Why S?", that is to ask the opponent to justify sentence S **(D4)**. The player can also ask the opponent to delete one of the contradictory sentences from their set of commitments by making the move "Resolve S" **(D5)**.

The second type of rules in system H are structural rules, which specify when the player can make a given speech act, i.e., how specific moves of the opponent should be answered.

Structural rules:

(S1) The players make moves in turns, one move per turn. "Retract S" is an exception which can co-occur with "Why S?";

[4] The moves were not indicated in the original description of formal dialectics. For convenience's sake, we adapted the (Di) notation, where i stands for the ordinal number of the rule.

(S2) "Question about $S, T, \ldots, X$" must be followed by these moves:

(a) "Statement $\neg(S \vee T \vee \ldots \vee X)$",

(b) "Retract $S \vee T \vee \ldots \vee X$",

(c) "Statement S" or "Statement T", or ... or "Statement X",

(d) "Retract $S, T, \ldots, X$";

(S3) "Why S" must be followed by:

(a) "Statement $\neg S$",

(b) "Retract S",

(c) "Statement T", if T is an equivalent sentence to sentence S on the basis of an initial definition.

(d) "Statement T, $T \rightarrow S$" for any T;

(S4) "Statement S, T" cannot be used except for 3(d) situation;

(S5) "Resolve S" must be followed by:

(a) "Retract S",

(b) "Retract $\neg S$".

In formal dialectics, due to **(S1)**, each player can make only one speech act per turn. The same rule allows for an exception, i.e., it is simultaneously permitted to retract from a commitment and request justification. Based on **(S2)**, having been asked to specify standpoint about a sentence (sentences), the opponent can: negate the disjunction of these sentences; retract the disjunction; justify at least one of the disjuncts; or commit to none of the sentences asked. The **(S3)** rule specifies how a request for justifying a sentence can be answered: by negating it; retracting the statement that a sentence is true; stating that an equivalent sentence to the sentence asked is true; justifying the sentence by stating that another sentence is true and by implication, that which is preceded by the stated sentence and followed by the justified sentence. Thus, this rule characterises the way in which argumentation applying *modus ponens* can be made in formal dialectics. Due to **(S4)** the argumentation can be performed solely by using this rule. Finally, according to **(S5)**, after the "Resolve S" speech act one may retract from S or $\neg S$.

Commitment rules constitute the third group of rules. It is a set of sentences to which the player commits to publicly, i.e., publicly acknowledges that he is certain as to their truth. The commitment store does not have to be the same as the player's (actual) set of beliefs. Hamblin indicates that in his system, which is a system describing natural communication, the requirement that sentences belonging to the commitment store are consistent is dispensable. In the case of natural dialogues, the player is not ideally "rational" and the player's set of beliefs is not necessarily consistent (Hamblin 1970: 263). The opponent may ask to resolve an inconsistency at any time, for the benefit of one of the sentences, by making the "Resolve S" speech act. The rules stipulated below state how sentences can be placed in and deleted from the commitment store.

Commitment rules:

(C1) "Statement S" places S in the speaker's commitment store, except when it is already there. Additionally, the act places S in the hearer's commitment store, unless his next locution is "Statement $\neg S$", or "Retract S" or "Why S?" Insertion of S in the hearer's commitment store is suspended until the hearer, directly or indirectly, accepts the proposed reasons for S;

(C2) "Statement S, T" places S and T in both the hearer's and the speaker's commitment stores on the rule specified in **(C1)**;

(C3) "Retract $S, T, \ldots, X$" deletes every extract of $S, T, \ldots, X$ from the speaker's commitment store, unless they are axioms;

(C4) "Question $S, T, \ldots, X$?" places the sentences $S \vee T \vee \ldots \vee X$ in the speaker's commitment store, unless it is already there; the statement is also placed in the hearer's commitment store, unless he answers with: "Statement $\neg(S \vee T \vee \ldots \vee X)$" or "Retract $S \vee T \vee \ldots \vee X$";

(C5) "Why S?" places S in the hearer's commitment store, unless it is already there, or he answers with "Statement $\neg S$" or "Retract S".

According to **(C1)** and **(C2)** rules, stating S or S, T, places these sentences in both the speaker's and hearer's commitment store. The hearer can "block" placing these sentences in his commitment store by one of these three means: stating that the negation of the opponent's sentence is true; retracting the statement that a sentence is true; or asking for its justification. Retracting the statement that sentences are true, based on **(C3)**, erases all

these sentences from the speaker's commitment store. According to **(C4)**, asking whether the sentences are true places these sentences both in the speaker's and hearer's commitment stores. Similarly to **(C1)**, the hearer can block placing the sentence, this time by using one of the two means: by stating that the negation of the sentence is true; or by retracting the sentence. **(C5)** specifies that the request for justifying sentence S places the sentence in the hearer's commitment store, unless the sentence is not "blocked" by stating the negation of S or retracting S.

2. Systems for Formal Dialogues

The second paradigm of creating dialogue systems is aimed at modelling the dialectic means of verifying the tautology of formulae, which can be used to define the rules of proper reasoning. Lorenzen's dialogical logic (Lorenz, Lorenzen 1978) is a pioneering system for this paradigm.[5] The system describes formal dialogues, i.e., the ones which are carried out in the language of a given formal logic and are based on the rules of the logic. The description of dialogical logic in this study is limited to the rules of propositional calculus.

In dialogical logic, two players participate in one game: the *proponent*, i.e., the person defending a formula A, and the *opponent*, i.e., the person attacking the formula A. At the beginning of each party, the proponent states a formula which is at stake in the game. The subsequent moves in the dialogues are either an attack against, or a *defence* of, the sentence previously made by the opponent. Following the differentiation introduced by Lorenz (1987: 85)[6], let P signify proponent, O – opponent, $X = \{O, P\}$ is any player, and A and B signify the formulae of propositional calculus. Thus, X *attack* (A) means that the player X attacks the sentence A, and X *defend* (A, B) means that the player X defends the sentence A with the help of the sentence B. The player's winning move is a move whereby the opponent does not have the possibility to make a move permitted within the rules of a given game.

[5] Dialogical logic is called the Lorenzen system, although his most cited position is from his joint publication with Lorenz. However, it is Lorenzen, and not his student, who is considered the system's author.

[6] Lorenz sees an attack as a predicate having one argument with the name of the attacked statement, and defence as a predicate having two arguments, the first of which is the name of the defended statement, and the second – the statement with the use of which the player performs the defence.

Lorenzen's system is defined by structural and specific rules of the game. The structural rules specify what types of moves are permitted on a given stage of the game. For propositional calculus, the following rules are in force (symbols based on: Alama, Uckleman 2011):

Structural rules of the game:

(D00) P makes the first move; after that, O and P make moves in turns;

(D10) P can state an atomic formula only if it has been stated earlier by O;

(D13) P's defence can be attacked only once;

(E) O can react only to P's directly preceding sentences.

According to **(D00)** each game is initiated by the proponent and after that each player makes one move per turn. The **(D10)** rule introduces a limitation on stating an atomic formula by the proponent, as the formula can be stated only if it has been stated by O earlier. The **(D13)** rule, on the other hand, limits the opponent, who can only attack the proponent's defence only once. The **(E)** rule indicates that the opponent can only attack or defend the sentence that directly precedes the attack or defence. Proponents, however, can address any earlier move made by O.

The detailed rules of the game specify the means of a player's attacks and defences of a formula. All attacks and defences depend on the main functor in the attacked or defended sentence. The following expressions are used to describe the rules of the game: (1) **?** is a type of attack used in relation to disjunction and it stands for the "whether" question in relation to the attacked sentence; (2) $k?$ is a type of attack on conjunction and signifies an attack on a specific proposition of a sentence, i.e., for $k \in \mathbb{N}$, k-th proposition of the conjunction is attacked; (3) $\otimes$ is a symbol which indicates the player is unable to make a move in response to the opponent's move.

According to **(P1a)**, a negation can only be attacked by proving the sentence is the negation of the attacked sentence (see: Table 1). If no defence is provided for negation (rule **(P1d)**), the attacked player should choose an action relating to another available connective at a given stage of the game, or end of the game. To attack a conjunction, it is necessary to ask about the validity of one of the propositions being a part of the conjunction **(P2a)**; to defend the attack, it is solely necessary to state the sentence that the player was asked about is true **(P2d)**. To attack a disjunction, it is required to ask about the disjunction's justification **(P3a)**; to defend it, it is enough to

			Attacks	Defences
(P1)	negation	$\neg A$	A	$\otimes$
(P2)	conjunction	$A \wedge B$	1?	A
			2?	B
(P3)	disjunction	$A \wedge B$	?	A
				B
(P4)	implication	$A \rightarrow B$	A	B

Table 1. Detailed rules of the game (adapted from Lorenz 1987: 87).[7]

state that one of the propositions of the disjunction is true **(P3d)**. Finally, to attack an implication, it is necessary to state that its precedent is true **(P4a)**; to defend it, it is required to confirm that the following sentence is true **(P4d)**.

II. The Dynamics of Cognitive Processes in a Dialogue

In this chapter, we present our motivation for creating the said systems in the context of cognitive-communicative processes modelling (pt. 1) and examples of cognitive processes in a dialogue studied in both paradigms (pt. 2).

1. The Motivation for Creating Dialogue Systems

Formal dialectics is a pioneering system, which describes natural dialogues, that is dialogues occurring in everyday practice in a natural language. The result of the dialogues described in a formal dialectics system is that of accepting a certain sentence, whose acceptance is justified. Hamblin's system rules models a dialogue so that no incorrect argumentation can be made. These errors are called fallacies (gr. *σόφισμα*; łac. *fallacia*), and they are deceptive cognitive-communicative techniques applied, for instance, in public speeches, dialogues and discussions (Hołówka 1998; Koszowy et al. 2013; Tokarz 2006). Addressing fallacies is substantiated both cognitively – their

[7] For simplification's sake of subsequent descriptions, the original description of dialogical logic has been extended by labelling the rules by **(P1)**–**(P4)** and using the "a" and "d" indices to indicate whether the rule refers to an attack or a defence, for instance, for the **(P1)** rule which specifies the functioning of a negation, the **(P1a)** rule shall signify an attack on a negation, and **(P1d)** – defence of a negation.

deletion increases the likelihood of gaining knowledge (e.g., Koszowy 2013) – as well as practically – their deletion facilitates achieving the main aims of dialogues and discussions, including determining different attitudes on a given issue (e.g., van Eemeren, Grootendorst 1992). In effect, fallacies have become one of the main topics addressed within the framework of interdisciplinary studies on argumentation (Woods, Walton 1989; Hansen, Pinto 1995; Walton 1995).

Dialogue is a natural environment for the cognitive process of argumentation and, thus, for incorrect argumentation. As a result, Hamblin created a dialogue system based on rules designed in such a way that the sentences which include incorrect argumentation cannot be made in a dialogue game. Hamblin devoted special attention to such fallacies as circular reasoning and many questions. Circular reasoning (in other words, *petitio principii* or *idem per idem*) occurs in reasoning when the conclusion is one of the premises, which may be stylistically different from the conclusion (begging the question). The fallacy of many questions is a communicative-cognitive tactic, which embraces many simple questions disguised as one complex question. The manipulative characteristics of this move is due to the fact that the dialogue party who responds to only one question actually accepts the assumptions of all the other component questions of the complex question (Walton 1999: 379).

In creating formal dialectics, Hamblin assumed that the system has to be consistent in terms of the established rules; in the meaning that one move cannot simultaneously be permitted and banned on the grounds of a given system. These rules should be defined so that they strictly define each locution on a given stage of the game, i.e., they should clarify when a move can be made and what form it can have. A consistent system seems to be a basic assumption in creating rules of any game. However, Hamblin underscores that in dialogues that people engage in, in everyday practice, this rule is frequently omitted. Many systems, which have adapted Hamblin's assumptions, have since been created, the most famous of which are system *DC* (Mackenzie 1979), system *CB* (Woods, Walton 1978), systems *PPD* and *RPD* (Walton, Krabbe 1995), system *TDG* (Bench-Capon 1998), and system *ASD* (Reed, Watlon 2007).

In system H, the cognitive process in a dialogue can be described in the categories of making one's commitments public, which the player can perform by such attacks as "Statement S" or "Retract S". The dialogue also enables the gaining of new information by interaction between the question and the response. For example, one player can ask for justifying a sentence

by a "Why S?" locution, to which the opponent can reply with "Statement T, $T \rightarrow S$", thus justifying the sentence S with T and the implication of these sentences (presenting an argumentation for the S sentence).

The main motivation for creating dialogical logic, on the other hand, was applying game theory to argumentation in propositional calculus, first-order logic and intuitionistic logic. This approach led to the development of communicative models created in order to verify the rules of correct inference. In effect, Lorenzen constructed the *pragmatic notion of truth*, which specifies the tautology of sentence A with an existing winning strategy for the proponent in a dialogue game for A (Lorenz 1987: 83). This system has become the inspiration to create a number of other systems which verify the truth of sentences on the grounds of other logics, for example, modal logic (Rahman et al. 1997), hybrid logic (Blackburn 2001) or linear logic (Blass 1992).

The cognitive processes described in the original view of dialogical logic can be expressed through the attacks and defences for given language structures. An attack on a formula or its part is a question about the truth of a previously attacked formula or its part, or an assumption of its pat being true. Defence, on the other hand, is aimed at providing evidence for the formula or its part, which has been attacked previously. Thus, a player who wants his opponent to demonstrate that an implication is true, attacks it by assuming its precedent is true. To defend the implication, the player has to assume the following sentence to be true.

2. Argumentation and Proving

The present chapter describes means of dialogue modelling in which the participants carry out the cognitive processes of argumentation and proving. Their dynamics are discussed through the example of dialogue games realised in accordance with the rules of formal dialectics and dialogical logic.

In the example dialogue in Table 2, the player White, in the first move, announces a lack of knowledge about B, and asks to justify its negation: Why $\neg B$?. Black then answers by presenting argumentation in which he justifies that sentence $\neg B$ is true. Having stated A, $A \rightarrow \neg B$, Black announces his belief about A, the implication $A \rightarrow \neg B$, and manifests that, in his mind, an inference has taken place, which, basing on implication and its precedent, $\neg B$ has been derived. This move is a discursive symbol of the speaker's cognition of a certain structure for the hearer's argumentative act. However, the following course of dialogue shows that White will not use this possibility,

displaying a sceptical attitude towards Black's argumentation.

In the second move, White refers only to implication, which, according to the rules of formal dialectics, means that White has publicly accepted (acquired) that a fact is being described by sentence A. In effect, A is placed in the commitment store. However, if White retracts, it means that he has not accepted (has not acquired) the message that A implies $\neg B$. Yet, White simultaneously asks for validating this implication, which means readiness to accept it under the condition that Black provides White with acceptable argumentation for proving the implication. In the next move, Black withdraws from his commitment to $A \rightarrow \neg B$, which results in deleting this sentence from his commitment store.

WHITE	BLACK
1. Why $\neg B$? White's commitment store does not change.	Statement A, $A \rightarrow \neg B$ $\neg B$ is placed. $A \rightarrow \neg B$ is placed.
2. Retract: $A \rightarrow \neg B$ Why $A \rightarrow \neg B$? A is placed.	Retract: $A \rightarrow \neg B$ $A \rightarrow \neg B$ is deleted.

Table 2. An example of Hamblin's game (adapted from: Hamblin 1970: 267).

The fundamental aim of formal dialectics was not a mere study of the cognitive process of argumentation, but the study of its correctness. Thus, Hamblin introduces rules regulating the conditions of making attacks on argumentation so that it is impossible to make such mistakes as circular reasoning. Hamblin's dialogic game allows for the elimination of this error by adding two rules:

Additional rules of system H:

(W) "Why S?" move cannot be made if S is not in the hearer's commitment store or is in the speaker's commitment store.

(R1) A response to "Why S?", unless it is "Statement $\neg S$" or "Retract S", has to concern the sentences which have already been placed in the players' commitment stores.

The consequences of adapting these rules, for the possibility of committing circular reasoning, are illustrated by the example in Table 3. According

to **(R1)** rule, if Black responds "B, $B \rightarrow A$" to White's question "Why A?" then this response means that both B and $B \rightarrow A$ must be both in White's and Black's commitment stores. In this case, White's second move is incorrect due to the **(W)** rule – White could not have asked the question "Why B?" because B is already in his commitment store.

WHITE	BLACK
1. Why A?	Statement B, $B \rightarrow A$
2. Why B?	Statement A, $A \rightarrow B$

Table 3. An example of circular reasoning (adapter from: Walton, Batten 1984).

An example course of a game in Lorenzen's system is described in Table 4. The following labels were used to describe this example: P signifies the proponent; O – opponent; k – k-th move in a dialogic game; l signifies the number of the move where the formula is attacked in the move (k).

O			P	
			$((a \rightarrow b) \wedge a) \rightarrow b$	(0)
(1)	$((a \rightarrow b) \wedge a)$	0		
(3)	$(a \rightarrow b)$	1	1?	(2)
(5)	A	1	2?	(4)
(7)	B	3	a	(6)
			b	(8)

Table 4. An example of Lorenzen's game (adapted from: Lorenz 1987).

In this example, what is at stake is the truth of the $((a \rightarrow b) \wedge a) \rightarrow b$ formula. In move (0) in the cognitive process of proving in dialogue, the proponent P states the truth of the formula. In move (1), the proponent makes: O attack $(((a \rightarrow b) \wedge a) \rightarrow b)$. The main functor of the attacked sentence is the implication functor. Thus, according to the **(P4a)** rule, player O makes the move assuming the precedent of the implication, that is $((a \rightarrow b) \wedge a)$. In move (2), P cannot defend an attack as it is described in the **(P4d)** rule. According to **(D10)**, the proponent may not state the truth of an atomic sentence if they have not been previously stated by the opponent. Hence, P attacks in move (2) O's previous sentence, that is, P

attack $((a \rightarrow b) \wedge a)$. The main attacked functor in the sentence is the conjunction functor; therefore, according to **(P2a)**, P asks about the truth of the first proposition of conjunction. According to **(P2d)**, O defends the attack in move (3), that is: O defend $((a \rightarrow b) \wedge a, (a \rightarrow b))$, assuming that the first proposition of the conjunction, $a \rightarrow b$ is true.

P again attacks the sentence $(a \rightarrow b) \wedge a$ in move (4), this time asking about the second proposition of the conjunction. In (5), O defends the conjunction: O defend $((a \rightarrow b) \wedge a, a)$. According to **(P4a)**, P can attack the implication $a \rightarrow b$ by assuming the truth of its precedent, but since it is an atomic formula (see **(D10)**), it is only possible thanks to the fact that O assumed its truth in move (3). According to **(P4d)**, O in move (7) states the implication's successor, b, by making the move: O defend $(a \rightarrow b, b)$.

According to **(D10)**, P can in move (8) state the truth of the atomic sentence b because O has stated it previously (see move (7)). The move is a response to the request for its justification, which was made by O in move (1). P defend, assuming the truth of b, that is, the attacked implication's successor: P defend $(((a \rightarrow b) \wedge a) \rightarrow b, b)$. The move ends the game. The proponent wins because he makes the final permitted move in the game. According to the game's assumptions and the pragmatic definition of truth, the formula $((a \rightarrow b) \wedge a) \rightarrow b$ is true in pragmatic sense (is a tautology of propositional calculus).

III. Reconstruction of the Two Types of Dialogue Systems

In this chapter, we offer a unified description of Hamblin's (pt. 2) system and Lorenzen's system (pt. 3) using Prakken's general framework (pt. 1) as a methodological basis.

1. Prakken's General Framework

Prakken (2006) puts forward a general framework of formal dialogue systems, highlighting those components which can be found in the majority of such systems. The central category in the description includes three rules: rules determining permitted speech acts in a given dialogic game (locution rules), rules describing permitted responses to the speech acts (protocol rules), and rules describing the effects of making certain moves (effect rules).

In the first group of rules, Prakken distinguishes the six most frequently used speech acts and provides their least controversial interpretation.

The rules of permitted moves:[8]

(PR1) Claim "*Claim* φ" is made when the speaker states that φ is true;

(PR2) Concession "*Concede* φ" is used when the speaker confirms that φ is true;

(PR3) Argumentation "φ *since* Ψ",[9] where $\Psi = \{\psi_1, \psi_2, \ldots, \psi_k\}$ for $k \in \mathbb{N}$ is used when the speaker gives the reasons why the statement φ is true; Ψ set is a set of argumentation premises;

(PR4) Challenging "*Why* φ" is used when the speaker questions the φ statement and asks for substantiation;

(PR5) Questioning "*Question* φ" is used when the speaker asks the hearer to give an opinion about the truth of φ;

(PR6) Withdrawing "*Retract* φ" is used when the speaker declares that he is no longer committed to φ; this speech act is used in a dialogue when the speaker has already been committed to φ; in other cases it is enough to state $\neg\varphi$ when being asked about φ.

According to Prakken, in a majority of dialogue systems, the moves which allow us to perform the following moves are present: claim (*Claim* φ) or confirm (*Concede* φ) that a statement is true; argue for a sentence: φ *since* Ψ; or declare that the player no longer accepts that a sentence is true: *Retract* φ. It is also possible to ask questions in two ways in a majority of systems: ask if the sentence is true (*Question* φ); or ask for its justification (*Why* φ).

The second group of rules, which Prakken uses to describe dialogue systems, specifies the protocol rules:

Protocol rules:

(PO1) The following moves are permitted after *Claim* φ: (1) *Why* φ, (2) *Claim* $\neg\varphi$, (3) *Concede* φ;

(PO2) The following moves are permitted after *Why* φ: (1) φ *since* Ψ (or: *Claim* ψ for each *psi* $\in \Psi$), (2) *Retract* φ;

[8] For consistency's sake, we introduced the (PRi) labels, where i is the ordinal number of the rule.

[9] In Prakken's original description, this speech act is presented as φ *since* S. The symbols have been substituted for convenience's sake.

(PO3) The following moves are permitted after φ *since* Ψ (for $\Psi = \{\psi_1, \psi_2, \ldots, \psi_k\}$ for $k \in \mathbb{N}$: (1) *Why* ψ, where $\psi \in \Psi$, (2) *Concede* ψ, where $\psi \in \Psi$;

(PO4) The following moves are permitted after *Question* φ: (1) *Claim* φ, (2) *Claim* $\neg\varphi$, (3) *Retract* φ.

Basing on **(PO1)**, after the speech act of a statement, the opponent can: ask for justification of the sentence; state that its negation is true; or accept that the sentence is true. According to **(PO2)**, after *Why* φ, it is permitted to: give reasons why the sentence φ is true by argumentation or stating that one of its premises is true; or resign from commitment to φ. According to **(PO3)**, the opponent can follow the argumentation with: ask to give reasons for the premise; or to accept that the premise is true. Basing on the **(PO4)** rule, having been asked whether the sentence is true, it is possible to: provide a sentence; negate the sentence; retract from claiming that the sentence is true.

Prakken also provides rules specifying how making certain speech acts influences the commitment store (i.e., a group of sentences which a given player declares as his beliefs). Let s denote a player, $s(m_n)$ – the speech act made by s in the move m_n (where $n \in \mathbb{N}$), and $C_s(d, m_n)$ – the commitment store of the player s in the move m_n in the dialogue d.

Effect rules:

(PZ1) If $s(m_n) =$*Claim* φ, then $C_s(d, m_n) = C_s(d, m_{n-1}) \cup \{\varphi\}$;

(PZ2) If $s(m_n) =$*Concede* φ, then $C_s(d, m_n) = C_s(d, m_{n-1}) \cup \{\varphi\}$;

(PZ3) If $s(m_n) = \varphi$ *since* Ψ, where $\Psi = \{\psi_1, \psi_2, \ldots, \psi_k\}$ for $k \in \mathbb{N}$, then $C_s(d, m_n) \supseteq C_s(d, m_{n-1}) \cup \Psi$;

(PZ4) If $s(m_n) =$ *Why* φ, then $C_s(d, m_n) = C_s(d, m_{n-1})$;

(PZ5) If $s(m_n) =$ *Retract* φ, then $C_s(d, m_n) = C_s(d, m_{n-1}) \setminus \{\varphi\}$.

Basing on the **(PZ1)** and **(PZ2)** rules, having made *Claim* φ and *Concede* φ, the sentence φ is placed in the previous commitment store of the player. It has been specified that with **(PZ3)**, after φ *since* Ψ, the previous store has been extended by a store of premises (i.e. $C_s(d, m_{n-1}) \cup \Psi$) and is included in the current store (i.e. $C_s(d, m_n)$) because the current store also includes the implicational premise: $\psi_1 \wedge \psi_2 \wedge \ldots \wedge \psi_k \rightarrow \varphi$. Having made why

φ, according to **(PZ4)**, the player's commitment store remains unchanged. If I retract φ is made, basing on **(PZ5)**, the sentence φ is removed from the earlier commitment store.

Reframing Humblin's System

A reconstruction of Hamblin's system is presented in the present part. It is conducted in such a manner that the description of cognitive processes in dialogue represented by formal dialectics in Prakken's framework of main elements of dialogue is possible. To achieve this, system H needs to be expressed in the categories of three types of rules specified by Prakken: locution rules, protocol rules and effect rules.

Players in system H make similar speech acts to those in Prakken's description, which means that in both cases players can give reasons why a sentence is true, ask for justification, or retract from stating that a sentence is true. However, the interpretation of most speech acts in system H and in Prakken's framework are different. Thus, it is necessary to reformulate some of the rules adapted in formal dialectics. According to **(D1)**, the player can make "Statement S" or "Statement S, T". In Prakken's language, these acts can be interpreted as:

- *Claim* φ, where φ is sentence S;
- *Concede* φ, where φ is sentence S;
- φ *since* Ψ in the case when the player makes "Statement S, T", where one of these sentences (e.g. T) must be an implication, and the second sentence (S) is the implication's antecedent; then φ follows the implication (succeeds T sentence), and $\Psi = \{S, T\}$.

In Prakken's language this speech act is expressed as: *Claim* φ (see the general framework rule **(PR1)**), and it can be used in formal dialectics when one of the players makes the speech act "Statement S", and his opponent does not have S in the commitment store yet. This situation has been described in the reconstructed system H by rule **(HL1)** (see below: locution rules). The second speech act: *Concede* φ can be made in formal dialectics only when the opponent already has φ in the commitment store (see **(HL2)**).

The third of the abovementioned acts, which was described in **(PR3)**, φ *since* Ψ is reconstructed on the basis of **(S3d)** and **(S4)** in system H. **(S3d)** indicates that the response to "*Why S*?" (which in Prakken's language

denotes an illocutionary act why, see the reconstruction "*Why S*?" below), that is an appropriate answer to justifying S can make two sentences T, $T \to S$. The response is *modus ponens*, and hence the act "Statement T, $T \to S$" can be viewed as argumentation. Additionally, **(S4)** indicates that making two sentences is only possible in the case described in **(S3d)**, that is when one of these sentences is an implication and the second is its precedent. Therefore, it disqualifies using different rules of inference, except for *modus ponens*, in formal dialectics (see **(HL3)** below).

Yet another system H rule **(D2)** says that the player can make the move: "Retract $S, T, \ldots, X$" in the dialogue, which in Prakken's language can be interpreted as:

- *Retract* $\varphi_1 \wedge \varphi_2 \wedge \ldots \wedge \varphi_k$, where $\varphi_1 \wedge \varphi_2 \wedge \ldots \wedge \varphi_k$ is a conjunction of sentences $S, T, \ldots, X$ and $k \in \mathbb{N}$.

The effect of making even the simplest version of this move (i.e. "Retract S") on the player's commitment store (see **(C3)**) is identical to the effect of the move: *Retract* φ in Prakken's description (see **(PZ5)**). Hence, the moves have been equated. What is more, the reconstruction of the contents of *Retract* to the form of a conjunction can be achieved on the basis of **(C3)** which specified that, having made the move from the speaker's commitment store, each of the sentences made is deleted. Therefore, the commitment store not being a part of "Retract" is treated as a conjunction of this store (see **(HL4)** below).

Basing on **(D3)**, the player can make "*Question* $S, T, \ldots, X$?", which in Prakken's language can be treated as making:

- *Question* $\varphi_1 \vee \varphi_2 \vee \ldots \vee \varphi_k$, where $\varphi_1 \vee \varphi_2 \vee \ldots \vee \varphi_k$ is the disjunction of sentences $S, T, \ldots, X$ and $k \in \mathbb{N}$.

Making the "Question S" is identical to *Question* φ in Prakken's framework. This interpretation is possible due to **(S2)** and **(PO5)**, which specify that after both of the moves the following acts are permitted: (i) responding with the sentence which the player has been asked about, (ii) negating the sentence, and (iii) retracting the sentence. The content reconstruction of *Question* to the disjunction form can be conducted by **(C4)**. According to the rule, making "*Question* $S, T, \ldots, X$" places $S \vee T \vee \ldots \vee X$ in the player's commitment store. Thus, the set of sentences contained in "*Question* $S, T, \ldots, X$?" is treated as a disjunction of this set (see **(HP5)**). Basing on another rule of formal dialectics, **(D4)**, the player can make "*Why S*?". In the general framework, the act can be realised with:

- *Why* φ, where φ is S.

Basing on **(PO3)**, **(S3)**, and **(C5)**, "Why S" and *Why* φ are used in an analogous manner in both systems. Both of these sentences can be followed by either retracting from a commitment or arguing for the sentence (see **(HL6)**).

The speech act described in **(D5)**: "Resolve S" can be interpreted in Prakken's language as a complex act:

- *Question* φ, *question* ¬φ, where φ is S.

"Resolve S" does not have a directly corresponding sentence in Prakken's framework. In system H, this move is included neither in the rules of permitted rules nor in operation rules on the commitment store. In effect, its reconstruction can only be performed based on the structural rule **(S5)**. It specifies that "Resolve S" can be followed by: "Retract S" or "Retract ¬S". In Prakken's framework, it is either I retract φ or I retract ¬φ. Additionally, based on Prakken's protocol rules, *Retract* can follow *Why* φ **(PO2)** or *Question* φ **(PO4)**. "Resolve S" is not a request to justify S, just like why **(PR4)**, but the hearer's response to state one's position towards φ, just like Question **(PR5)**. Thus, the only act which can potentially realise the sentence similar to "Resolve S" is: *Question* φ, where φ is S.

However, system H assumes that after "Resolve S", not only can the opponent retract S, but also ¬S. According to **(PO5)** in Prakken's framework, having made *Question* φ, the hearer can make *Retract* φ; however, *Retract* ¬φ is impossible. On the other hand, this act can be a response to *Question* ¬φ. In this case, the complex move *Question* φ, *Question* ¬φ seems to be the only possible reconstruction of "Resolve S" (see **(HL7)**).

Hamblin's "Resolve S" is a single move; thus, in the reconstructed system H, the move *Question* φ, *Question* ¬φ is also treated as a single act. It eliminates the problem of equating "Resolve S" with making two moves: "Question S" and "Question ¬S" which in Prakken's language would also mean making: *Question* φ and *Question* ¬φ. In formal dialectics, the player can only ask these two questions in two separate moves, which are intermitted by the opponent's move. To conclude, system H allows us to make the speech acts which conform to Prakken's framework. The moves are the following:

Locution rules:[10]

[10] The locution rules in the reconstructed formal dialectics have been labelled by HMi, where HM stands for Hamblin-Locution, and i – the ordinal number of the rule.

(HL1) Claim "*Claim* φ" is used when the speaker states that φ is true when his opponent does not have this sentence in his commitment store;

(HL2) Concession "*Concede* φ" is used when the speaker states φ when the opponent has the sentence in his commitment store;

(HL3) Argumentation "φ *since* Ψ" occurs when the speaker argues for φ with the use of set of sentences Ψ; the argumentation can be used only according with the rule *modus ponens*, thus $\Psi = \{\psi \rightarrow \varphi, \psi\}$;

(HL4) Withdrawal "*Retract* $\varphi_1 \wedge \varphi_2 \wedge \ldots \wedge \varphi_k$", for $k \in \mathbb{N}$, is used when the speaker resigns from deeming all the sentences $\varphi_1 \wedge \varphi_2 \wedge \ldots \wedge \varphi_k$ true;

(HL5) Question "*Question* $\varphi_1 \vee \varphi_2 \vee \ldots \vee \varphi_k$", for $k \in \mathbb{N}$, is used as the opponents query whether the sentences $\varphi_1 \vee \varphi_2 \vee \ldots \vee \varphi_k$ are true;

(HL6) Challenge "*Why* φ" is used as a request to state why φ is true;

(HL7) Complex question "*Question* φ, *question* $\neg\varphi$" is a request to make a statement about φ by removing the sentence or its negation from the hearer's commitment store.

Another group of rules in Prakken's framework, the protocol rules, is characterised similarly by Hamblin's structural rules. In effect, the reconstruction of the formal dialectics protocol primarily entails writing down Hamblin's rules **(S1)**–**(S5)** with the reconstructed protocol rules **(HL1)**–**(HL7)**. Only **(S3d)** and **(S4)** have undergone a bigger change in system H. **(Sd3)** describes how a player can perform argumentation. Due to **(S4)**, it is permitted to state that two sentences are true (i.e. argue) with the speech act "*Statement* S, T" only in the situation specified in **(S3d)**, which in the reconstructed system is explicitly expressed as the argumentative move φ *since* Ψ. **(S4)** has been removed from the rules of response in the reconstruction of the speech act as a move which is permitted in system H **(HL3)**, and not a rule which describes the game's protocol.

Protocol rules:[11]

(HP1) Each of the players makes one move per turn. The exceptions are:

[11] The protocol rules in the reconstructed formal dialectics have been labelled by HPi, where HP stands for: Hamblin-Protocol, and i – the ordinal number of the rule.

1. *Retract* φ, which can co-occur with *Why* φ,
2. Compounding two simple acts *Question* φ, *question* $\neg\varphi$;

(HP2) *Question* $\varphi_1 \vee \varphi_2 \vee \ldots \vee \varphi_k$ can be followed by:

1. Confirming the negation of the act's content, that is (a) *Claim* $\neg(\varphi_1 \vee \varphi_2 \vee \ldots \vee \varphi_k$, or *Concede* $\neg(\varphi_1 \vee \varphi_2 \vee \ldots \vee \varphi_k$,
2. *Retract* $\neg(\varphi_1 \vee \varphi_2 \vee \ldots \vee \varphi_k$,
3. Saying that one of these sentences is true, i.e.: (a) *Claim* φ_1 or *Claim* φ_2 or ... or *Claim* φ_k, or (b) *Concede* φ_1 or *Concede* φ_2 or ... or I concede φ_k,
4. Withdrawing all sentences, i.e. *Retract* $\varphi_1 \wedge \varphi_2 \wedge \ldots \wedge \varphi_k$;

(HP3) *Why* φ can be followed by:

1. Saying that φ is false, i.e. (a) *Claim* $\neg\varphi$ or (b) *Concede* $\neg\varphi$,
2. *Retract* φ,
3. Giving the ψ sentence, which is an equivalent sentence to φ on the basis of a primitive definition, i.e. making (a) *Claim* ψ or (b) *Concede* ψ,
4. Justifying the sentence, i.e. making φ *since* Ψ, where $\Psi = \{\psi \rightarrow \varphi, \psi\}$;

(HP4) *Question* φ, *Question* $\neg\varphi$ can be followed by:

1. *Retract* φ,
2. *Retract* $\neg\varphi$.

Effect rules in formal dialectics, just like structural rules, are specified in a similar way to their description in the general framework for dialogue systems. Thus, their reconstruction will entail writing down the rules of formal dialectics **(C1)**–**(C5)** in Prakken's language, with the addition of a few characteristic features of formal dialectics. First of all, making speech acts in system H does not only result in changes to the speaker S's commitment store, but also in hearer H's as well. Moreover, not only do the changes in H's commitment store depend on the speech act, which S makes in m_n, but also on the move which H makes in the next move m_{n+1}. Finally, **(C1)** has been reconstructed in the form of two rules: **(HE1)** and **(HE2)** (see below) because "Statement S" **(D1)** in the new interpretation includes two

interpretations: *Claim* φ **(HE1)** and *Concede* $\neg\varphi$ **(HE2)**. Making *Claim* φ means that the opponent does not have the sentence φ in his commitment store, and that is why we shall assume that φ is placed in both S's and H's commitment stores. S makes I concede φ when H has already committed to φ; thus, φ is only placed in the speaker's commitment store.

Let $s \in \{N, O\}$ signify a player, where N stands for the speaker and O for the hearer $s(m_n)$ – the speech act made by s in move m_n, and $C_s(d, m_n)$ s's commitment store in move m_n in dialogue d. The rules of system H written below have been reconstructed in the language of Prakken's general framework.

Effect rules:[12]

(HE1) If $s(m_n) =$ *Claim* φ, and N makes the speech act, then:

1. $C_N(d, m_n) = C_N(d, m_{n-1}) \cup \{\varphi\}$,
2. $C_O(d, m_n) = C_O(d, m_{n-1}) \cup \{\varphi\}$, unless O will not make *Claim* $\neg\varphi$, *Concede* $\neg\varphi$, or *Why* φ in m_{n+1} move.

(HE2) If $s(m_n) =$ *Concede* φ and I makes the concession, then:

1. $C_N(d, m_n) = C_N(d, m_{n-1}) \cup \{\varphi\}$,
2. $C_O(d, m_n) = C_O(d, m_{n-1})$;

(HE3) If $s(m_n) = \varphi$ *since* Ψ, where $\Psi = \{\psi \to \varphi, \psi\}$ and N makes the speech act, then:

1. $C_N(d, m_n) = C_N(d, m_{n-1}) \cup \Psi$,
2. $C_O(d, m_n) = C_O(d, m_{n-1}) \cup A$, where $\psi' \in A$, if $\psi' \in \Psi$ and unless O makes in move m_{n+1}: *laim* $\neg\psi'$, *Concede* $\neg\psi'$, *Retract* $\neg\psi'$, *Why* $\neg\psi'$;

(HE4) If $s(m_n) =$ *Retract* $\varphi_1 \wedge \varphi_2 \wedge \ldots \wedge \varphi_k$ and N makes the speech act, then:

1. $C_N(d, m_n) = C_N(d, m_{n-1}) \setminus \{\varphi_1, \varphi_2, \ldots, \varphi_k\}$,
2. $C_O(d, m_n) = C_O(d, m_{n-1})$;

(HE5) If $s(m_n) =$ *Question* $\varphi_1 \vee \varphi_2 \vee \ldots \vee \varphi_k$ and N asks the question, then:

[12] Rules of commitment rules in the reconstructed formal dialectics have been labelled with HEi, where HE stands for Hamblin-Effects and i – the number of the rule.

1. $C_N(d, m_n) = C_N(d, m_{n-1}) \cup \{\varphi_1 \vee \varphi_2 \vee \ldots \vee \varphi_k\}$,
2. $C_O(d, m_n) = C_O(d, m_{n-1}) \cup \{\varphi_1 \vee \varphi_2 \vee \ldots \vee \varphi_k\}$, unless O claims $\neg(\varphi_1 \vee \varphi_2 \vee \ldots \vee \varphi_k)$ or does not concede $\neg(\varphi_1 \vee \varphi_2 \vee \ldots \vee \varphi_k)$ in m_{n+1};

(HE6) If $s(m_n) =$ *Why* φ and N makes the act, then:

1. $C_N(d, m_n) = C_N(d, m_{n-1})$,
2. $C_O(d, m_n) = C_O(d, m_{n-1}) \cup \{\varphi\}$, unless O makes *Claim* $\neg\varphi$ or *Concede* $\neg\varphi$ in m_{n+1}.

In **(HE1)**–**(HE6)**, some fragments of the original system H formulation have been changed, which were not related to its reconstruction in Prakken's language, but to some technicalities. Firstly, **(C1)**, **(C2)**, and **(C4)** were changed in relation to the limitation caused by the original framework, which specifies that having made the acts described there, the sentences constituting their content are placed in the speaker's commitment store, unless these sentences have already been placed there. According to **(HE1)**, (**HE2)**, **(HE3)** and **(HE5)**, after: *Claim* φ, *Concede* φ, φ *since* Ψ, and *Question* φ, the sentence which is the content of these acts is always placed in the speaker's commitment store. This change applies one of the basic laws of set theory. If φ is an element of a certain set (e.g. the commitment store before the speech act of confirmation), and the singleton set $\{\varphi\}$ (which can be the result of, for instance, stating φ) is added to that set, then the output set is not "extended". In other words, for any two sets, if these two sets contain the same element, then the said element will occur only once in the set which contains their sum, e.g.: $\{x\} \cup \{x\} = \{x\}$.

Moreover, the reconstruction of **(C1)**, **(C2)**, **(C4)** and **(C5)** to **(HE1)**-**(HE3)** and (**HE5)**-**(HE6)** has been conducted without taking an equivalent act, "Retract S", into consideration. In formal dialectics, "Retract S" realises two functions: retracting from stating that a sentence is true, and "blocking" placing the content of the previous locution in the commitment store of the player who "blocks" it. This process of "blocking" has been reconstructed in the following manner: firstly, the sentence S, which is the content of the locutions described with the discussed rules, is placed in the commitment store of the player X, the hearer. Next, when X makes "Retract S", the sentence S is removed from his commitment store. As illustrated in Table 5, modelling the said process either with the use of "blocking" (in the original formulation of formal dialectics), or with the use of placing a sentence, which

is later deleted (in the reframed approach), has the same final effect on the hearer's commitment store.

WHITE	BLACK
1. Statement S	*Retract* S
S is added	The commitment store does not change

Table 5. An example dialogue in the original formal dialectics.

In the example above, once White has stated S, Black makes: "Retract S", thereby, basing on **(C1)**, he "blocks" placing S in his commitment store. Thus, according to the original description of system H, Black's commitment store does not change. In the reconstruction we put forward, the same example can be illustrated with the rules **(HE1)** and **(HE4)**. After White has stated that S is true, the sentence has been added to Black's commitment store (see **(HE1)**). In the next move, Black retracts from stating that S is true, which removes this sentence from his commitment store (see **(HE4)**). In the new version of dialogical logic, making the two moves has no effect on Black's commitment store as well. Based on the aforementioned example, it can be stated that the function of placing, and then deleting, the sentence from the commitment store and the "blockade" function, which prevents placing the sentence in the commitment store with the use of "Retract $S, T, \ldots, X$" are equivalent from the aspect of the effects exerted on the commitment store.

3. Reframing Lorenzen's System

The present part is devoted to a brief reconstruction of dialogical logic, which has been carried out in a similar fashion to the reconstruction of formal dialectics. In other words, the Lorenzen system rules have been formulated so that it would be possible to describe: the speech acts which players make in a game based on dialogical logic (the locution rules), protocol rules (the rules of permitted answers) and the effect rules (the effects of making certain moves).

In the original formulation of dialogical logic, the players can only defend and attack formulas of certain logic. However, attacking and defending consists of, for example, stating that a sentence is true or requesting its justification. Thus, these actions can be described with the speech acts specified in the locution rules of Prakken's general framework. For example,

basing on the rule of dialogical logic **(P2a)**, attacking the conjunction: X *attack* $(A \wedge B)$ is made by questioning the truth of a sentence which is a proposition of the conjunction. In Prakken's language, this move can be made by: *question* φ, where φ is any proposition of the attacked conjunction, i.e. sentence A or sentence B (see the reconstructed rule **(LL5)** below). On the other hand, basing on **(P2o)**, defending the conjunction $(A \wedge B)$ consists in stating a sentence whose truth has been questioned in an attack. The defence can be made by: (1) *Claim* φ, where φ is either sentence A or B (see **(LL1.2)**; or (2) *Concede* φ, where φ is either sentence A or B for a proponent, when φ is an atomic formula **(LL2.2)** (for a detailed description of the reconstruction of the locution rules, see: Yaskorska, Budzyńska 2016). As a consequence of this reconstruction, rules **(P1)**–**(P4)** of dialogical logic can be described in line with the standard adapted in Prakken's general framework for dialogue systems in the following manner:

Locution rules:[13]

(LL1) Claim '*Claim* φ' is made when the player: (1) attacks $\neg A$, then φ is sentence A, (2) defends $A \wedge B$, then φ is either sentence A or B, (3) attacks $A \rightarrow B$, then φ is sentence A, (4) defends $A \rightarrow B$, then φ is sentence B;

(LL2) Concession '*Concede* φ' for φ being an atomic formula when the proponent: (1) attacks $\neg A$, then φ is sentence A, (2) defends $A \wedge B$ is either sentence A or B, (3) attacks $A \rightarrow B$, then φ is sentence A, (4) defends $A \rightarrow B$, then φ is sentence B;

(LL3) Argumentation 'φ *since* Ψ' is made when the player defends $A \vee B$; then φ is sentence $A \vee B$, and Ψ is a set which includes sentence A or B;

(LL4) Challenging '*Why* φ' is made when the player attacks $A \vee B$, then φ is sentence $A \vee B$;

(LL5) Questioning '*Question* φ' is used when the player attacks $A \wedge B$; then φ is either sentence A or B.

The second type of rules in Prakken's language includes protocol rules. Each game in Lorenzen's system includes the attack and defence of sentences,

[13] The locution rules in the reconstructed dialogical logic have been labelled with LLi, where LL stands for: Lorenzen-Locutions, and i – the ordinal number of the rule.

which can be a negation, conjunction, disjunction or implication. Thus, the reconstruction of the rules we offer consists of characterising all the possible answers after certain attacks and defences of these structures, which are described with the use of structural and specific rules of dialogical logic, considering the permitted attacks of speech acts described by rules **(LL1)**–**(LL5)**. For example, responding to an attack and responding to a defence can be made in the following manner: basing on **(P2a)**, attacking a conjunction is performed via asking whether one of its propositions is true, which is performed by *Question* φ. The response, i.e. defending against the attack, is assigning truth to the attacked proposition of the conjunction realised by *Claim* φ (see the reconstructed rule **(LP7.1)** below); or in the case when φ is an atomic sentence, and the attack is made by the proponent: *Concede* φ (see **(LP7.2)**).

In turn, answering to the defence of a conjunction in dialogical logic can be realised as follows. Let us assume that the player defends a conjunction by *Claim* φ (see **(LP7.1)**). If φ is a negation of any sentence, then, considering Lorenzen's rule **(P1a)**, the opponent can respond with an attack by stating a sentence which is contradictory to the attacked sentence by *Claim* ¬φ (see **(LP7.1)**) or *Concede* ¬φ, if ¬φ is an atomic formula and the proponent is the attacking player **(LP3.2a)**. If φ is a conjunction of sentences, then due to the **(P2a)** rule, the opponent can respond by an attack which questions one of its propositions, by making *Question* ψ, where ψ is a proposition of the conjunction φ (**(LP3.3)** below). If φ is a disjunction, then due to rule **(P3a)**, the opponent can attack by performing the locution *Why* φ **(LP3.4)**. However, if φ is an implication, then basing on **(P4a)**, the player can attack by responding with *Claim* ψ (LP3.2c), where ψ is the antecedent of the implication φ.

In formulating the rules of permitted responses, we have also taken into consideration the structural rules of dialogical logic. For instance, **(LP2)** is a reconstructed **(D10)**, which says that the proponent can make a simple assertive speech act which contains an atomic sentence, only after the opponent has made it (the full description of the reconstruction of rules of permitted responses can be found in: Yaskorsa, Budzyńska 2016). Below, we enumerate the reconstructed rules of responses in dialogical logic expressed in Prakken's general framework.

Protocol rules:[14]

[14] The rules of permitted answers in dialogical logic have been labelled with LPi, where LP stands for: Lorenzen-Protocol, and i – the ordinal number of the rule.

(LP1) In the initial move, the player P makes *Claim* φ, where φ is a sentence whose tautology is the subject of the game; next, the players make moves in turns, one move per turn;

(LP2) The proponent cannot make the move *Claim* φ, where φ is an atomic sentence; P can state that the atomic sentence is true only if it has been stated by the opponent by making *Concede* φ;

(LP3) After *Claim* φ, the defender of the sentence can make one of the following moves:

1. *Claim* ψ, if (a) φ is the sentence's negation, and ψ a sentence contradictory to it, (b) φ is an attacked implication, and ψ is the antecedent of φ (LP3.1 is performed by the proponent, bearing in mind the limitations described in **(LR2)**),
2. *Concede* ψ, if the player is the proponent, and ψ an atomic sentence, or that ψ has been earlier stated as a true sentence, and if (a) φ is this sentence's negation and ψ a sentence contradictory to it, (b) φ is the attacked implication, and ψ follows φ, (c) φ is an implication and ψ precedes ψ,
3. *Question* ψ, if φ is a conjunction of sentences, and φ is an operand of a conjunction φ,
4. *Why* φ, if φ is a disjunction,
5. An attack or a defence in relation to a permitted act which has earlier been made by the opponent, if the player is the proponent,
6. No move, if (a) *Claim* φ is an attack on a negation and φ is an atomic sentence, (b) *Claim* φ is the proponent's defence and the opponent has already attacked this defence;

(LP4) If the proponent makes *Claim* φ, where φ is an atomic sentence, it is followed by:

1. *Claim* ψ, if I confirm φ is an attack on implication, and φ is a successor of the attacked implication, when the proponent says *Claim* ψ;
2. No move, if (a) *Concede* φ is an attack on negation and φ is an atomic sentence, (b) *Concede* φ is a defence made by the proponent and the opponent has already accepted the defence;

(LP5) After φ *since* Ψ, where $\Psi = \{\psi\}$, the following moves must be made:

1. *Claim* φ, if (a) ψ is a sentence's negation, and φ a sentence contradictory to it, (b) ψ is an implication, and φ precedes ψ (LE5.1 is made by the proponent, considering the limitation described in **(LE2)**),
2. *Concede* φ, if the player is the proponent, and φ is an atomic sentence or if φ has already been stated to be true, and (a) ψ is the sentence's negation, and φ a sentence contradictory to it, (b) ψ is an implication, and φ precedes ψ,
3. *Question* φ, if ψ is a conjunction of sentences, and φ is a proposition of the conjunction ψ,
4. *Why* ψ, if ψ is a disjunction,
5. An attack or a defence against any previous act made by the opponent, if the player is the proponent,
6. No move for the opponent, if φ *since* Ψ is a defensive move made by the proponent, and the opponent has already accepted the defence;

(LP6) The following moves are permitted after *Why* φ:

1. φ *since* Ψ (LO6.1 is made by the proponent, considering the limitation described in **(LR2)**),
2. an attack or defence against a permitted act which has already been made by the opponent, if the player is the proponent;

(LP7) The following moves are permitted after *Question* φ:

1. *Claim* φ (the rule is made by the proponent, considering the limitation described in **(LR2)**),
2. *Concede* φ, if the player is the proponent, and φ an atomic sentence;
3. an attack or defence against a permitted locution which has already been made by the opponent, if the player is the proponent;

The third type of rules indicated by Prakken concern the rules of operation on the commitment store. The dialogical logic itself does not include the notion of a commitment store, which is why it is impossible to

find rules which specify the effects of making certain moves in this system. These rules, however, can be characterised based on the reconstruction of locution rules in the dialogical logic **(LL1)**–**(LL5)** and the effect rules for specific acts in Prakken's general framework **(PZ1)**–**(PZ5)**. In the reconstruction which we offer, it is assumed that during one game the players use a *temporary commitment store* C', that is a commitment store adapted for the time of the game. In turn, the commitment store C described by Prakken will be a set where the formula's whose truth is in question during the game will be placed in or deleted from. The formula is placed when the proponent wins the game, and it is deleted when the opponent wins.

Let C'_s denote a temporary commitment store of the player s in a given dialogue game, m_n is the n-th move in this dialogue (where $n \in \mathbb{N}$) and $s(m_n)$ is a kind of move made by the player s in move m_n in this dialogue.

Effect rules:[15]

(LE1) If $s(m_n) =$ *Claim* φ, then $C'_s(d, m_n) = C'_s(d, m_{n-1}) \cup \{\varphi\}$;

(LE2) If $s(m_n) =$ *Concede* m φ, then $C'_s(d, m_n) = C'_s(d, m_{n-1}) \cup \{\varphi\}$;

(LE3) If $s(m_n) = \varphi$ *since* Ψ, then $C'_s(d, m_n) \supseteq C'_s(d, m_{n-1}) \cup \Psi$;

(LE4) If $s(m_n) =$ *Why* φ, then $C'_s(d, m_n) = C'_s(d, m_{n-1})$;

(LE5) If $s(m_n) =$ *Question* φ, then $C'_s(d, m_n) = C'_s(d, m_{n-1})$.

IV. A Comparison of Systems for Natural and Formal Dialogues

The reconstruction of Lorenzen's and Hamblin's systems has allowed a unified description of these systems and, by extension – it allows for the comparing of cognitive processes in dialogue modelled by these systems. The present chapter indicates the basic differences and similarities between the cognitive processes of argumentation and proving by juxtaposing these three types of rules obtained from the reconstruction: the locution rules (pt. 1), the protocol rules (pt. 2) and the effect rules (pt. 3).

[15] The rules of operation on the commitment store in the reconstructed dialogical logic have been labelled with LEi, where LE stands for: Lorenzen-Effects, and i – the ordinal number of the rule.

1. Types of Moves in a Game

The juxtaposition of the locution rules in force in the reframed dialogical logic and formal dialectics is presented in Table 6.

General framework	Dialogical logic		Formal dialectics
Claim φ	X attack:	negation implication	Statement S
	X defend:	conjunction implication	
Concede φ	X attack:	negation implication	Statement S
	X defend:	conjunction implication	
φ *since* Ψ	X defend:	disjunction	Statement T, $T \to S$
Retract φ	—		Retract $S, T, \ldots, X$
Question φ	X attack:	disjunction	Question $S, T, \ldots, X$
Why φ	X attack:	disjunction	Why S
Question φ, *question* ¬φ	—		Resolve S

Table 6. A juxtaposition of locution rules.

In the reframed Lorenzen system, it is visible that during formal dialogues, the players can use almost all speech acts provided in the Prakken's general framework, except for *Retract* φ. The lack of possibility to retract indicates certain important characteristics of the cognitive process of proving which distinguishes it from argumentation. In dialogical logic, stating that sentences are true consists in assuming that they are true during the game. If a player assumes that a certain formula is true, then having made a few steps, it is impossible to resign from this assumption (in the same game).

In the original description of formal dialectics, similarly to Prakken's general framework, the rules of permitted moves were defined. However, making some of the speech acts is interpreted differently in both of the systems. For instance, Hamblin defines a speech act "Statement S" which is made always when the player wants to state that a sentence is true, i.e. wants to declare his beliefs about a certain fact and to inform his opponent about it. Expressing such a communicative intention of the speaker with the use of

one speech act is a kind of simplification. According to Prakken's framework, three acts describing these dialogue situations are possible: (1) *Claim*, when the speaker has the aim of informing the opponent about his beliefs, (2) *Concede*, when he wants to inform him that he agrees with the opponent's standpoint, (3) *since*, when he additionally justifies a given sentence.

Making speech acts is different in both systems in terms of content and the acts made. It is connected with the fact that in communication realised on the grounds of these systems, the players gain knowledge about different types of objects corresponding to different linguistic structures. Having a natural dialogue based on formal dialectics, the players gain knowledge about facts. In a formal dialogue, the players attain knowledge about dependencies between facts, the dependencies being characterised by adequate tautologies. However, it is possible to describe some common communicative-cognitive processes in these systems, e.g., the act *Claim* φ expresses the same activity in both systems. It means that the behaviour of the cognitive subjects, in terms of dialogue systems of argumentation and proving, is essentially similar.

2. Rules of the Game

In the reconstructed Lorenzen's and Hamblin's systems, the most differences can be seen in the rules of permitted responses which are juxtaposed in Table 7.

In Lorenzen's system, the rules of responses are specified only for the opponent; the proponent, in turn, can make any move pertaining to the opponent's previous utterances. In Hamblin's system, the rules of permitted answers pertain to both of the players; however, they are formulated only in the responses to the speech act with which the opponent has asked a question. In other words, the limitations in system H are only specified for the party responding to questions. This means that in the proving process, only the attacking party is limited, and in the process of argumentation – only the defending party. The aim of system H is to model natural communicative-cognitive processes, and more specifically, errors in argumentation. Therefore, the system imposes limitations solely on responses to questions, that is, the means in which one can justify or express one's standpoint once specific questions have been asked.

In dialogical logic, after the request for justifying a sentence, the opponent can only perform argumentation; in formal dialectics, on the other hand, apart from argumentation, he can also confirm that a sentence is true or

retract from stating a sentence. What is also indicated is the difference between the communicative-cognitive processes in both models. In a formal dialogue, the player has to defend his standpoint when he is asked for argumentation, as otherwise he loses. However, in a natural dialogue, the player does not have to argue for every sentence that has been attacked by the opponent.

Speech act	Response in dialogical logic	Response in formal dialectics
statement	O: no move claim concession challenging P question any act	any act
confirmation	O: no move claim	any act
argumentation	O: no move claim concession challenging question P: any act	any act
challenging	O: argumentation P: any act	claim concession argumentation withdrawal
question	O: claim P: any act	claim
request for resolution		withdrawal

Table 7. Juxtaposition of the protocol rules.

Yet another difference between the modelling of communication in Lorenzen's and Hamblin's systems is the possibility to change the rules during one game. System H provides for the possibility of changing roles, that is, at a certain stage, it is possible for the player to shift the role from the role of the party asking questions (the cognising party) to the validating party. It permits: (1) having dialogues with a few subjects of discussion,

and (2) having a dialogue where both players acquire information by asking questions. Let us assume that Black states that A is true in the first move. White asks Black to justify the sentence in the second move, which allows him to acquire knowledge about the facts which constitute the justification of the sentence if Black makes argumentation in the third move. If White states that another sentence, B, is true in the fourth move, the roles change and in this case, Black can become the asking and the cognising party. Lorenzen's system does not allow such a change, which means that dialogical logic permits the verification of whether a sentence is true and acquires the conviction only about one formula. Thus, in argumentation, as well as in proving, both players acquire knowledge, but the cognitive process in the systems is different. Parties in natural dialogue exchange information, whereas in a formal dialogue, players together acquire knowledge about a formula.

3. The Effect Rules

Juxtaposing the effect rules store **(LE)** and **(HE)** reveals certain basic differences between the systems and the cognitive processes in dialogue which they describe. In the reframed approach to dialogical logic, only a temporary commitment store is used, which in reality only constitutes the player's assumptions (assumptions in evidence), and not a set of beliefs that he has publicly declared. The proponent by, for example, making a statement, does not reveal his knowledge about the world, but tries to justify or negate the truth of a formula in an interaction with the second player. The players do not acquire knowledge about the content of the speech act during a dialogue, as it is in formal dialectics. The discussing parties assume or refute that a given formula is true only after the game has ended, when they have acquired knowledge whether a sentence at stake is a tautology or not.

On the other hand, the rules of operation on the commitment store in system H are characterised by the effects of moves on the commitment store of the party who performs the act (the speaker) and the hearer's commitment store, which allows us to analyse the influence of making given speech acts on the speaker's and hearer's public states of knowledge. What is more, the player can retract from stating that a sentence is true, whose truth has been stated by the opponent, which may be interpreted as a manifestation of different views on whether a sentence is true or not.

Conclusion

We have shown that the two models of dialogue which have different aims – argumentation and proving – can be described with the use of a single language basing on the philosophical notion of a speech act. Unifying the description of the two systems, which gave rise to two basic paradigms of formal modelling of dialogue – formal dialectics and dialogical logic – has been performed by the reconstruction of the systems according to Prakken's standard. As a result, it is possible to compare the factual similarities and differences between the cognitive processes of argumentation and proving.

This paper indicates a few basic characteristic features of these processes. In dialogue games, players gain knowledge by making certain moves, e.g. an attack or a request to justify a sentence. In a natural dialogue, the player (the cognising party) can acquire knowledge about facts by interacting with another player (the informing party), by requesting to justify a given sentence and receiving an appropriate inferential structure in response, which provides the justification. The cognitive process of argumentation is thus realised jointly by both parties in the sense that the cognising party initiates the process by asking a question, and the informing party gives an answer to the question asked.

In a formal dialogue, however, players jointly acquire knowledge about the validity of schemata of proving (both are cognising parties) because they jointly perform the process of proving. The role of the informing subject is taken over by the rules of a given logic in the sense that they regulate the means of performing a game. It allows for the discussing parties to decide who will be the winner in a given game, and – whether a formula is a tautology (if the proponent wins) or not (when the opponent wins).

The logical rules in both dialogical logic-type systems are fully deterministic, i.e., a dialogue always permits us to decide who wins a given game. These rules are coded mainly in the limitations imposed on the opponent in protocol rules, which force him to make subsequent moves in the direction which will lead to resolution. An unambiguous result of a dialogue process of proving forces both of the players to accept the result (assuming that they are rational). In contrast with the seemingly "aggressive" resonance of the term "attack", specifying one of the moves permitted in the original Lorenzen system, a formal dialogue is cooperative in nature. However, in natural dialogues, the opponent does not have to accept the opponent's argumentation, and, at a certain stage of the game, the proponent can change his standpoint and retract from acknowledging his own conclusions,

which is typical for everyday practices.

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