

# Linguistic, Pragmatic and Evolutionary Factors in Wason Selection Task

Olimpia Matarazzo, Fabrizio Ferrara

**Abstract**—In two studies we tested the hypothesis that the appropriate linguistic formulation of a deontic rule – i.e. the formulation which clarifies the monadic nature of deontic operators – should produce more correct responses than the conditional formulation in Wason selection task. We tested this assumption by presenting a prescription rule and a prohibition rule in conditional vs. proper deontic formulation. We contrasted this hypothesis with two other hypotheses derived from social contract theory and relevance theory. According to the first theory, a deontic rule expressed in terms of cost-benefit should elicit a cheater detection module, sensible to mental states attributions and thus able to discriminate intentional rule violations from accidental rule violations. We tested this prevision by distinguishing the two types of violations. According to relevance theory, performance in selection task should improve by increasing cognitive effort and decreasing cognitive effort. We tested this prevision by focusing experimental instructions on the rule vs. the action covered by the rule. In study 1, in which 480 undergraduates participated, we tested these predictions through a  $2 \times 2 \times 2 \times 2$  (type of the rule x rule formulation x type of violation x experimental instructions) between-subjects design. In study 2 – carried out by means of a  $2 \times 2$  (rule formulation x type of violation) between-subjects design – we retested the hypothesis of rule formulation vs. the cheater-detection hypothesis through a new version of selection task in which intentional vs. accidental rule violations were better discriminated. 240 undergraduates participated in this study. Results corroborate our hypothesis and challenge the contrasting assumptions. However, they show that the conditional formulation of deontic rules produces a lower performance than what is reported in literature.

**Keywords**—Deontic reasoning; Evolutionary, linguistic, logical, pragmatic factors; Wason selection task

## I. INTRODUCTION

THE selection task was devised by Wason [1] [2] to identify which states of the world people check in order to determine the value of truth of a conditional rule. Participants are presented with a rule of the form “if  $p$  then  $q$ ” – where  $p$  stands for the antecedent clause and  $q$  for the consequent clause of the conditional utterance – and with four cards showing on one side the information of presence/absence of the antecedent and on the other side the information of presence/absence of the consequent. The four cards – of which only one side is visible – take, respectively, the values of  $p$ ,  $not-p$ ,  $q$ ,  $not-q$ .

Olimpia Matarazzo is with the Psychology Department, second University of Naples, Italy (e-mail: olimpia.matarazzo@unina2.it). Fabrizio Ferrara is with the Department of Relational Sciences “Gustavo Iacono”, University of Naples “Federico II” (e-mail: faber708@hotmail.it).

Participants are requested to select which of the four cards needed to be turned over in order to determine whether the rule is true or false.

For an affirmative rule, as the above-mentioned one, the logically correct answer is to select  $p$  card (in order to check if the presence of the antecedent entails the presence of the consequent) and  $not-q$  card (in order to check if the absence of the consequent entails the absence of the antecedent). Likewise, for a rule with affirmative antecedent and negative consequent (if  $p$  then  $not-q$ ) the correct answer corresponds to selecting  $p$  and  $q$ , i.e.  $not(not-q)$ . According to propositional logic, the valid procedure entails the application of *Modus ponens* (selection of  $p$ ) and of *Modus tollens* (selection of  $not-q$ ). In Popper’s terms, this means choosing the falsifying answer. In a closed task – i.e. a task in which the rule concerns a set of defined and fully explorable states of the world (represented by the four cards) – selecting  $p$  and  $not-q$  cases allows to establish both the truth and the falsity of the sentence. In an open task – where the rule concerns an undefined set of cases, that cannot be fully explored – selecting  $p$  and  $not-q$  cases remains the logically correct solution, but it allows only to ascertain the falsity of the sentence, and not its truth.

In early Wason’s experiments – and, more generally, in all the experiments in which abstract rules have been used – only a small number of participants provided the correct response. The most frequently selected answers were the two cards showing  $p$  and  $q$  or the only  $p$  card (for a review see [3] [4]). Wason [1] [2] has explained these results in terms of verification bias. People select only the cards compatible with the rule and the state of the world it represents:  $p$  and  $q$  in the affirmative rule or  $p$  and  $not-q$  in the rule with negative consequent.

Selection task with thematic rules, both familiar and unfamiliar to participants, yields a pattern of answers similar to that found with abstract rules (for a review see [3] [4] [5] [6]). In fact, although in a few experiments some rules produced a high number of falsifying answers, as the rule “Every time I go to Manchester, I travel by car” [7], subsequent experiments failed to replicate these results using similar rules [8].

The pattern of answers changes dramatically when deontic rules are used, as “If a letter is sealed, then it has a 50 lire stamp on it” [9] or “If a person is drinking beer, then the person must be over 19 years of age” [8]. Several studies showed an increase of the falsifying answers that ranges from 60% to 90%. Selection tasks with deontic rules, however, are structurally different from tasks with descriptive rules expressed by indicative conditionals [10] [11]: in these latters, the truth value of the rule is uncertain; reasoners do not know if it is true or false and, consequently,

they must reason “about” the rule; instead, in deontic tasks, the truth value of the rule is certain; reasoners are invited to take it as true and, consequently, they must reason “from” the rule. Moreover, in descriptive tasks, experimental instructions require that participants select cases in order to find out whether a certain rule is true or false; instead, in deontic tasks, they require or imply that participants select cases that violate a certain rule.

Several explanations have been offered for the people ability in resolving the selection task with deontic rule. Cheng and Holyoak [12] proposed the pragmatic-reasoning-schemas theory, according to which people draw inferences using knowledge structures (called pragmatic reasoning schemas) acquired through daily experience during ontogenetic development. These schemas are domain-specific sets of rules, defined in terms of goals and relations to these goals, and are activated as a function of situational requirements. The most common schemas are permission, obligation and causality. Manktelow and Over [13] hypothesize that deontic effect depends on a specific interpretation of the rule in terms of precautions (if one performs a dangerous act D, then one must take precaution P). According to these latter authors, people reason successfully with this type of rules because of their adaptive function in reducing risk in hazardous situations. In a similar vein, Cosmides & Tooby [14][15] claim that the selection task is solved easily when the rule is interpreted as a social contract rule. The social contract is a situation in which one party is forced to satisfy a requirement in order to get a benefit. According to the social contract theory, the human mind is equipped with a neurocognitive module, acquired during phylogenetic development, that is specialized for reasoning about social contracts. This module operates on the basis of a cost-benefit representation and possesses an evolved “look for cheater” algorithm. So, when in the selection task a rule is interpreted as a social contract (if you take the benefit, then you must satisfy the requirement), the “look for cheater” algorithm is activated to detect potential violators of the rule: individuals who have accepted the benefit (*p*) without satisfying the requirement (*not-q*). The choice of *p* and *not-q* cards coincides with the logical solution but it is independent from the formal reasoning. Indeed, when a switched rule [14] is presented (if you satisfy the requirement, then you are entitled to take the benefit), participants still tend to select the cards corresponding to “benefit taken” and “cost not paid”, which, this time, coincide with *not-p* and *q*. Some research [16] [17] reported that the “look for cheater” algorithm is influenced by mental state attributions: accidental violations are less likely to elicit good performance than intentional violations. This difference has been found also in children 3 years old, using the evaluation task, a cognitively less demanding variant of the selection task [18].

From a domain-general perspective, Sperber, Cara, and Girotto [19] posit that relevance theory enables to explain previous findings in selection tasks, with both indicative and deontic conditionals, in a pragmatic viewpoint. According to this theory, people select the most relevant cards using a specific mental mechanism (called relevance mechanism), specialized for the discourse comprehension, which function is to infer the speaker’s communicative intentions. An information is judged relevant when - integrated with previous knowledge - it produces cognitive effects which lead to draw new inferences, such that new beliefs are

achieved. In the former are set aside. However, achieving cognitive effects involves a cost in the form of processing effort: *ceteris paribus*, the greater the cognitive effort required to produce cognitive effects, the less relevant the information is judged to be. In Wason selection task with affirmative rules, people select the cards *p* and *q* because they are the most relevant ones. To make relevant the *p* and *not-q* cards the selection task should be constructed so that the *p* and *not-q* cases become easier to represent than the *p* and *q* cases and thus entail a minor cognitive effort. According to the “recipe” furnished by the authors [19], this effect can be obtained in several ways: by citing *p* and *not-q* cards in the scenario in which the conditional rule is embedded or by using *p* and *not-q* cases for which lexical entries are available. In addition, in order to increase the cognitive effect of the falsifying choice, context must be created in which discovering the existence of *p* and *not-q* cases is more interesting than discovering *p* and *q* cases: for example making *p* and *q* cases banal and *p* and *not-q* cases controversial, or making *p* and *not-q* cases undesirable from the point of view that solvers are instructed to adopt, i.e. the point of view of who is responsible for enforcing the rule. According to the relevance theory, deontic selection tasks are resolved more easily than the descriptive ones just because their structure respects these requirements [20]. Looking for violators of a rule makes *p* and *not-q* cases most relevant than *p* and *q* cases. Moreover, in each language, usually there are far more lexical entries for rule violators (thieves, fraudsters, cheaters etc.) than to designate people who observe norms.

The lively debate between relevance theory and evolutionary approach [21]-[24] has shown contrasting results: in some studies [21] the presentation of social contract or precaution rules produced the pattern of response predicted by the evolutionary theory but in other studies this effect did not emerge [23] or was only partially found [24]. The relevance theory seems more able to account for a wider amount of results but the debate is still open.

From a formal perspective, Fodor [25] and Buller [26] argue that logical factors can account for people differential performance on selection tasks with indicative and deontic conditionals. They assume that, since these two conditionals have different logical forms, they entail different patterns of inference. Indicative conditionals, such as “If a card has an ‘A’ on one side, then it has a ‘4’ on the other side” [2] [7], make factual assertions that one state of the world, expressed by the antecedent clause, entails another state of the world, expressed by the consequent clause. On the contrary, deontic conditionals, such as “If an envelope is sealed, then it must have a 20 cent stamp” [12], impose an obligation about the state of the world expressed by the consequent clause which has to be accomplished under the condition expressed by the antecedent clause. Thus, indicative conditionals are authentic conditionals involving two propositions and a dyadic operator, “if...then”, that connects them. Instead, deontic conditionals are improper conditionals because operators such as “must”, “it is permissible” etc. are monadic: they operate only on the action indicated by the consequent, under the condition expressed by the antecedent. In logical terms, the dyadic or monadic nature of the respective operators is clear: indicative conditionals are designated by  $p \rightarrow q$  (if *p*, then *q*), whereas deontic propositions are designated by *OA* (*A* is obligatory), *PA* (*A* is permissible) etc. According to Fodor

[19] and Buller [20], deontic formulations centered on obligations, permissions or prohibitions make it easier to produce correct falsifying answers in Wason selection task, thanks to their logical form. For example, in a statement of the form "If one wants X, then s/he must do A" it is straightforward to infer that *not-A* cases violates *OA* (given the presence of X condition under which A is obligatory), whereas it is more difficult to backward infer that a conditional statement of the form "if *p*, then *q*" is false if the negation of the consequent entails the affirmation of the antecedent.

These considerations suggest that the more appropriate formulation in natural language of an obligatory deontic proposition (defined as "permission rule" in the pragmatic-reasoning-schemas theory [12]) should be "To do X, one must do Y", because it clearly denotes that X is the condition under which Y is requested. Similarly, the more appropriate linguistic formulation for a prohibition should be "To do X, it is not allowed to do Y".

We assume that if these two formulations are more appropriate than the conditional ones, then deontic rules presented in this way should make their logical status more comprehensible and thus facilitate the production of correct responses.

## II. OVERVIEW OF THE PRESENT STUDIES

The general aim of this research was to compare the above mentioned hypothesis with two other hypotheses derived from the social contract theory and the relevance theory. According to the first theory, a deontic rule expressed in terms of cost-benefit should elicit a cheater detection module. Since this module is highly specialized and is influenced by mental state attributions, an intentional rule violation should produce a better performance, in selecting cards which correspond to "benefit accepted" and "cost not paid", than an accidental rule violation [16] [17]. For this purpose we compared selection tasks in which people could have violated the rule intentionally with tasks in which they could have violated it accidentally.

According to the relevance theory, the performance in selection task should improve by increasing cognitive effect and decreasing cognitive effort. In order to manipulate the latter factor, we changed the focus of the experimental instructions stressing either the rule or the action the rule required/prohibited to do. In the second condition cognitive effort should be reduced by decreasing the working memory load. Indeed, instructions focused on the action were shorter than the ones focused on the rule. Moreover, by focusing people attention on the action covered by the rule, this type of instructions conformed to Gricean maxim of quantity [27] implicating the information that checking the observance/violation of a rule implies checking the status of the action controlled by the rule. Thus, this type of instructions should emphasize the pragmatic relevance of the deontic selection task.

In the first study we tested these hypotheses with two types of social contract rules, a prescription rule and a prohibition rule. The first was expressed as "To do X, one must do Y" in the appropriate deontic formulation, and as "If one want to do *p*, then one must do *q*" in conditional formulation. The second was expressed as "To do X, one must not have done Y" in the appropriate deontic formulation, and as "If one want to do *p*, then one must not have done *q*" in conditional

formulation. In both rules, the condition under which the rule was in force (or the antecedent in the conditional formulation) was always in affirmative verbal form. Nevertheless, the prescription rule presented also the consequent in affirmative form, whereas the consequent of the prohibition rule was in negative verbal form.

In the second study we put aside the hypotheses that in the first study did not affect performance (i.e. manipulation of cognitive effort and type of rules) and contrasted the hypothesis concerning the appropriate linguistic formulation of the deontic rule with the hypothesis about the differential performance produced by intentional vs. accidental rule violation. Although in the first study this difference did not affect results, it could be possible that in the experimental manipulation it had not been clear that the rule violation implied the benefit acceptance without paying any cost. So, in the second study we stressed this aspect and better discriminated cheaters from accidental rule violators. Moreover, in the second study we more clearly separated the effect of the rule formulation from the effect of the type of instructions which in the first study could be overlapped.

## III. STUDY 1

### Method

#### A. Design and Participants

The 2 X 2 X 2 X 2 research design involved the manipulation of four between-subjects variables: type of rule (prescription vs. prohibition), rule formulation (conditional vs. appropriate deontic formulation), type of violation (intentional vs. accidental), and experimental instructions (focused on the rule vs. focused on the action the rule requires or prohibits).

Four hundred and eighty undergraduates, with no knowledge of logic or psychology of reasoning, participated in the study as unpaid volunteers. Their age ranged between 18 and 36 ( $M = 22,69$ ;  $SD = 3,02$ ). Participants were randomly assigned to one of the sixteen experimental conditions ( $n = 30$  for each condition).

#### B. Materials and Procedure

All the selection tasks were embedded in scenarios having the same structure and four sources of variation. The scenarios had been preliminarily tested with 20 undergraduates to ascertain their level of comprehensibility. The protagonist was a travel agency employee which had to check whether all departing customers complied with a particular travel rule. The prescription rule was: "If a tourist wants to go to Bulgaria, then s/he must take out a medical insurance policy" (conditional formulation), or "To go to Bulgaria, one must take out a medical insurance policy" (appropriate deontic formulation). The prohibition rule was: "If a tourist wants to go to Libya, then he/she must not have visa for Israel on passport" (conditional formulation), or "To go to Libya, one must not have visa for Israel on passport" (appropriate deontic formulation). The customers of the travel agency had been informed of the rule (intentional violation) or could not have been informed of it (accidental violation).

In order to find out whether customers complied with the rule, the travel agency employee had to examine four piles of departing clients' paper files. Each paper file bore on one side the personal data of customers with their travel destination and, on the other side, the customers' travel documents, among which it was specified whether they had taken out medical insurance (in prescription rule condition) or whether they had a visa for Israel on their passport (in prohibition rule condition). Some paper files had been sorted according to client destination, others according to medical insurance (or passport visas).

In the conditions with experimental instructions focusing on the rule, participants were asked to indicate which paper files the travel agency employee should turn over in order to determine:

- whether the customers complied or not with the rule "If a tourist wants to go to Bulgaria, he/she must take out a medical insurance policy" (in prescription rule with conditional formulation condition)
- whether the customers complied or not with the rule "If a tourist wants to go to Libya, he/she must not have visa for Israel on passport" (in prohibition rule with conditional formulation condition)
- which customers complied and which customers did not comply with the rule "To go to Bulgaria, one must get a medical insurance" (in prescription rule with appropriate deontic formulation condition)
- which customers complied and which customers did not comply with the rule "If a tourist wants to go to Libya, he/she must not have visa for Israel on passport" (in prohibition rule with appropriate deontic formulation condition).

In the conditions with experimental instructions focusing on the action, participants were asked to indicate which paper files the travel agency employee should turn over in order to determine:

- whether there were customers who must take out medical insurance (in prescription rule with conditional formulation condition).
- whether there were customers who have not been allowed to enter in Libya (in prohibition rule with conditional formulation condition)
- which customers must take out medical insurance (in prescription rule with appropriate deontic formulation condition)
- which customers have not been allowed to enter in Libya (in prohibition rule with appropriate deontic formulation condition).

The cards presented stood for the piles of customers' paper files. They were randomized across participants. One instance of the cards presented in the prescription rule condition was the following:

Customer destination: Bulgaria	Customer destination: France	Medical insurance: taken out	Medical insurance: not taken out
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In table I the frequencies of card selections in the sixteen experimental conditions were reported.

The responses were preliminarily classified as correct (*p* and *not-q* in the prescription rule with affirmative verbal form; *p* and *q* in the prohibition rule with negative consequent) and incorrect (all the others), as it is shown in table II. Thus they were analyzed through a 2 x 2 x 2 x 2 ANOVA (type of rule x rule formulation x type of violation x experimental instructions). Results showed only the main effect due to the rule formulation ( $F = 27,476$ ;  $df = 1,464$ ;  $p < 0,001$ ). The appropriate deontic formulation of the rule produced a higher percentage of correct answers than the conditional formulation (66,7% vs. 43,3%).

#### D. Discussion

Only the hypothesis about the rule formulation is supported by the results. The appropriate deontic formulation produces a number of correct answers significantly greater than the conditional formulation. The type of rule (prescription vs. prohibition), the manipulation of the cognitive effort and pragmatic relevance of the task by means of experimental instructions (focusing on the rule vs. focusing on the action), and the type of rule violation (intentional vs. accidental) do not affect performance. These findings suggest that, in deontic reasoning, the role of logical-linguistic factors is greater than generally acknowledged in literature. Nevertheless, some precautions have to be taken before putting forward this interpretation. First, it is possible that the manipulation of the type of violation has not been effective. Intentional violators have been identified as the customers who had been informed of the rule. Nevertheless, in the scenarios it was not clearly specified that the rule violation implied the benefit acceptance without paying any cost. For example, the customers who did not comply with the rule should probably face the risk of not being admitted to Libya or of having to pay a penalty to enter in Bulgaria. Moreover, it should be noted that the experimental instructions presented with the conditional formulation of the rule requested to investigate the hypothetical states of affairs introduced by the conjunction *whether*:

- whether the customers complied or not with the rule;
- whether they must perform an action etc.

Instead, the instructions presented with the appropriate deontic formulation of the rule eliminated the reference to hypothetical state of affairs and referred to distinct classes of people, even though they implicitly assumed that some classes may be empty (i.e. if all the customers had taken out medical insurance, then the class of those who must take it was empty). Consequently, in this study the effect of appropriate deontic rule formulation could have been added to the effect of removing the reference to the hypothetical state of affairs in favor of the reference to classes of events.

In order to avoid these misinterpretations, we carried out a second study in which we left out the variables that clearly did not affect performance and contrasted the hypothesis about the rule formulation with the hypothesis about the type of violation, after ameliorating the manipulation of experimental conditions.

STUDY 1. FREQUENCIES OF CARD SELECTIONS IN THE SIXTEEN EXPERIMENTAL CONDITIONS (N = 30 FOR CONDITION)

	Prescription (affirmative) rule								Prohibition (negative consequent) rule							
	Intentional violation				Accidental violation				Intentional violation				Accidental violation			
	Rule Inst		Action Inst		Rule Inst		Action Inst		Rule Inst		Action Inst		Rule Inst		Action Inst	
	C F	D F	C F	D F	C F	D F	C F	D F	C F	D F	C F	D F	C F	D F	C F	D F
p not-q	12	22	13	19	17	21	16	21	4	5	1	5	6	1		2
p q	6	4	5	3	6	3	3	3	12	17	12	19	11	19	11	22
p	2	1	4	3	1	1	8	1	7	4	7	1	6	4	7	4
not-q	1	1	3		1		1	2	1	3		1	2			
q	4			1	2	4	1	1	1		5	3		1	4	
p q not-q	4	1	4	3	2	1	1	2	1		1		3	2	3	1
others	1	1	1	1	1				4	1	4	1	2	3	5	1

## Legend

Rule Inst: Instructions focused on the rule

Action Inst: Instructions focused on the action requested or prohibited by the rule

C F: Conditional formulation

D F: Appropriate deontic formulation

TABLE II

STUDY 1. PERCENTAGE OF CORRECT ANSWERS AS A FUNCTION OF TYPE OF RULE, RULE FORMULATION, TYPE OF VIOLATION AND EXPERIMENTAL INSTRUCTIONS

	Prescription (affirmative) rule				Prohibition (negative consequent) rule			
	Intentional violation		Accidental violation		Intentional violation		Accidental violation	
	Instructions focused on the rule	Instructions focused on the action	Instructions focused on the rule	Instructions focused on the action	Instructions focused on the rule	Instructions focused on the action	Instructions focused on the rule	Instructions focused on the action
Conditional formulation	40	43	57	53	40	40	37	37
Appropriate deontic formulation	73	63	70	70	57	63	63	73

## IV. STUDY 2

## Method

## A. Design and Participants

The 2 X 2 research design involved the manipulation of two between-subjects variables: formulation of the rule (conditional vs. appropriate deontic) and type of violation (intentional vs. accidental).

Two hundred and forty undergraduates, with no knowledge of logic or psychology of reasoning, participated in the study as unpaid volunteers. Their age ranged between 18 and 32 (M = 22,11; SD = 2,75). Participants were randomly assigned to one of the four experimental condition (n = 60 for each experimental condition).

## B. Material and Procedure

In this study we have considered only the prescription rule and have uniformed the instructions by focusing them on the action requested by the rule and using the same format for all the experimental conditions.

Like in experiment 1, a short story set in a travel agency introduced each selection task. All the stories had the same structure and two sources of variation. They had been

preliminarily tested with 10 undergraduates to prove their level of comprehensibility. The protagonist, an agency employee, had to check whether all departing customers have complied with the rule “If a traveler wants to go to Tokyo, then he/she must pay 100 euros more on flight price” (conditional formulation), or “To go to Tokyo, one must pay 100 euros more on flight price” (appropriate deontic formulation). Customers were aware of a possible rise in price when buying the package tour. Nevertheless, they also knew that the contract with the travel agency established that if they don’t pay this surcharge within a certain period before departure, it would be paid by the travel agency. Customers had been informed of the price rise (intentional violation) or could not have been informed of it (accidental violation). Note that customers that had been informed of the price rise also knew that if they were not discovered within a short time, they would not be required to pay the surcharge.

In order to find out whether customers complied with the rule, the travel agency employee had to examine four piles of departing clients’ paper files. Each paper file bore on one side the personal data of customers with their travel destination and, on the other side, the information about the surcharge payment. Some paper files had been sorted according to travel destination, others according to the information about the surcharge payment.

In all the tasks, participants were asked to indicate which paper files the travel agency employee should turn over in order to determine whether there were customers who had to pay the surcharge.

The cards presented stood for the piles of customers' paper files. They were randomized across participants. One instance of the cards presentation was the following:

Destination: Tokyo	Other destinations	Surcharge: paid	Surcharge: not paid
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### C. Results

In table III the frequencies of card selections in the four experimental conditions were reported.

The responses were preliminarily classified as correct (*p* and *not-q*) and incorrect (all the others), as it is shown in table IV. Thus they were analyzed through a 2 x 2 ANOVA (rule formulation x type of violation). Once again results showed only the main effect due to the rule formulation ( $F = 9,113$ ;  $df = 1,236$ ;  $p < 0,001$ ). The appropriate deontic formulation of the rule produced a higher percentage of correct answers than the conditional formulation (54% vs.35%).

TABLE III  
STUDY 2. FREQUENCIES OF CARD SELECTIONS IN THE FOUR  
EXPERIMENTAL CONDITIONS (N = 60 FOR CONDITION)

	Intentional violation		Accidental violation	
	C F	D F	C F	D F
p not-q	20	32	21	33
p q	11	7	15	5
p	14	5	10	7
not-q	5	5	5	6
q	1	6	1	1
p q not-q	3			1
q not-q			3	1
all cards	2		1	4
others	4	5	4	2
all cards	2		1	4
others	4	5	4	2

C F: Conditional formulation

D F: Appropriate deontic formulation

TABLE IV  
STUDY 2. PERCENTAGE OF CORRECT ANSWERS AS A FUNCTION OF RULE  
FORMULATION AND TYPE OF VIOLATION

	Intentional violation	Accidental violation
C F	35	35
D F	53	55

C F: Conditional formulation

D F: Appropriate deontic formulation

### D. Discussion

Results support the hypothesis on the appropriate deontic formulation of the rule. The facilitation effect due to the logical-linguistic factor still remains after disentangling it from the potential effect due to the experimental instructions. On the contrary, these results are incompatible with social contract

theory. Like in the previous experiment, the prediction that the "look for cheaters" algorithm discriminates between intentional violators and accidental violators has not been corroborated, despite the fact that in this study the cheaters were better defined than in previous study.

### V. CONCLUSION

Both studies support our hypothesis about the appropriate formulation of deontic rules. Removing the dyadic operator "if...then" from the rule formulation and presenting it in a linguistically more proper way to indicate a monadic operator makes it easier to comprehend its logical status and thus facilitates performance (66,7% vs. 43,3% in study 1; 54% vs. 35% in study 2). To our knowledge, these are the first studies that test the role of this logical-linguistic factor. Our results suggest that its importance is larger than current tendencies in reasoning literature tend to admit. Nevertheless, we are aware that this evidence should become more robust and well documented before drawing any theoretical considerations about the nature of deontic reasoning. Further research should investigate this phenomenon more exhaustively and test the role of appropriate formulation for other types of deontic rules. Moreover, further studies should be addressed to separately investigate the effect of the reference to classes of events instead of the reference to hypothetical state of affairs in experimental instructions. In our first study this effect was tested together with the effect of the appropriate formulation; in the second it has been left out. Our results challenge the prediction of the social contract theory that people's innate ability to detect cheaters is influenced by mental state attributions. Rather, they seem to propose that the "look for cheaters algorithm" is not "evolved" enough to differentiate between intentional and accidental violators. This finding remains constant also after clarifying that the intentional violation of the rule implied the benefit acceptance without paying the cost, as we have done in study 2.

Our results also fail to support the previsions drawn from relevance theory according to which increasing cognitive effect and decreasing cognitive effort should ameliorate performance in selection task. Although the instructions focused on the action were supposed to require less cognitive effort and stress the pragmatic relevance of the task, they don't facilitate the production of correct answers compared to the instructions focused on the rule (55.4% vs. 54.6%). The lack of facilitating effect can be attributed to the particular structure of selection task with deontic statements which requires to reason from a rule. As relevance theorists argue [19] [20], detecting possible violators of a rule makes *p* and *not-q* instances (or *p* and *q* for negative consequent rules) automatically relevant. Thus, one could infer that further manipulations to make these instances more relevant are useless and do not produce any effect. However, it should be noted that in our studies the violation-detection effect has not been found: the conditional formulation of a deontic rule is far from triggering their potential violators. In fact, an unexpected and surprising finding emerged from this research is the poor production of correct answers (43.3% in study 1; 35% in study 2) elicited by standard social contract rules presented with conditional formulation.

Generally, selection tasks with this type of rules produce 60% to 95% of correct answers (for a review see [5] [21]). Very few studies, carried out to challenge the evolutionary hypothesis of domain-specific modules of reasoning, have shown lower percentages of answers [23] [24]. Nevertheless, the experimental manipulations enabling to modify the original tasks used by Cosmides and her colleagues [14] [21], and thus weaken people's performance, were not present in our studies. For example, in order to demonstrate that the facilitating effect of social contract rules is due to relevance intuitions, Carlisle and Shafir [23] "weighed down" a selection task originally tested by Cosmides - eliciting 75% of correct answers - by making the scenario intricate and ambiguous. The task modified in this way produced only 37% of correct answers, i.e. a result almost similar to our findings. Our tasks, however, were not intricate and difficult to understand, as pre-tests had shown. In the study of Noveck *et al.* [24] - where Cosmides' original task has been manipulated in order to separate the factors enabling to transform a deontic selection task into a social contract task (i.e. the cost-benefit information and the rule enforcement information) - results have shown that high performance was partially due to irrelevant information, but also that at least half of the correct responses derived by the cost-benefit information. Nevertheless, in our second study, where the latter information were clearly specified, the results obtained with the conditional formulation of the social contract rule were even lower than in the first study, where this information could be more ambiguous.

In sum, our results seem to challenge both the hypothesis of a cheater-detection evolutionary module and the hypothesis of a structural "facility" of deontic reasoning, due to a pragmatic search of the instances violating the rule. They only support the idea that the more appropriate linguistic formulation of a deontic rule enhances the production of falsifying responses. At present, the available evidence does not still allow to establish whether this effect occurs because the proper linguistic formulation makes the different logic form between a deontic and a conditional rule explicit.

Future research is needed to further investigate this hypothesis.

#### REFERENCES

- [1] P. C. Wason, "Reasoning," in *New horizons in psychology*, B. Foss, Ed. Harmondsworth: Penguin, 1966, pp. 135-151.
- [2] P. C. Wason, "Reasoning about a rule," *Quarterly Journal of Experimental Psychology*, vol. 20, no. 3, pp. 273-281, 1968.
- [3] J. St. B. T. Evans, "Matching bias in conditional reasoning: Do we understand it after 25 years?," *Thinking and Reasoning*, vol. 4, no. 1, pp. 45-110, 1998.
- [4] J. St. B. T. Evans, "Logic and Human Reasoning: An assessment of the deduction paradigm," *Psychological Bulletin*, vol. 128, no. 6, pp. 978-996, 2002.
- [5] D. Cummins Della Rosa, "Evidence for the innateness of deontic reasoning," *Mind & Language*, vol. 11, no. 2, pp. 160-190, 1996.
- [6] K. I. Manktelow and J. St. B. T. Evans, "Facilitation of reasoning by realism: Effect or not-effect?," *British Journal of Psychology*, vol. 70, pp. 477-488, 1979.
- [7] P. C. Wason and D. Shapiro, "Natural and contrived experience in a reasoning problem," *Quarterly Journal of Experimental Psychology*, vol. 23 pp. 63-71, 1971.
- [8] R. A. Griggs and J. R. Cox, "The elusive thematic-materials effect in Wason's selection task," *British Journal of Psychology*, vol. 73, no. 3, pp. 407-420, 1982.
- [9] P. N. Johnson-Laird, P. Legrenzi, and M. S. Legrenzi, "Reasoning and a sense of reality," *British Journal of Psychology*, vol. 63, pp. 395-400, 1972.
- [10] A. Noveck, "To what extent do pragmatic reasoning schemas affect performance on Wason's selection task?," *The Quarterly Journal of Experimental Psychology A*, vol. 49, no. 2, pp. 463-489, 1996.
- [11] N. Liberman and Y. Klar, "Hypothesis testing in Wason's selection task: Social exchange cheating detection or task understanding," *Cognition*, vol. 58, no. 1, pp. 127-156, 1996.
- [12] P. W. Cheng and K.J. Holyoak, "Pragmatic reasoning schemas," *Cognitive Psychology*, vol. 17, no. 4, pp. 391-416, 1985.
- [13] K. J. Manktelow and D. E. Over, "Deontic Thought and the selection task," In *Lines of thought: Reflections on the psychology of thinking*, K. J. Gilhooly, M. Keane, R. Logie, and G. Erdos, Eds. Chichester: Wiley, 1990.
- [14] L. Cosmides, "The logic of social exchange: Has natural selection shaped how humans reason? Studies with the Wason Selection Task," *Cognition*, vol. 31, no. 3, pp. 187-276, 1989.
- [15] L. Cosmides and J. Tooby, "Neurocognitive adaptations designed for social exchange," in *Evolutionary Psychology Handbook*, D. M. Buss, Ed. New York: Wiley, 2005, pp. 584-627.
- [16] L. Cosmides and J. Tooby, "Cognitive adaptations for social exchange," in *The adapted mind*, J. Barkow, L. Cosmides, J. Tooby, Eds. New York: Oxford University Press, 1992, pp. 168-228.
- [17] L. Fiddick, "Domains of deontic reasoning: Resolving the discrepancy between the cognitive and moral reasoning literatures," *The Quarterly Journal of Experimental Psychology A*, vol. 57, no. 4, pp. 447-474, 2004.
- [18] M. Nuñez and P. Harris, "Psychological and deontic concepts: Separate domains or intimate connection?," *Mind & Language*, vol. 13, no. 2, pp. 153-170, 1998.
- [19] D. Sperber, D. Cara, and V. Girotto, "Relevance theory explains selection task," *Cognition*, vol. 57, no.1, pp. 31-95, 1995.
- [20] V. Girotto, M. Kimmelmeyer, D. Sperber, J. van der Henst, "Inept reasoners or pragmatic virtuosos? Relevance and the deontic selection task," *Cognition*, vol. 81, no. 2, pp. B69-B76, 2001.
- [21] L. Fiddick, L. Cosmides, and J. Tooby, "No interpretation without representation: The role of domain-specific representations and inferences in the Wason selection task," *Cognition*, vol. 77, no.1, pp. 1-79, 2000.
- [22] D. Sperber and V. Girotto, "Use or misuse of the selection task? Rejoinder to Fiddick, Cosmides, and Tooby," *Cognition*, vol. 85, no.3, pp. 277-290, 2002.
- [23] E. Carlisle and E. Shafir, "Questioning the cheater-detection hypothesis: new studies with the selection task," *Thinking & Reasoning* vol. 11, no. 2, pp. 97-122, 2005.
- [24] I. A. Noveck, H. Mercier, and J.-B. Van Der Henst, "To what extent do social contracts affect performance on Wason's Selection Task," in *Against extreme domain specificity*, M. Roberts, Ed. Hove, UK: Psychology Press, 2007. Available: <http://l2c2.isc.cnrs.fr/publications/files/Noveck-Mercier-VDHenst.pdf>
- [25] J. Fodor, (2000). *The mind doesn't work that way: The scope and limits of computational psychology*. Cambridge: MIT Press, 2000.
- [26] D. J. Buller, "Evolutionary psychology: The emperor's new paradigm," *Trends in Cognitive Science*, vol. 9, no. 6, pp. 277-283, 2005.
- [27] H. P. Grice, (1975). "Logic and conversation," in *Syntax and semantics*, vol. 3: *Speech acts*, P. Cole, J. Morgan, Eds. New York: Academic Press, 1975, pp. 41-58.