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ORIGINAL ARTICLE

Conditionals and conditional thinking

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Abstract In this paper, we claim that the problem of conditionals should be dealt with by carefully distinguishing between thinking conditional propositions and conditional thinking, i.e. thinking on the basis of some supposition. This distinction deserves further investigation, if we are to make sense of some old and new experimental data concerning the understanding and the assertion of conditional sentences. Here we will argue that some of these data seem to refute the mental models theory of conditional reasoning, setting the ground for a different approach to the cognitive study of conditionals.

Keywords Conditionals · Conditional probability · Assertability · Ramsey's test · Reasoning · Mental models

1 Representation and understanding of conditionals

In the ''Stanford Encyclopedia of Philosophy'', on the term *conditional* Dorothy Edgington says:

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> Take a sentence in the indicative mood, suitable for making a statement: ''We'll be home by ten'', ''Tom cooked the dinner''. Attach a conditional clause to it, and you have a sentence which makes a conditional statement: ''We'll be home by ten if the train is on time'', ''If Mary didn't cook the dinner, Tom cooked it''. A conditional sentence ''If *A*, *C*'' or ''*C* if *A*'' thus has two contained sentences or sentence-like clauses. *A* is called the antecedent, *C* the consequent. If you understand *A* and *C*, and you have mastered the conditional construction (as we all do at an early age), you understand ''If *A*, *C*''. What does ''if'' mean? Consulting the dictionary yields ''on condition that; provided that; supposing that''. These are adequate synonyms. But we want more than synonyms. A theory of conditionals aims to give an account of the conditional construction which explains when conditional judgements are acceptable, which inferences involving conditionals are good inferences, and why this linguistic construction is so important. Despite intensive work of great ingenuity, this remains a highly controversial subject (Edgington 2001).

One cannot but agree with the last statement by Edgington. In the last few years many contributions have dealt with conditionals, and many different theories have attempted to clarify how individuals use conditional sentences: yet, all these theories have been less than successful, and none has prevailed upon the others (for reviews see Edgington 1995).

In the present paper we do not put forward a new logical theory of conditionals; neither do we propose a new psychological theory of them—one that attempts to account for the many different ways in which people assert and evaluate conditional statements. Our goal is less ambitious: we will discuss the psychological problem of how individuals understand conditionals, but only by identifying the minimal constraints imposed upon their assertion and evaluation. These constraints could help to define the core of a cognitive theory of conditional's use and evaluation.[1]

A specific conjecture that we will take into account is that there are some conditional sentences that are understood, and yet they are not considered totally defined, i.e. to be such that for any truth-values of the antecedent and the consequent, they have a definite truth-value.[2] It is indeed quite easy to show that some conditional sentences are understood with reference to some, but not all, couples of truth-values for the antecedent and the consequent. Before presenting data and arguments in order to corroborate and further specify this core idea, let us remark that many theories seem to claim that such a phenomenon is only apparent. For example, the treatment of conditionals

[1] Ours will be a Popperian approach: we will take into account some hypotheses that are suggested, without being proved, by empirical data, and we will defend their plausibility by arguing that they can explain some features and phenomena that other accounts do not manage to explain.

[2] From a Popperian perspective, the existentially quantified hypothesis that some conditionals are understood without being totally defined is unfalsifiable, but it could be proved; if proved (as indeed it seems possible), its negation would be falsified, a relevant result in itself.

within mental models theory, developed by Johnson-Laird and Byrne, holds that conditionals are implicitly taken to have a value in any case.

In mental models theory the model for a conditional like ''if p then q'' is:

p q
...

where the three dots (ellipsis) stand for the other possibilities consistent with the truth of the conditional, that are not explicitly represented. The ellipsis distinguishes a conditional from a conjunction (Johnson-Laird and Byrne 2002).

The implicit models can be made explicit (*fleshed out*) and the result of the *fleshing out* is the following set of models:

p q
¬ p q
¬ p ¬ q

Johnson-Laird wrote: «People realize that there are other possibilities consistent with the conditional [...]. But [...] they do not represent them explicitly» (Johnson-Laird 2000, p. 34). However, are we sure that people realize that there are ''other possibilities consistent with the conditional''? As we will point out, there is experimental evidence that *some conditional sentences are not considered to have a truth-value, not even implicitly*.

In an excerpt from *Deduction* Johnson-Laird and Byrne seem to be quite close to a conception of conditionals that does not presuppose that they have a definite truth-value for any truth-values of the antecedent and the consequent. They state:

> the function of an antecedent is to establish a context, i.e. a state of affairs to be presupposed in interpreting the consequent [...]. The consequent is interpreted in a context where the antecedent is presupposed, and so the conditional has nothing to say—at least initially—about any alternative where the antecedent fails to hold [...]. When the truth of a conditional is assessed in a situation where its antecedent is false, it is judged to be ''irrelevant'', because the models:
>
> [•] ▲
> ...
>
> do not specify anything explicitly about a situation in which there is no circle (Johnson-Laird and Byrne 1991, pp 66–67).

Johnson-Laird and Byrne's idea is correct: the conditional seems to say nothing about a situation with respect to which the antecedent is false. Then why not refer only to what is explicitly specified? Nothing at all is said about a situation in which the antecedent is false. So why take the conditional as implicitly evaluated as true in respect of this? The assignment of truth is well motivated from a logical point of view, but why should this be something

belonging to the logical competence of the human mind? Johnson-Laird and Byrne's idea that the conditional is taken to say nothing about a situation in respect of which the antecedent is false might suggest, against Johnson-Laird and Byrne's intentions, that when the antecedent is represented as false, the conditional is taken to lack a truth-value. Such a hypothesis is inconsistent with the claim that people ''realize'', by making a mysterious mental note, that there are other possibilities, which are not explicitly represented (models where the antecedent is false) making the conditional true.[3]

If we reject the idea that people have an implicit knowledge of the completely defined notion of conditional, suggested by the characterization of the corresponding logical connective by means of the well known truth table, we might think that people have, or also have, a different, incomplete notion of conditional, a notion such that some conditional sentences are taken to lack a truth-value when the antecedent is represented and judged false.

The idea that individuals could have an incomplete notion of conditional, implying that some conditionals might exist that are not considered to have a truth-value, not even implicitly, is corroborated by experimental data showing that people consider conditionals with false antecedents to be ''irrelevant''. One of the paradigms used is the truth table task, in which people are asked to classify truth table cases with regard to a conditional statement. If asked to determine whether such cases are true, false or irrelevant, people frequently classify FT and FF cases as irrelevant (Evans and Newstead 1977). The basic idea underlying those experiments is the notion that some conditionals have a *defective truth table*; this has received some support in the psychological literature. This proposal was originally put forward by Wason (1966), who argued that conditionals with false antecedents were psychologically irrelevant. Evans (1972) found that people asked to exhaustively represent the cases consistent with a conditional and the cases that contradicted it, systematically omitted false-antecedent cases in both tasks.

The findings of the following experiment are consistent with the idea that the notion of conditional is not completely defined, at least in some instances. They also provide evidence against the mental models' account of condi-

[3] Asserting that there are alternative implicit models representing conditionals with a false antecedent implies asserting that the conditional can be considered true in cases where the antecedent is false. The evaluation of the false-antecedent cases would be less immediate than the evaluation of the true-antecedent case, because it deals with implicit models. In other words, the theory does not set any constraint concerning the possibility to evaluate conditionals; it simply posits that in some cases—the false-antecedent cases—the evaluation is harder, because those cases are less accessible to cognition than the true-antecedent case. From this perspective, Johnson-Laird's account of conditionals' comprehension is not very different from the typical view of reasoning errors proposed by mental-rules theories. Actually, Lance Rips in *Psychology of Proof* (1994) states that: «people are not always successful in producing a mental proof [...] for every deductively correct argument (relative to some logic system). They may not possess or may not be able to apply an inference rule that is crucial for a particular proof. Resource limitations—for example, capacity restrictions in working memory—may keep them from completing a proof» (Rips 1994, p. 103). That is, according to Rips it is possible that some rule is not immediately available, in much the same way as, according to Johnson-Laird, reasoning errors occur when people forget about the existence of implicit models.

tionals, by showing that some instances of conditional sentences are not judged as accurate a description of a set of situations as their equivalent disjunctions and negated conjunctions.

2 Experiment 1

In this experiment we presented the participants with a set of cards representing the three cases in which a standard conditional is true, and six sentences; of these, three sentences (a conditional, a disjunction, and a negated conjunction) correctly described the set; the remaining three sentences (again a conditional, a disjunction and a negated conjunction) incorrectly described it. The participants had to choose one or more sentences that correctly described the set of cards, ranking them according to their order of choice.

2.1 Method

2.1.1 Participants

Eighty-five undergraduates from the University of Padova participated in the experiment. None of them had taken any previous course in logic or psychology of reasoning.

2.1.2 Materials and procedure

After informed consent, a five-page booklet was handed out to the participants. The instructions on the first page read:

> *In the following four problems imagine that I have a deck of six cards, each one representing a geometrical figure. Do not assume that the figures on the six cards are all different: it may be that two or more cards have the same figure on them. I will display the cards in front of you as a set of three hands of two cards each. I will not display the cards at random; rather, I will follow a specific criterion that you have to identify by choosing the sentence or sentences that, in your view, correctly describe the display. If you choose more than one sentence, rank them according to their order of choice (e.g. first choice, second choice, etc.). Each problem is different: try not to be affected by considerations regarding other problems when responding to a problem.*

Each of the following four pages reported a different display of cards and six sentences. Three sentences (a conditional, its equivalent disjunction, and its equivalent negated conjunction) correctly described the display. The other three sentences (a conditional, a disjunction, and a equivalent negated conjunction) did not describe the display correctly. Four problems were used so as to balance the presence of negations in the correct conditional sentences (and, by consequence, also in the other sentences): e.g., if the correct conditional

sentence in problem 1 was ''if p then q'', in the remaining three problems it was ''if p then not q'', ''if not p then q'', and ''if not p then not q'', respectively. This manipulation partly counterbalanced the linguistic complexity of the conditional, disjunctive and negated conjunctive sentences. Figure 1 is an example of a problem whose correct conditional sentence does not involve negations.

2.2 Results and analyses

The ranking of the chosen correct sentences was recoded into preference scores: first choice = 3, second choice = 2, third choice = 1.

The mean preference score was 1.0 for conditional sentences, 1.1 for negated conjunctions, and 1.6 for disjunctions. The preference score for disjunctions was reliably higher than the preference score for conditionals ($p < 0.0001$) and for negated conjunctions ($p < 0.01$). Preference scores for negated conjunctions and conditionals were not reliably different. Table 1 shows the frequency of selection of each correct sentence as first, second, or third choice (in percentages): disjunctions were selected as first choice reliably more frequently than conditionals and negated conjunctions ($p < 0.01$).

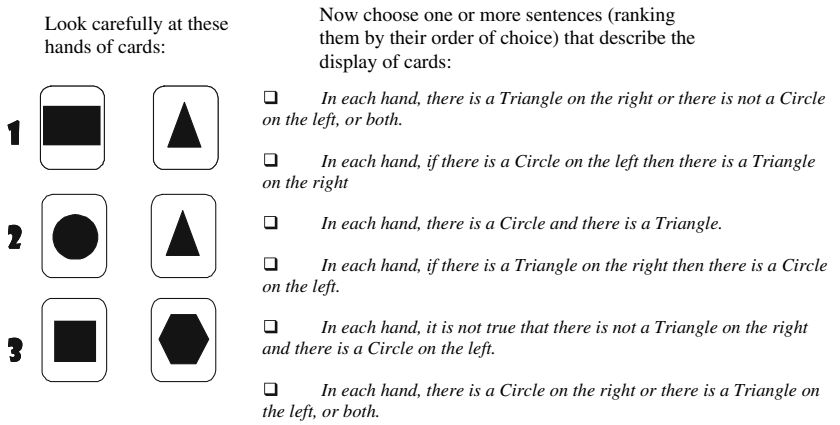

Fig. 1 Example of a typical problem in Experiment 1

Table 1 Percentages of choice for each correct sentence

Choice	Sentences		
	Conditional	Negated conjunction	Disjunction
First choice	23	22	47
Second choice	15	16	9
Third choice	4	9	15
Not selected	59	53	42

2.3 Discussion

The results show that disjunctions are preferred to conditionals (and to negated conjunctions) when describing three hands of cards that exactly match the true cases of a standard conditional (true antecedent—true consequent, false antecedent—true consequent, false antecedent—false consequent).

This finding is not consistent with mental models theory. Actually, the information required in order to represent the three logical possibilities consistent with each sentence was directly available to the participants, conveyed by the diagrams showing the display of cards: hence, according to mental models' perspective, the three types of sentences should have been regarded as equally proper descriptions of the display of cards. However, this was not the case. Since performance failures in this task could not be accounted for by the difficulty of explicitly representing all the possible instances consistent with a conditional, the results suggest that, rather than having difficulties in representing explicitly some instances, people seems to have difficulties in realizing that those instances, once they have been made explicit, are correctly represented by a true conditional. In other words, some people involved in evaluating conditionals, in at least some situations, behave as though they did not grasp a totally defined notion of conditional.

In the cognitive and philosophical literature there are some hints that some conditionals with a false antecedent are not considered to have a truth-value; however, these hints were never fully specified, because of some intrinsic difficulties. One of these difficulties is the following. There must be instances of conditionals that are considered true even when their antecedent is false. For example, a sentence like ''If Paolo is not in Milano, he is in Padova'', can be taken as true also when Paolo *is* in Milano.[4] Since there are utterances of conditional statements of both sorts, how can we discriminate the ones having a truth status when the antecedent is false from the ones without? Let us go back to the results of Experiment 1. In that experiment, people asked to describe a display of cards that mirrored the truth table of a conditional preferred disjunctions over conditionals. Why is this so? The result cannot follow from linguistic complexity alone, because, if anything, the disjunctions used in the experiment appeared to be more complex than the corresponding conditionals (furthermore, rotating negations in the conditional sentences had the effect of balancing the complexity of the three types of sentences across the experiment). A possible reason is that, for some participants, the conditional sentences could not be asserted because of the instances with a false antecedent (two hands of cards out of three). That is, whilst the disjunctive and negated conjunctive statements *seem* to refer to the three hands of cards, the conditional statement seems to refer to one hand only, the one that satisfies the antecedent; it seems to say nothing about the two hands that do not

[4] Not in every circumstance. If it is known that Paolo is always in Milano, and with it the thought that he may go or stay in Padova cannot be entertained, then the statement is perceived as weird, and, possibly, it would not be asserted.

satisfy the antecedent. The previous argument suggests that the conditionals that do not have a truth-value when their antecedent is false are those conditionals that cannot be asserted because of the known falsity of their antecedent. More precisely, the two following constraints seem to identify the conditionals that do not have a truth-value when their antecedent is false: (a) they are thought of as sentences to be typically used to make assertions; (b) their assertion is identified with the assertion of their consequent under the condition that the antecedent is true, in the sense that the commitment in the assertion concerns only the consequent and is made only in respect of the circumstance in which the antecedent is true. As a consequence of (b), no proposition, constituted by the propositions expressed by the antecedent and the consequent, is asserted.

The identification of the assertion of a conditional with a conditional assertion was first stated by Quine (1952) in the following terms:

> an affirmation of the form 'if p then q' is commonly felt less as an affirmation of a conditional than as a conditional affirmation of the consequent. If, after we have made such an affirmation, the antecedent turns out true, then we consider ourselves committed to the consequent, [...]. If on the other hand the antecedent turns out to have been false, *our conditional affirmation is as if it had never been made* (Quine 1952, p. 12, italics added).

Here Quine is speaking of the common way of using and understanding conditionals. So he is stating a general thesis. We do not endorse it in its full generality. In our opinion (a) and (b) do not characterise the common understanding of *all* conditionals in *all* circumstances. For example, let us consider again the sentence ''If Paolo is not in Milano, he is in Padova''. It doesn't seem that its affirmation is taken to be as never made if it turns out that Paolo is in Milano.

It should be pointed out that thesis (b), like Quine's, not only implies that asserting a conditional involves a conditional commitment to the consequent, but also involves no other commitment. At least the positive aspect of thesis (b) can be experimentally supported. Conditionals are spontaneously preferred when coping with an assertion task. This is made quite evident by some new experimental data.

3 Experiment 2

In this experiment we first showed the participants three cards representing the true cases of a standard conditional, and then asked them to answer a question concerning the presence of a figure (corresponding to the consequent of a conditional consistent with the cards) on a specific card drawn at random. As in the previous experiment the participants were offered six possible answers: two conditionals (correct and incorrect), two disjunctions (correct and incorrect), and two negated conjunctions (correct and incorrect). According to

the conjecture that people use conditional sentences to conditionally assert their consequents, in this task they should prefer conditional sentences to disjunctive or negated conjunctive sentences.

3.1 Method

3.1.1 Participants

Nineteen undergraduates from the University of Padova. None of them had taken any previous course in logic or psychology of reasoning.

3.1.2 Materials and procedure

After informed consent, a five-page booklet was handed out to the participants. The general instructions were on the first page. Each of the following four pages reported a problem, with specific instructions, a display of cards, and the six possible answers. An example problem follows.

> *Imagine that a person displays in front of you the following cards. The two sides of each card are separated by a line and coded by a letter: A side and B side. Both sides represent a geometrical figure. Please scan the cards accurately* (Fig. 2).
> *Now, the same person shuffles the three cards, draws one of them at random, without looking at its contents and without showing them to you, and asks you: ''is there a Circle on the B side of the drawn card?''*

Please answer the question by choosing one of the following sentences:

- There is a Circle on side B, or there is not a Square on side A, or both.
- It is not true that there is a Square on side A and not a Circle on side B.
- If there is a Square on side A then there is a Circle on side B.
- There is a Circle on side B or there is not Triangle on side A, or both.
- It is not true that there is a Triangle on side A and not a Circle on side B.
- If there is a Triangle on side A then there is a Circle on side B.

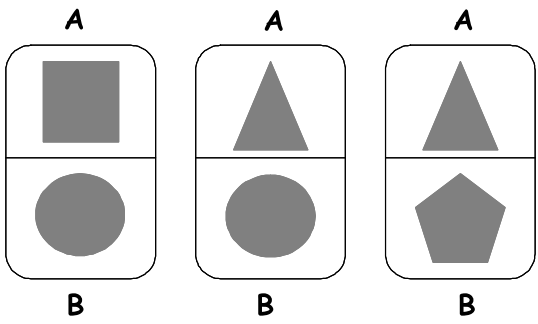

Fig. 2 Example of a typical problem in Experiment 2

Three out of the six response sentences (a conditional, its equivalent disjunction, and its equivalent negated conjunction) were correct. The other three sentences (a conditional, its equivalent disjunction, and its equivalent negated conjunction) were incorrect. The presence of negations in the antecedent and consequent of the correct conditional sentence was counterbalanced across the four problems, as in the first experiment.

3.2 Results and analyses

A score for each correct answer was assigned to each participant, corresponding to how many times that answer was selected in the four problems; incorrect answers were not considered: e.g., if a participant chose the conditional correct sentence in two problems, the correct negated conjunction in one problem, and an incorrect answer in the remaining problem, he or she would score 2 for conditional sentences, 1 for negated conjunctive sentences, and 0 for disjunctive sentences.

The mean score for the conditional sentences (1.53) was reliably higher ($p < 0.01$) than the mean score for the negated conjunctive sentences (0.68) and for the disjunctive sentences (0.68). The trend was quite consistent across participants: 13 participants out of 19 gave higher ratings to conditionals than to disjunctions ($p < 0.05$), and 12 participants out of 19 gave higher ratings to conditionals than to negated conjunctions ($p < 0.05$). The results show that, in this task, conditional sentences were considered a more proper sort of utterance than disjunctive or negated conjunctive sentences.

3.3 Discussion

The previous findings suggest a strict dependency between uttering a conditional sentence and having to conditionally assert its consequent (an assertion that, in the previous task, was required in order to answer a direct question). Moreover, contrary to Quine, the assertion is not considered cancelled if the antecedent turns out to be false (e.g., in the previous task, the sentence ''if there is a Square on side A then there is a Circle on side B''). Of course there is an exception, that can be illustrated by a ''thought experiment'': imagine that none of the cards shown to the participants had a square on it; in that case, the conditional ''if there is square on side A then there is a circle on side B'' would not have been considered correct. In summary, there is a strict dependency between uttering a conditional sentence and having to conditionally assert its consequent, with the restriction that a consequent would hardly ever be asserted by conditioning it to an antecedent acknowledged as false in all possible instances.

These remarks show that the results of the experiment do not prove that the conditional is considered non assertable, when the antecedent is false or, more precisely, non assertable because it lacks a truth value. It is clear that the conditional form is understood as a form of assertion but not that, in general, the assertion is taken as cancelled if the antecedent turns out to be false.

What exactly is compatible with our experimental results must be further investigated. If the propositions are considered as entities which in every case bear a truth-value, we can conclude that sometimes the conditionals are used to make conditional assertions and not to assert conditional propositions.[5] It is trivial to point out that, if the antecedent is true, in a non-probabilistic and not non-monotonic interpretation, the assertion is correct only if the consequent is true, and is incorrect if the consequent is false. As has already done, it is possible to think of a notion of conditional that is respectively true or false in such cases, and that does not have a defined truth-value in the cases with false antecedent. We may wonder if a conditional assertion that is taken as cancelled when the antecedent is false could be identified with the assertion of proposition built by means of a conditional connective that is not defined when the antecedent is false. The answer is negative: the assertion is not cancelled by virtue of the falsity of the antecedent, but by achieving the belief that the antecedent is false. Any person who asserts that A given B is committed to A under the condition of B. Such commitment depends on the supposition of B and is compatible with the falsity of B: only the acquisition of the belief that B is false can cancel the commitment to A given B.[6] That's in a first conception of conditional assertion, but not necessarily in other conceptions of conditional assertion, where the supposition of B is admitted with reference to situations that can be different from the real one. In this case, the assertion might be cancelled by the piece of information that there is no circumstance in which the supposition B is true. Again, cancellation would not be the effect of the fact that there are no such circumstances, but of the beginning of a belief that there are no circumstances.

In other kinds of conditional assertion—for example, conditional assertions of the form ''A and not-A, given B'' or similar that conclude a reductio ad absurdum—the commitment involved in the assertion does not clearly presuppose the belief that the antecedent is possibly true. So, to acknowledge that there are no hypothetical situations in which B is true does not cancel the conditional assertion, but—rather—it is implied by it: what allows us to assert ''A and not-A, given B'' also allows us to recognize that there are no hypothetical situations in which B is true. Here we do not consider this kind of assertion, and we focus on those in which we assert A given B supposing that the class of hypothetical situations in which B is true is not empty and assuming that the assertion is cancelled if we acquire the belief that this class is empty. That conditional assertions should be in general so conceived that they could be suggested by a particular reading of the well known Ramsey test and could be exemplified by Dorothy Edgington's related suppositional theory. Both approaches describe the process through which we arrive at an evaluation and, eventually, to believe a conditional ''A if B'' and this is a process of the same kind as that which can lead us to the assertion of A given B.

[5] Precisely, conditional sentences that represent propositions.

[6] Of course, the commitment to A given B is compatible with the commitment to A given C, and one of them can be made void without making void the other.

4 Conditional thinking and the assertion of conditional propositions

Ramsey, who can be considered the father of suppositional theory, formulated the problem of the assertion of a conditional in these terms: «if two people are arguing 'If *p*, will *q*?' and are both in doubt as to *p*, they are adding p hypothetically to their stock of knowledge, and arguing on that basis about *q*; [...] they are fixing their degrees of belief in *q* given *p*» (Ramsey 1931, in 1990, p. 155). Here Ramsey seems to describe what is going on in a process which can lead to the assertion of a conditional. His description clearly shows that people suppose the antecedent and then focus on the consequent. Focusing on the first part of Ramsey's proposal and recasting it in representational terms, the question 'If p, will q?' is answered by building a mental model of a hypothetical situation where p is true, and by considering the status of q within that model. In building the model, the individual tries to build representations of q that can be integrated with the representation of p. Recasting Ramsey's test in terms of mental representations could be incorrect, if it is taken to suggest that the content of p can be represented. Actually, no constraints are imposed on the possibility to suppose p. Specifically, p is not required to be consistent, or to be at least minimally plausible, and Ramsey did not say that finding out that p is either inconsistent or implausible affects in any way the possibility to suppose it; hence, it does not affect the possibility of asserting q given p, or ''q if p''. However, minimal credibility of p seems to be required to conceive as possible that the credibility of q is increased by the supposition of p; furthermore, this requirement seems also to be involved by the intention—usually not a conscious one—to commit only to q and to no other proposition. According to this reading of Ramsey's test, finding out that p is inconsistent or utterly unlikely removes any commitment toward the assertion of q.

The suppositional theory is presented by Dorothy Edgington as a development of Ramsey's ideas. It concerns the «thought process by which we assess conditionals» and claims that «to assess a conditional [...] you *suppose* (assume, for the sake of argument) that the antecedent is true, and consider what you think about the consequent, under that supposition» (Edgington 2003, p. 384). Also in the suppositional theory, if we hold that the only commitment present when asserting q given p is the commitment to q under the hypothesis that p is true, then this commitment seems to disappear, and the assertion itself seems to be void, if the hypothesis is found to be inconsistent, or impossible, or utterly unlikely.

Therefore, a possible reading of Ramsey's test seems to indicate that a further constraint on asserting a conditional is the attribution of a non-zero degree of believability to the antecedent. This feature is made explicit in the probabilistic interpretation of the assertability condition of 'if p then q' in terms of probability of q given p. In two recent studies, Evans and Over analyze what it means, psychologically, that an individual hypothetically assumes the antecedent of a conditional, as suggested by Ramsey's test (Over and Evans 2003; Evans et al. 2003). They argue that that test coincides with the psychological process of building two mental models, one with both true

antecedent and consequent, and one with the antecedent true, and the consequent false (i.e. the first two rows of the conditional's truth table), and then comparing the probability of the first model, representing the pq situation, with the probability of the second model, representing the pq situation. That is, the individuals focus on the possible cases of true antecedent, and judge the plausibility of the consequent relatively to such cases; they completely disattend the possible cases in which the antecedent is false. According to this hypothesis, the probability of a conditional, P(if p then q) is bound to the conditional probability P(q/p). Individuals try to establish the conditional probability P(q/p) on the ground of the relative probabilities of p&q and p&q, that is P(p&q) and P(p&q). This account ends by concluding that in order to assert a conditional, people often reason about the probability of the consequent given the antecedent. Simplifying a bit, we can say that people assert the conditional when this probability is high.

Despite some misleading formulations, such an account implies that no conditional proposition is expressed and asserted in the assertion of a conditional sentence. Conceptual analysis is enough to show that no conditional proposition is really entertained and committed to in the process leading to the conditional assertion of the kind we are considering. This outcome agrees with a result by Lewis (1976), according to which it is *not possible* that:

$$P(\text{if } p \rightarrow q) = P(q/p)$$

where "if p $\rightarrow$ q" expresses a conditional proposition satisfying some reasonable assumptions.

Lewis' result suggests that we have to choose between a propositional theory of conditionals and a probabilistic, non-propositional, theory of conditionals. The first implies that the assertion of a conditional sentence is the assertion of a sentence expressing a conditional proposition, the latter that the assertion of a conditional is really only a conditional assertion. Yet, for what concerns the explanation of people's behaviour in asserting conditionals, we think that it is possible to avoid this choice, and to hold that some pieces of behaviour are better explained by appealing to one theory and some others to the other theory. Of course, at least three problems have to be dealt with. First, is there a way of discriminating when a theory of the first kind applies and when a theory of the other kind applies? Second, if people are, in different circumstances, engaged both in the activity of conditionally asserting and in that of asserting conditional propositions, how are these activities coordinated? Third, is it possible to assign cognitive priority to one of these activities, in the sense that one is based on a deeper entrenched capacity and the other is in some way developed from it?

We think that attribution of irrelevance or denial of a truth-value in case of antecedent taken as false might characterise the conditional assertion we are considering. However, this does not provide yet a completely general and precise answer to the first question. As concerns the second question, the coordination problem, it should first be investigated how the considered kind of

conditional assertion is related to the assertion of conditional propositions from a logico-normative perspective. It appears, for example, that the fact that some people assert a conditional when the conditional probability of the consequent given the antecedent is high cannot generally be justified in terms of propositional assertion. In order to get an equivalence, we already wondered whether it was possible to introduce a non completely defined notion of conditional and a corresponding notion of proposition built by means of such a connective. Our answer was negative: the conditional assertion is not cancelled just because the conditional proposition lacks a truth-value. However this problem needs to be further investigated. The third question might admit the following positive reply: the capacity of conditionally asserting something is primitive in respect of the formation of conditional propositions of various kinds, and the formation of a conditional quasi-proposition might occur at an intermediate stage. In other words any conditional connective might be a cognitively derived notion. The hypothesis that, sometimes, some individuals take asserting conditional sentences as conditionally asserting their consequents might be interpreted as a way of exercising a cognitively more basic capacity.[7]

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References

Edgington D (1995) On conditionals. Mind 104:235–329
Edgington D (2001) Conditionals. Stanford encyclopedia of philosophy. http://www.plato.stanford.edu/entries/conditionals/
Edgington D (2003) What if? Questions about conditionals. Mind Lang 18:380–401
Evans JStBT (1972) Interpretation and matching bias in a reasoning task. Q J Exp Psychol 24:193–199
Evans JStBT, Handley SH, Over DE (2003) Conditionals and conditional probability. J Exp Psychol Learn 29:321–335
Evans JStBT, Newstead SE (1977) Language and reasoning: a study of temporal factors. Cognition 5:265–283
Johnson-Laird PN (2000) Perché la logica non è un buon modello del ragionamento. In Cherubini P, Giaretta P, Mazzocco A (eds) Ragionamento: psicologia e logica. Giunti, Firenze, pp 109–135
Johnson-Laird PN, Byrne RMJ (1991) Deduction. Lawrence Erlbaum Associates, Hillsdale
Johnson-Laird PN, Byrne RMJ (2002) Conditionals: a theory of meaning, pragmatics, and inference. Psychol Rev 109:646–678
Lewis D (1976) Probabilities of conditionals and conditional probabilities. Philos Rev 95:581–589
Over DE, Evans JStBT (2003) The probability of conditionals: the psychological evidence. Mind Lang 18:340–358
Quine WVO (1952) Methods of logic. Routledge, London
Ramsey FP (1990) General propositions and causality (original publications, 1931). In: Mellor DH (ed) Philosophical Papers. Cambridge University Press, Cambridge, pp 145–163
Rips LJ (1994) The psychology of proof. MIT Press, Cambridge
Wason PC (1966) Reasoning. In: Foss BM (ed) New horizons in psychology. Penguin Books, Harmondsworth, pp 106–137

[7] The specification and the development of these ideas are left for another occasion.