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The suppression of Modus Ponens as a case of pragmatic preconditional reasoning

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The suppression of the Modus Ponens inference is described as a loss of confidence in the conclusion C of an argument "If A1 then C; If A2 then C; A1" where A2 is a requirement for C to happen. It is hypothesised that this loss of confidence is due to the derivation of the conversational implicature "there is a chance that A2 might not be satisfied", and that different syntactic introductions of the requirement A2 (e.g., "If C then A2") will lead to various frequencies in the derivation of this implicature, according to previous studies in the field of causal explanation. An experiment is conducted, whose results support those claims. Results are discussed in the light of the Mental Logic and Mental Model theories, as well as in the light of the pragmatic approach to uncertain reasoning.

INTRODUCTION

The "suppression effect" has been demonstrated in studies focusing on the use of conditional syllogisms (Byrne, 1989; Rumain, Connell, & Braine, 1983). This phenomenon, which was originally part of the theoretical debate between Mental Model theorists (Johnson-Laird & Byrne, 1991; Johnson-Laird, Byrne, & Schaeken, 1992) and Formal Inference Rules theorists (Braine, 1978, 1990; Braine & O'Brien, 1991; Rips, 1983, 1994), currently deserves special attention, for it has introduced into the well-documented field of conditional reasoning the notions that appear to be at the core of future debates in the psychology of reasoning.

Writing about the suppression effect, various authors evoked, for example, the influence of content (Vadeboncoeur & Markovits, 1999), the interpretative component in reasoning (Bonatti, 1994; Chan & Chua, 1994; Fillenbaum, 1993),

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and the uncertainty of conditional rules (Liu, Lo, & Wu, 1996; Over, 1993; Stevenson & Over, 1995; Politzer & Bourmeau, in press) as well as their non-monotonic dimension (George, 1997a). The suppression effect is briefly described in the next section. Then we introduce the directions research has taken concerning this effect.

The demonstration of the suppression effect

From a "major" conditional premise of the form "if A1, then C", four inferences can be derived depending on the "minor" premise added to the major one—Evans, Newstead, and Byrne (1993) have offered a synthesis of endorsement rate studies conducted by Evans (1977), Kern, Mirels, and Hinshaw (1983), Marcus and Rips (1979), Markovits (1988), Rumain et al. (1983), Taplin (1971), and Wildman and Fletcher (1977):

- With the minor premise "A1", to derive the Modus Ponens inference (MP) is to conclude "C". This inference is endorsed by 89–100% of participants.
- With the minor premise "non-C", to derive the Modus Tollens inference (MT) is to conclude "non-A1". This inference is endorsed by 41–81% of participants.
- With the minor premise "non-A1", to derive the Negation of the Antecedent inference (NA) is to conclude "non-C". This inference, which is considered a fallacy, is endorsed by 17–73% of participants.
- With the minor premise "C", to derive the Affirmation of the Consequent inference (AC) is to conclude "A1". This inference, which is considered a fallacy, is endorsed by 23–75% of participants.

A "suppression effect" is said to occur when the introduction of a second conditional premise of the form "if A2, then C" following "if A1, then C" leads to a significant decrease in the endorsement rate of one or more of these four inferences.

The suppression of NA and AC was demonstrated by Rumain et al. (1983)—see also Markovits (1984, 1985). Byrne (1989) in turn demonstrated the suppression of MP and MT. It seems that NA and AC are suppressed by the introduction of an "alternative condition", whereas MP and MT are suppressed by the introduction of an "additional condition". Consider the following conditional statement:

"*If Mary has an essay to write, then she will study late at the library.*"

One example of an alternative condition to this conditional would be: "If Mary has textbooks to read, she will study late at the library." That is,

participants would be reluctant to conclude "Mary will not study late at the library" from the three premises:

(If A1 then C) *If Mary has an essay to write, then she will study late at the library*;
(If A2 then C) *If Mary has textbooks to read, then she will study late at the library*;
(non-A1) *Mary does not have an essay to write*.

Here what is suppressed is the NA inference. The suppression of MP can be achieved by introducing an additional condition to the first conditional "If Mary has an essay to write then she will study late at the library." For example, participants would be reluctant to conclude that "Mary will study late at the library" from the three following premises:

(If A1 then C) *If Mary has an essay to write, then she will study late at the library*;
(If A2 then C) *If the library stays open late, then she will study late at the library*;
(A1) *Mary has an essay to write*.

As our main concern here will be the suppression of Modus Ponens (see next section), we will now focus on the notion of an "additional condition".

The additional conditions of Byrne (as well as the "disabling conditions" of Cummins, see Cummins, 1995; Cummins, Lubart, Alksnis, & Rist, 1991; see also Thompson, 1994, 1995) are *requirements* that have to be fulfilled in order for the conclusion to occur (for Mary to study late at the library, it is required that the library stays open late). Politzer (2000) proposes using the term "Complementary Necessary Conditions" for such additional requirements: Additional conditions are necessary conditions expressed with a syntax that is usually devoted to sufficient conditions. A proper (modal) phrasing to express an additional condition would be: "If A2 then it is possible that C, else it is impossible that C" (e.g., "If the library stays open late, then it is possible that Mary will study late at the library, else it will be impossible for her to study late there"). In the following, we will use the term "preconditional statement" to designate conditional statements "If A2 then C" where A2 is a requirement for C (because such a statement embeds a *precondition* in a *conditional* syntax), and reserve the term "conditional statement" for statements such as "If A1 then C" where A1 is a sufficient condition for C. Thus, a statement like "If Mary has an essay to write, then she will study late at the library" will be called hereafter a conditional statement. But a statement like "If the library stays open late, then Mary will study late at the library" will be called hereafter a preconditional statement.

The suppression of Modus Ponens: Theoretical accounts

The existence of a general explanation of the four suppression effects may not be guaranteed: Such an explanation could be imagined on the ground of a double symmetry coming from classical logic—on the one hand, the symmetry between valid (MP, MT) and invalid (NA, AC) arguments; on the other hand, the symmetry between MP and MT and between NA and AC. With such a double symmetry, an explanation of the suppression of NA (for example) would be satisfying, with little change, for the suppression of the three other arguments. We should be mindful, however, that logical categories (e.g., valid vs invalid) are not always relevant in the psychology of reasoning, especially when pragmatic processes (that logical syntax and semantics have trouble accounting for) are involved.

As a consequence, it might be appropriate to proceed from one suppression effect to the other. It would be far too ambitious, however, to consider the four suppression effects in the present study. Thus, the choice has been made here to consider the suppression of Modus Ponens only. MP was chosen because the possibility of its suppression has particular theoretical consequences: There is considerable support (from theoretic and empirical points of view) to the idea that MP stands as a *rule* in the human inferential apparatus (see in particular Smith, Langston, & Nisbett, 1992). As a consequence, it should be of special importance to specify in which situations this rule does not apply.

Byrne (1989, 1991) offered the first explanation for the suppression of MP: Participants felt reluctant to endorse the conclusion because, when presented with the preconditional statement "If A2 then C", they integrated the two conditional premises into a single one of the form "If A1 *and* A2 then C". ("If Mary has an essay to write, then she will study late at the library" and "If the library stays open late, then she will study late in the library" would be integrated as "If Mary has an essay to write *and* if the library stays open late then she will study late at the library".) With such a conditional premise, knowing that A1 is true is no longer sufficient to conclude that C is true. In a recent study, Dieussaert, Schaeken, Schroyens, and d'Ydewalle (1999, 2000) discovered that this "integrative strategy" was actually used by a minority of participants. Moreover, the most frequent strategy was an "amendment" one; that is, participants first formed a putative conclusion on the base of the conditional premise "If A1 then C" and the categorical premise "A1", and in a second stage amended this putative conclusion in the light of the preconditional premise.

Some light could be shed on the two strategies isolated by Dieussaert et al. (1999, 2000) from an early proposal made by Politzer and Braine (1991) regarding the explanation of the suppression effect. Politzer and Braine (1991) argued that because of common world knowledge, participants would interpret "If A2 then C" as meaning "If C then necessarily A2". This new premise, together with the premise "If A1 then C", would lead to inconsistency through

the derivation of the proposition "If A1 then A2", known to be false. ("If Mary has an essay to write, then she will study late at the library", together with "If Mary studies late at the library, then necessarily the library stays open late" would lead to "If Mary has an essay to write then necessarily the library stays open late", a proposition that is obviously false.) Participants would then be reluctant to derive any further conclusion from an inconsistent set of premises.[1] One could actually think of two ways to derive a conclusion from two inconsistent knowledge bases (in this case two inconsistent conditionals). The first way is to build a single consistent base by merging the original bases in an appropriate way: this could be the integrative strategy. The second way is to try deriving conclusions without merging the bases; this leads to non-monotonic inference (e.g., the conclusions derived from the first base can be amended by the knowledge incorporated in the second base): this could be the amendment strategy.

Another theoretical approach to the suppression effect is to consider it within the framework of uncertain reasoning (see in particular Over, 1993, for the first appearance of such an account, and Politzer & Bourmeau, in press, for a recent, detailed exposition of this approach). There is considerable empirical support for the idea that doubting the certainty of a conditional premise (i.e., doubting that its antecedent is sufficient for its consequent) leads to doubt over the certainty of its conclusion when its antecedent is asserted (see for example Cummins, 1995; Cummins et al., 1991; George, 1995, 1997b, 1999; Liu et al., 1996; Thompson, 1994, 1995). If the effect of the preconditional statement "If A2 then C" is to bring doubt about the sufficiency of A1 in regard to C, then this doubt will propagate to the conclusion of the MP argument "If A1 then C; A1". With a three-response format ("C is true", "C is false", "one cannot tell") this doubt leads to the answer "one cannot tell" (participants do not have enough confidence in C to answer that "C is true"). Thus, in order to figure in a more precise fashion the processes that are at work here, it seems necessary to give participants the opportunity to *qualify* the certainty they would grant to the conclusion C.

How does a preconditional statement "If A2 then C" raise doubt about a conditional statement "If A1 then C"? One possible answer is to consider that the *mere mention* of an additional requirement A2 leads to uncertainty in the first conditional; uncertainty would be monotonically related to the perceived degree

[1]Politzer and Braine (1991) also considered the possibility of an "epistemic" (rather than logical) inconsistency between the first conditional and Gricean consequences of the second—which is the first appearance of a pragmatic account of the suppression effect. While we agree with Politzer's later pragmatic approach, we are not necessarily in line with all the considerations in Politzer and Braine (1991), especially not with the conversion hypothesis (interpretation of the second conditional as meaning "if C then necessarily A2"), as should be clear from our own experimental hypotheses.

of necessity of A2 in regard to C. Such seems to be the position of Chan and Chua (1994) or Neth and Beller (1999). Stevenson and Over's (1995) study could be seen as belonging to this same theoretical line—yet Stevenson and Over had an intuition that may not have received the interest it deserved (except in Politzer & Macchi, 2000, as well as in Politzer, 2000, and Politzer & Bourmeau, in press): They hypothesised that what was responsible for the suppression effect was a *conversational implicature* (Grice, 1975, 1978, 1989; Levinson, 1983) that could be cancelled by an appropriate additional premise. For example, they demonstrated that a set of premises of the following form did not lead to the suppression of MP:

If John goes fishing, he will have a fish supper,
If John catches a fish, he will have a fish supper,
John is always lucky when he goes fishing,
John goes fishing.

The conversational implicature that is responsible for the suppression of MP would therefore be in this case: "It is plausible for John not to catch a fish when he goes fishing." In the general case, with premises of the form "If A1 then C; If A2 then C; A1" (where the satisfaction of A2 is a requirement for C to happen), the conversational implicature would be: "There is a chance that A2 might not be satisfied." (With premises of the form "If Mary has an essay to write, then she will study late at the library; If the library stays open late then she will study late at the library; Mary has an essay to write", the conversational implicature would be: "There is a chance that the library might not stay open late.") The nature of this implicature will be discussed later: In brief, results from causal attribution studies (McClure & Hilton, 1997, 1998) make it plausible that the most natural way to consider a locutor who is asserting a preconditional statement "if A2 then C" as complying with Grice's Relevance maxim is to consider that he or she is implying that A2 might not be satisfied.

From this pragmatic point of view, the mere mention of an additional requirement A2 is no longer sufficient to lead to a suppression effect. *A suppression should only occur when a participant feels that he or she is expected to derive the implicature "there is a chance that A2 might not be satisfied" from the premises "If A1 then C; If A2 then C; A1"* (e.g., participants presented with the premises "if Mary has an essay to write, then she will study late at the library; if the library stays open late then she will study late at the library; Mary has an essay to write" may only doubt that "Mary will study late at the library" in the case where they feel that they are expected to derive the implicature "there is a chance that the library might not stay open late"). Although this claim derives from an intuition shared by Politzer (Politzer, 2000; Politzer & Bourmeau, in press; Politzer & Macchi, 2000) and Stevenson and Over (1995), it has not been yet the focus of any empirical investigation. Its empirical evaluation will be one of the objectives of the following experiment.

While the focus of this paper is on interpretative processes that take place before the actual computation of a conclusion, it may be useful to briefly indicate how our pragmatic approach can accommodate with a framework that would consider conditionals as expressing conditional probabilities, for it will enable us to answer the two following questions: (a) How does the increased probability that a precondition A2 is not satisfied affect the probability of the conclusion C? (b) Is our approach consistent with Chan and Chua's (1994) findings regarding the effects of the semantic characteristics of preconditions? These points are dealt with in the Appendix at the end of this paper.

We will finally turn to the last approach to the suppression of Modus Ponens (advocated in Byrne, Espino, & Santamaria, 1998, 1999), in order to introduce the second main hypothesis of the present study. Referring to the Mental Model theoretical framework, Byrne et al. (1998, 1999) suggest that suppression can be explained by counterexample availability. Specifically, the preconditional statement "If A2 then C" would be interpreted as an "additional requirement" that would provide participants with a counterexample to the conclusion of the MP argument "If A1 then C; A1; therefore C". (For example, there is a situation where Mary has an essay to write but does not work late at the library, namely the situation where the library does not stay open late.) Byrne et al. (1999) define additional requirements as "interpreted with background knowledge to mean that the antecedents refer to additional conditions for the same outcome (p. 351)", additional conditions being defined as "jointly necessary for the outcome (pp. 349–350)". From these two definitions, we can conclude that "If A2 then C" is interpreted as an additional requirement when A2 is considered a necessary but insufficient condition of C, that is, when "If A2 then C" is interpreted as a "reverse conditional" (see Table 1 for the truth-table of a reverse conditional).

Byrne, Espino, and Santamaria argue that the *first* conditional "If A1 then C" is interpreted as such a reverse conditional, hence leading to a suppression effect. Our point here is not to discuss this hypothesis, but to show that its corollary is for "If A2 then C" to have the same reverse conditional interpretation.

The model associated to the reverse conditional interpretation of "If A2 then C" should actually be the same as the model associated to the conditional "If C then A2" (i.e., the *conversion* of "If A2 then C"), as the truth-table of "If C then

TABLE 1
The truth-table of a "reversed conditional"

A2	*C*	*Reversed "if A2 then C"*
T	T	T
T	F	T
F	T	F
F	F	T

A2" is the one depicted in Table 1. Therefore, from an explanation in terms of counterexample availability we can derive the prediction that suppression will be comparable with the premises:

(If A1 then C)	*If Mary has an essay to write, then she will study late at the library*;
(If A2 then C)	*If the library stays open late, then she will study late at the library*;
(A1)	*Mary has an essay to write.*

and with the premises:

(If A1 then C)	*If Mary has an essay to write, then she will study late at the library*;
(If C then A2)	*If she studies late at the library, then the library stays open late*;
(A1)	*Mary has an essay to write.*

The pragmatic approach that was introduced earlier supports a different prediction. What was hypothesised to be the main mechanism behind the suppression of MP was the derivation of the implicature: "There is a chance that A2 might not be satisfied." Participants who do not derive this implicature from the premises "If A1 then C; If A2 then C; A1" and participants who do not derive this implicature from the premises "If A1 then C; If C then A2; A1" should indeed demonstrate the same confidence in C. Again, participants who do derive this implicature from the premises "If A1 then C; If A2 then C; A1" and participants who do derive this implicature from the premises "If A1 then C; If C then A2; A1" should demonstrate comparable degrees of confidence in C. But the *mean* confidence expressed in C should be a function of the proportion of subjects deriving the implicature. That is, the more a formulation of the preconditional statement ("If A2 then C" vs "If C then A2", e.g., "If the library stays open late then Mary will study late at the library" vs "If Mary studies late at the library then the library stays open late") is likely to lead to the derivation of the implicature "there is a chance that A2 might not be satisfied" (e.g., "there is a chance that the library might not stay open late"), the lower the mean confidence in C (e.g., "Mary will study late at the library") will be.

There is indeed a pragmatic reason (see later) for the formulation "If A2 then C" to be more likely than the formulation "If C then A2" to lead to the key implicature "there is a chance that A2 might not be satisfied". Thus, according to our pragmatic approach, we should expect more suppression (more doubt on the conclusion C) with the formulation "If A2 then C": When one is asserting that "If Mary has an essay to write then she will study late at the library", one is offering a goal-based explanation for Mary's late presence in the library. But if one adds "If the library stays open late, then Mary will study late in the library", one is

now offering a precondition-based explanation for Mary's late presence in the library. Goals are usually preferred to preconditions as explanations (see for example Leddo, Abelson, & Gross, 1984; McClure, Lalljee, Jaspars, & Abelson, 1989). But there are situations where a precondition-based explanation can be more felicitous than a goal-based explanation: situations where the precondition is not readily available, cannot be presupposed, is not easily satisfied (as demonstrated by McClure & Hilton, 1997; see also McClure & Hilton, 1998). For example, saying that "Mr X ate because there was food available" is more felicitous than to say "Mr X ate because he was hungry" when Mr X is a refugee who had been starving for three weeks due to lack of food.

As a consequence, one way to make a preconditional statement "if A2 then C" a relevant contribution to a conversation is to assume that the locutor intended to mean that A2 might not be readily available or easily satisfied. The belief that A2 might not be satisfied can thus be considered a Relevance implicature of the statement "if A2 then C". No such principle holds for the converse statement "If C then A2". *Therefore, we should expect lower mean confidence in C (due to a higher proportion of participants deriving the key implicature "there is a chance that A2 might not be satisfied") with the premises "If A1 then C; If A2 then C; A1" than with the premises "If A1 then C; If C then A2; A1".* For example, we should expect lower mean confidence in the conclusion "Mary will study late at the library" (due to a higher proportion of participants deriving the key implicature "there is a chance that the library might not stay open late") with the premises "If Mary has an essay to write then she will study late at the library; if the library stays open late then she will study late at the library; Mary has an essay to write" than with the premises "If Mary has an essay to write then she will study late at the library; if she studies late at the library then the library stays open late; Mary has an essay to write". This claim will be empirically evaluated in the following experiment.

The preconditional statement "If A2 then C" is logically equivalent to its contraposition "If non-C then non-A2". (That is, "If the library stays open late then Mary will study late at the library" is logically equivalent to "If Mary does not study late at the library then the library does not stay open late".) Similarly, the converse of "If A2 then C" (i.e., "If C then A2") is logically equivalent to its obverse "If non-A2 then non-C". For example, the converse of "If the library stays open late then Mary will study late at the library" is "If Mary studies late at the library, then the library stays open late"; this last formulation is logically equivalent to the obverse formulation of the original statement, "If the library does not stay open late, then Mary will not study late at the library". (Note that this obverse formulation seems to be the more felicitous way to express the preconditional status of A2 in regard to C.) At this stage, we have no specific prediction regarding the tendency of the contraposition and the obversion of "If A2 then C" to encourage the derivation of the implicature "there is a chance that A2 might not be satisfied": Logical equivalence does not entail pragmatic

equivalence; thus, two logically equivalent statements (as are a statement and its contraposition) might not lead to the same pragmatic implicatures. Nevertheless, the general pragmatic approach we introduced to explain the suppression of Modus Ponens should hold whatever the syntactic formulation of a precondition. Hence, the contraposition and the obversion of "If A2 then C" can be integrated into a generalised, more powerful version of our first hypothesis:

Whatever the syntactic formulation of the preconditional statement (If A2 then C, If C then A2, If non-A2 then non-C, If non-C then non-A2), a suppression should only occur when a participant feels that he or she is expected to derive the implicature "there is a chance that A2 might not be satisfied" from the premises "If A1 then C; [preconditional statement]; A1". For example, whatever the formulation of the second conditional ("If the library stays open late then Mary will study late at the library", " If Mary does not study late at the library then the library does not stay open late", " If the library does not stay open late, then Mary will not study late at the library", "If Mary studies late at the library, then the library stays open late"), a suppression of the conclusion "Mary will study late at the library" should only occur for those participants feeling expected to derive the implicature "there is a chance that the library might not stay open late" from the premises "If Mary has an essay to write then she will study late at the library; [preconditional statement]; Mary has an essay to write". This generalised version of our first hypothesis is to be evaluated in the following experiment.

EXPERIMENT

Method

Participants. A total of 60 undergraduate students at the University of Toulouse-2, all native French speakers, participated in this study (15 male and 45 female; mean age = 20 years and 3 months old, sd = 1 year and 4 months).

Materials. Each questionnaire included five problems, each of these problems using a different formulation of the preconditional statement (if A2 then C, if C then A2, if non-A2 then non-C, if non-C then non-A2, no precondition). Each of the five problems was constructed from a different set of propositions (see Table 2), on the following model:

If A1 then C,
[preconditional statement],
A1.

Here are some problems that were used: "If Stephen came back on Friday then he went to Irene's party; If he was invited then he went to Irene's party; Stephen came back on Friday" (precondition: if A2 then C); "If it rained then Mark got wet; If he did not go out then Mark did not get wet; It rained" (precondition: if

TABLE 2
The five sets of premises used to create the questionnaires

Set	*A1*	*C*	*A2*
1	Stephen came back on Friday	He went to Irene's party	He was invited
2	It rained	Mark got wet	He went out
3	Cedric had his car fixed	He went for Ann at the train station	He woke up in time
4	Mary was forty on Saturday	She threw a party	She is OK with her age
5	Emma had an essay to write	She studied late at the library	The library stayed open

non-A2 then non-C); "If Cedric had his car fixed then he went for Ann at the train station; If he went for Ann at the train station then he woke up in time; Cedric had his car fixed" (precondition: if C then A2); "If Mary was forty on Saturday then she threw a party; If she did not throw a party then she is not okay with her age; Mary was forty on Saturday" (precondition: if non-C then non-A2); "If Emma had an essay to write then she studied late at the library; Emma had an essay to write" (no precondition).

Participants were encouraged to consider the three premises as turns in a conversation. Thus, the study can be considered as using "weakened" deductive reasoning instructions, that is, instructions that encourage belief-based reasoning over purely logical, formal reasoning (see Evans & Over, 1996, pp. 127–128, for a discussion of the effects of augmented vs weakened deductive reasoning instructions). This point will be taken into account while interpreting the experimental results. Five different questionnaires were constructed, so that each set of propositions would be associated once with each formulation of its preconditional statement. The formulation of the preconditional statement is thus considered a five-level within-subject factor. The order of problems was reversed in two of the five questionnaires.

For each problem, participants were asked to express their degree of confidence in the proposition C on a 7-point scale, ranging from "no chance to be true" to "certainly true". In addition, for each problem except the "no precondition" ones, subjects were asked to say if, in their opinion, the second interlocutor (the one asserting the precondition) intended to convey the idea that A2 might not be satisfied.

Procedure. Participants were approached while they were sitting on the campus lawn. No time limit was imposed, and participants were quickly debriefed after completing the questionnaire. The questionnaires were distributed to small groups of students (2–5), so that the experimenter could easily observe that participants did not communicate while taking part in the experiment, and that they did not change their confidence ratings after considering the implicature question. The experiment was conducted in French.

Results

The mean confidence ratings of the conclusion C as a function of the five different formulations of the preconditional statement appear in Table 3.

Analyses revealed a main effect of the formulation of the preconditional statement, $F(4, 60) = 10.05$, $p < .001$. The confidence participants expressed in C when no precondition was introduced was significantly higher than it was with any type of preconditional statement: $F(1, 60) = 30.944$, $p < .001$ when compared to the statement "if A2 then C"; $F(1, 60) = 25.863$, $p < .001$ when compared to the statement "if non-C then non-A2"; $F(1, 60) = 21.602$, $p < .001$ when compared to the statement "if non-A2 then non-C"; $F(1, 60) = 6.139$, $p < .05$ when compared to the statement "if C then A2". It is noteworthy that the mean confidence in the conclusion when no precondition was introduced was only 5.57 on a 7-point scale, which is arguably not very high for a straightforward Modus Ponens inference. This is probably a consequence of our "weakened" instructions (enjoining participants to consider the premises as turns in a conversation rather than as logical truths), as it is consistent with what Stevenson and Over (1995) observed in their second experiment, which used weakened instructions similar to ours. Nevertheless, although lower than might be expected, this mean rating remains higher than any other in this experiment.

The confidence in C was significantly higher when the preconditional statement was "if C then A2" than when it was "if A2 then C", $F(1, 60) = 6.709$, $p < .05$), "if non-C then non-A2", $F(1, 60) = 5.841$, $p < .05$), or "if non-A2 then non-C", $F(1, 60) = 5.760$, $p < .05$). No other comparison achieved significance.

Generally speaking, this pattern of results held whatever the scenario: Highest confidence ratings were observed when no precondition was introduced and when the precondition was framed as "if C then A2". (One exception was the birthday party scenario, for which the formulation "if C then A2" did not lead to higher confidence ratings than the other formulations.)

Participants were asked to say if, in their opinion, the interlocutor asserting the preconditional statement intended to convey the idea that there was a chance that A2 might not be satisfied. The percentages of participants answering "yes" to this question was 78.3% with the statement "if A2 then C", 76.7% with the

TABLE 3
Mean confidence ratings[a] in the conclusion as a function of different formulations of the preconditional statement

If A2 then C	*If non-C then non-A2*	*If non-A2 then non-C*	*If C then A2*	*No precondition*
4.02 Std = 1.85	4.23 Std = 1.61	4.23 Std = 1.61	4.92 Std = 1.87	5.57 Std = 1.61

[a]Confidence is rated on a seven-point scale.

statement "if non-C then non-A2", 73.3% with the statement "if non-A2 then non-C", but only 45% with the statement "if C then A2". Those frequencies are significantly different (Cochran $Q = 20.203$; df = 3; $p < .001$).

Again, whatever the scenario, the percentage of participants answering "yes" to this question was always the lowest for the formulation "if C then A2".

Table 4 shows the mean confidence ratings of C when participants assumed a preconditional statement to convey doubt on the satisfaction of A2 and when they did not. For each of the formulations of the precondition that appear in Table 4, the confidence participants expressed in C when they assumed that the preconditional statement conveyed the idea that there was a chance that A2 might not be satisfied was significantly lower than the confidence they expressed in C when they did not assume such a thing. ($t = –4.507$, $p < .001$, for "if A2 then C"; $t = –1.682$, $p < .05$, for "if non-C then non-A2"; $t = –3.402$, $p < .001$, for "if non-A2 then non-C"; $t = –3.077$, $p < .01$, for "if C then A2".)

Confidence in C when participants assumed the preconditional statement to convey the idea that there was a chance that A2 might not be satisfied was significantly lower than confidence in C when no precondition was introduced ($t = –5.417$, $p < .001$, for "if A2 then C"; $t = –5.473$, $p < .001$, for "if non-C then non-A2"; $t = –4.960$, $p < .001$, for "if non-A2 then non-C"; $t = –2.407$, $p < .05$, for "if C then A2"). But such was not the case when participants did not derive this implicature: the confidence in C expressed by those participants did not significantly differ from the confidence in C they expressed when no precondition was introduced ($t = –2.007$, *ns*, for "if A2 then C"; $t = –.968$, *ns*, for "if non-C then non-A2"; $t = –.792$, *ns*, for "if non-A2 then non-C"; $t = –1.182$, *ns*, for "if C then A2"). Again, there were no differences based on materials.

Our first hypothesis as well as its generalised version are thus supported by the results: Loss in confidence in C only occurs when participants feel that the preconditional statement conveys the idea that the additional requirement might

TABLE 4
Mean confidence rating[a] in the conclusion as a function of four formulations of the preconditional statement, depending on the assumption that the preconditional statement conveyed doubt or not on the satisfaction of the precondition A2

If A2 then C		*If non-C then non-A2*		*If non-A2 then non-C*		*If C then A2*	
Conveying doubt	*Not conveying*	*Conveying doubt*	*Not conveying*	*Conveying doubt*	*Not conveying*	*Conveying doubt*	*Not conveying*
N = 47	*N* = 13	*N* = 46	*N* = 14	*N* = 44	*N* = 16	*N* = 27	*N* = 33
3.62 Std = 1.81	5.46 Std = 1.13	4.04 Std = 1.69	4.86 Std = 1.17	3.84 Std = 1.58	5.31 Std = 1.14	4.15 Std = 1.77	5.55 Std = 1.73

[a]Confidence is rated on a 7-point scale.

not be satisfied, whatever the syntactic formulation of the preconditional statement. Our second hypothesis is also supported by the results: Mean confidence in C is higher when the preconditional statement is expressed as "If C then A2", compared to "If A2 then C", because the latter statement is more prone to encourage the derivation of the implicature "there is a chance that A2 might not be satisfied".

GENERAL DISCUSSION

We hypothesised that among participants presented with premises like:

If Mary has an essay to write, then she will study late at the library;
If the library stays open late, then she will study late at the library;
Mary has an essay to write,

the only ones that would express uncertainty in the conclusion "Mary will study late at the library" would be those feeling that they were expected to derive the implicature "there is a chance that the library might not stay open late". We obtained results supporting this hypothesis, as well as its superior version, generalised to the contraposition, obversion, and conversion of the statement "if the library stays open late, then she will study late at the library". According to our second hypothesis, we observed that the conversion of the original preconditional statement, "if Mary studies late at the library then the library stays open late" leads to lower uncertainty in the conclusion "Mary will study late in the library", through a lower frequency in deriving the implicature "there is a chance that the library might not stay open late".

The Mental Model as well as the Mental Logic theories do not seem to be able to account for such results.[2] In particular, the observation that a precondition formulated as "If C then A2" ("If Mary studies late at the library then the library stays open late") leads to a lower suppression of Modus Ponens than a precondition formulated as "If A2 then C" (" If the library stays open late, then Mary will study late at the library") goes contrary to what could be expected from the proposals of Politzer and Braine (1991)—for the Mental Logic theory—or Byrne et al. (1999)—for the Mental Model theory. The former explain the suppression of MP through the reformulation of "If A2 then C" into "If C then A2": The formulation "If C then A2" should therefore have the same effect on the endorsement of C as the formulation "If A2 then C", which is not what we observed. The latter explain the suppression of MP by assuming than the participants semantically interpret "If A2 then C" as a reversed conditional.

[2]This should not be a surprise, as this study focused on pragmatic, interpretative issues, which are known to be outside the theoretical range of both the Mental Model and the Mental Logic theories (see, e.g., Bonatti, 1994; Fillenbaum, 1993).

This reverse interpretation of "If A2 then C" is equivalent to the semantics of "If C then A2". Again, these two formulations should have the same effect on the endorsement of C, a prediction that is disconfirmed by our results.

One possible concern with the methodology of the present study is with the direct questioning of participants regarding the derivation of the key implicature: Straightforwardly asking whether the speaker intended to convey the idea that A2 might not be satisfied could indeed be seen as giving away the positive answer. If true, this could generate two different problems. First, the directness of the question could make participants consider an implicature they had not derived by themselves, which would in turn have them artificially decrease their ratings of the conclusion. Actually, this could be the case only if participants could change these ratings after having answered the implicature question. But, as mentioned in the Method section, the experimenter was able to ensure that participants did not behave this way. A second problem could be that the directness of the question might have influenced participants into answering "yes" (a) whatever the syntactic form of the preconditional statement, or (b) whatever their rating of the conclusion. If such an influence indeed took place to some degree, it went against our hypotheses and not in their direction, thus actually making our case stronger.

In line with the uncertainty account of the suppression of Modus Ponens (Chan & Chua, 1994; Neth & Beller, 1999; Over, 1993; Politzer & Bourmeau, in press; Stevenson & Over, 1995), we have empirically established the validity of the pragmatic account proposed in Stevenson and Over (1995) as well as in Politzer (2000), Politzer and Bourmeau (in press) and Politzer and Macchi (2000): What seems to be responsible for the suppression of MP is a conversational implicature related to the non-satisfaction of the additional requirement that is introduced in the second conditional premise. We have extended this account by showing that different syntactic introductions of this requirement lead to different frequencies in the derivation of this implicature.

This study focused on the suppression of Modus Ponens only. Is it possible to extend the present analysis in some way to the suppression of the Modus Tollens, Negation of the Antecedent, and Affirmation of the Consequent inferences?

Of course, the goal/precondition opposition that was used in order to analyse the suppression of MP is not relevant to the suppression of NA and AC, as these two suppressions do not involve the introduction of preconditions. Moreover, it should be noted that the derivation of NA and AC appears to be itself a pragmatic phenomenon. Thus, in order to account for the pragmatic processes at work in the *suppression* of NA and AC, it shall be necessary to clarify first what are the pragmatic processes at work in the *derivation* of these inferences (see Horn, 2000, and van der Auwera, 1997, for two recent pragmatic accounts of "conditional perfection", i.e. the tendency to strengthen "If P then Q" into "If and only if P, then Q", and see Geis & Zwicky, 1971, for the princeps paper on this issue).

The suppression of the Modus Tollens inference is usually demonstrated using the same premises as the suppression of MP. It would be reasonable to assume that the premises:

If Mary has an essay to write, then she studies late at the library;
If the library stays open late, then she studies late at the library;
Mary does not study late at the library,

would lead to uncertainty in the conclusion "Mary has no essay to write" through the implicature "there is a chance that the library might not stay open late". But the situation is more confused with the following (logically equivalent to the first) set of premises:

If Mary has an essay to write, then she studies late at the library;
If Mary does not study late at the library, then the library does not stay open late;
Mary does not study late at the library.

Here there appears to be a straightforward inference to the conclusion: "The library does not stay open late." The salience of this inference could be responsible for the discounting of the Modus Tollens inference that can be derived from the first conditional and the categorical premise. It is thus unclear how our experimental apparatus could adapt to the study of the suppression of MT. As we pointed out earlier in this paper, it seems that each of the four suppression effects deserves a study of its own.

This work has taken advantage of research conducted in the field of social cognition, namely causal attribution and causal explanation research. As more and more researchers agree on the idea that reasoning and decision making cannot occur in a social vacuum, it should be emphasised that social cognition research can provide cognitive psychologists with appropriate descriptors and classifications , as well as with suggestive empirical results. In the present study, conditional reasoning was considered through a goal/precondition opposition provided by causal attribution research.

We believe that this study can help establish the importance of the pragmatic approach in reasoning and decision research (see Hilton & Slugoski, 2000a, 2000b; Nagy, 1997; Politzer, 1997), for we have clearly demonstrated here that people do not reason solely on the basis of the syntactic or semantic qualities of what is said, but also (or mainly) on the basis of the *reason why* it is said. The suppression of Modus Ponens can thus be added to the various so-called reasoning and decision-making biases whose mechanisms have been enlightened by a pragmatic approach (see Dulany & Hilton, 1991; Hilton, 1990, 1995; Politzer & Macchi, 2000; Tetlock, Lerner, & Boettger, 1996).

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APPENDIX

Different authors (e.g., Chan & Chua, 1994; Liu et al., 1996; Oaksford, Chater, & Larkin, 2000; Stevenson & Over, 1995) have argued for the existence of a probabilistic component in conditional reasoning, relating conditional statements "if A then C" to conditional probabilities p (C | A). Let us consider a probabilistic transcription of the set of premises that leads to a suppression of Modus Ponens.

The conditional "If A1 then C" can be expressed as the conditional probability p (C | A1) = α, the exact value of α depending on available general knowledge and experimental instructions (that may encourage formal reasoning or belief-based reasoning).

The preconditional statement "If A2 then C" has to be expressed as *two* different probabilities. First, general knowledge about the nature of A2 as a requirement for C is expressed as p (C | non-A2) = β. The value β will usually be close to zero, as the non-satisfaction of the requirement β usually makes it impossible for C to occur (but see later). Second, we have demonstrated that the preconditional statement "If A2 then C" leads to the key implicature that "A2 might not be satisfied", which implicature can be expressed as the probability p (non-A2) = γ , with $\gamma > 0$.

Finally, the categorical premise "A1" can straightforwardly be expressed as p (A1) = 1.

Now let us make two intuitively sound (if not rigorously demonstrated) assumptions: (a) p (C | A1 and non-A2) is close to p (C | non-A2) (when the *requirement* A2 is not met, the occurrence of A1 will not really change the probability of C occurring); and (b) p (C | A1 and A2) is close to the value that was granted to p (C | A1) (as A2 is, according to the pragmatic approach, a

background assumption of the statement "If A1 then C", the conditional probability of C given A1 is computed assuming that A2 is satisfied). For example, the probability of Mary studying late at the library when she has an essay to write and the library does not stay open late should be close to the probability of Mary studying late at the library when the library does not stay open late, and the probability of Mary studying late at the library when she has an essay to write and the library does stay open late should be close to the probability of Mary studying late at the library when she has an essay to write.

Because we know from the categorical premises "A1" that the situations where A1 is false have a null probability, we can give the following decomposition of p (C):

$$p\,(\mathrm{C}) = p\,(\mathrm{A1\ and\ A2}) \,.\, p\,(\mathrm{C} \mid \mathrm{A1\ and\ A2}) + p\,(\mathrm{A1\ and\ non\text{-}A2}) \,.\, p\,(\mathrm{C} \mid \mathrm{A1\ and\ non\text{-}A2}) \,.$$

Hence, from the considerations exposed in the previous paragraphs and the fact that A1 and A2 are usually independent events, we can give the following approximation of p (C):

$$p\,(\mathrm{C}) \approx \gamma \,.\, \beta + (1 - \gamma) \,.\, \alpha \,.$$

From this approximation, it appears that p (C) should converge towards β (the probability of C occurring in spite of the non-satisfaction of the precondition) when γ (the probability that the precondition is not satisfied) increases. In the general case, where β is close to zero, the probability of the conclusion will decrease towards zero as the probability that the precondition is not satisfied increases towards one, hence the standard suppression of Modus Ponens.

Chan and Chua (1994) have investigated situations wherein β may not be close to zero, but depends on the semantic characteristics of the precondition A2, in particular its "relative salience" in regard to C, i.e., its strength as a requirement. Indeed, requirements with low "relative salience", that is, weak requirements, may be expressed by higher values of β: The weaker the requirement A2 in regard to C, the higher the chance that C occurs despite the non-occurrence of A2, that is, the higher the probability p (C | not-A2). Hence, as p (C) converges towards the value β in the formulajust given, the weaker the requirement A2, the higher the confidence in C and the weaker the suppression effect, which is what Chan and Chua (1994) have observed.