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Consequential Conditionals: Invited and Suppressed Inferences From Valued Outcomes

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Consequential conditionals are defined as "if P then Q" statements, where P is an action, and Q a predicted outcome of this action, which is either desirable or undesirable to the agent. Experiment 1 shows that desirable (viz. undesirable) outcomes invite an inference to the truth (viz. falsity) of their antecedent. Experiment 2 shows that the more extreme the outcome is, the stronger the invited inference is. Experiment 3 shows that *modus ponens* from premises "If A then C, A" can be suppressed with the introduction of a consequential conditional, "If C then Q," where Q is an undesirable outcome. Experiment 4 shows that the more undesirable Q is, the larger the suppression is. The authors discuss how these results can enrich current approaches of conditional inference on the basis of mental models, complementary necessary conditions, and conditional probabilities.

Conditional statements can address different sorts of questions. For example, some statements describe causal relations between facts (e.g., "If the match is struck, then it lights"), whereas some describe regulations (e.g., "If she cannot prove she is 18, then she cannot have a beer"). Some statements are inducements (e.g., "If you do not pay me, I will sue you"), whereas some are definitions (e.g., "If its three sides are of equal length, then a triangle is equilateral"). Some do not even seem to conditionalize anything on anything, as in, "If you are hungry then there are biscuits on the sideboard" (Austin, 1962). We may thus distinguish between different classes of conditional contents, with such names as, respectively, *causal*, *deontic*, *inducements*, *definitions*, or *biscuits*.[1]

Some of these classes may have distinctive logical properties (e.g., definitions are always biconditionals), yet, more interestingly, differences between classes of conditional content often go beyond formal logic: For example, a distinctive feature of social regulation conditionals is to draw attention to the detection of cheaters (Gigerenzer & Hug, 1992). More generally, classes of conditional content can be said to differ systematically in the inferences they pragmatically invite rather than in the inferences they logically entail.

From these observations, a research program on conditional reasoning and content can be developed. Gigerenzer (1995) has suggested that such a program should combine two steps: (a) the modeling of the *mapping algorithm*, which recognizes a given conditional statement to belong to a certain class, or, in Gigerenzer's terms, to fall within a certain modular domain of thought and (b) the description of the subsequent activity of the module, in particular the kind of inferences it makes.

In this article, we broadly follow this program with respect to a specific class of conditional statements, *consequential conditionals*. Although pervasive in everyday reasoning, consequential conditionals have not yet been a topic of psychological research.[2] We provide a characterization of those statements, a detailed experimental account of the inferences they invite, and a discussion of the theoretical developments suggested by our series of studies.

The first section (Consequential Conditionals and the Inferences to the Antecedent) defines consequential conditionals (i.e., provides the mapping algorithm that allows them to be recognized) and introduces their main hypothesized property, the inference to the antecedent. To summarize, consequential conditionals have the taking of an action by a third party for their antecedent and some positive or negative consequence of this action for their consequent, and they invite an inference to the truth (when the consequence is positive) or falsity (when the consequence is negative) of their antecedent. In Experiment 1 we demonstrate the existence of this inference to the antecedent. It is then suggested that this inference not only depends on the valence of the consequence but also on its extremity, a hypothesis which we investigate in Experiment 2. The next section builds on those results to predict a novel experimental effect: It should be possible to suppress modus ponens inference from the premises "If A then C, A" to Conclusion C by introducing the consequential conditional "If C then Q," where Q is an undesirable outcome. In Experiment 3 we demonstrate such a suppression effect. In Experiment 4 we extend the results of Experiment 3 by showing that the more undesirable that

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[1] On the engaging subject of "biscuit" conditionals (e.g., "If you are hungry, then there are biscuits on the sideboard," or "If you need help, my name is Joe"), see DeRose and Grandy (1999).

[2] A possible exception may be George's (1991) selection task study, although his conditionals were general statements (e.g., "If one takes Vitamin X, one resists infections"), whereas we define consequential conditionals as particularized statements (e.g., "If Julie takes Vitamin X, she will resist infections").

Outcome Q is, the larger the effect. In the last section we discuss the contribution of our results to current approaches to conditional reasoning that are based on mental models, complementary necessary conditions, and conditional probabilities.

Consequential Conditionals and the Inference to the Antecedent

Following Gigerenzer's (1995) suggestion, we approached consequential conditionals by addressing in turn the two following issues: (a) how consequential conditionals are recognized as such (and distinguished from other types of conditionals) and (b) what inferences they invite.

How Does One Recognize a Consequential Conditional?

Consequential conditionals are statements of the form "If P then Q," presenting five distinctive features:

1. P is an action of a third party, the agent. The agent is neither the speaker nor the hearer.
2. Q is a consequence of the taking of the action, P.
3. Q is valued: It is either a good (positive, desirable) or a bad (negative, undesirable) outcome to the agent.
4. To take or not to take Action P is a matter of choice to the agent.
5. The agent knows Q to be a consequence of P.

Consider the following statement: "If the CEO admits fraud, he will be sent to jail." The antecedent P is an action of an agent (the CEO), who is neither the speaker nor the hearer. The consequent Q is a valued outcome of this action, in this case the negative outcome of being sent to jail. To admit or not to admit fraud is a matter of choice to the CEO. Last, we can expect the CEO to be aware of his being sent to jail as a potential consequence of his admitting fraud. Thus, the statement is recognized as a consequential conditional with a negative outcome (i.e., a *negative consequential*).

Consider this second example: "If Sophie takes this drug, she will be cured." The antecedent P is an action of Sophie, who is neither the speaker nor the hearer. The consequent Q is a positive outcome for Sophie, that is, being cured from her disease. Sophie is free to decide to take or not to take the drug, and she can be expected to know of the consequence of her taking the drug. Thus, the statement is recognized as a consequential conditional with a positive outcome (i.e., a *positive consequential*).

Not only do the five features above enable us to recognize a consequential conditional but they also enable us to distinguish between consequential conditionals and other conditional statements. We now consider in turn in which way consequential conditionals are different from inducements, means–end statements, deontics, and mere causal statements. (For the sake of brevity, we do not consider here the differences between consequential conditionals and such classes of content as definitions or Austinian "biscuit" conditionals, as we believe these differences to be apparent enough not to need a detailed account.)

Consequential conditionals are not inducements. Inducements (promises, pieces of advice) and deterrents (threats, warnings) have a lot in common with consequential conditionals. Indeed, inducements and deterrents have an action as their antecedent and a valued outcome as their consequent, as illustrated in the following examples: "If you mow my lawn, I'll give you 10 euros" (promise); "If you throw your trash on my lawn, I'll sue you" (threat); "If you stand close to the counter, you'll be served faster" (advice); and "If you stand close to the dog, it will bite you" (warning). The main difference, though, between inducements–deterrents and consequentials is that the antecedent of a consequential is always some potential action of a third party, whereas the antecedent of an inducement or a deterrent is always some potential action of the hearer.

Consequential conditionals are not means–end statements. Means–end conditionals are prominent in practical reasoning, when an agent, identified by the first pronoun "I" is considering possible ways to achieve his or her goals (see Walton, 1990, for an in-depth coverage of practical reasoning). For example, an agent whose desire is to be healthier may think, "If I quit smoking, I'll be healthier," and an agent whose desire is to be richer may think, "If I sell my stocks now, I'll be richer." Again, means–end conditionals share with consequential conditionals an action as their antecedent and a valued (usually positive) outcome as their consequent. Yet again, the main difference between the two classes of statements is that means–end conditionals always have an action of the speaker as their antecedent, whereas the antecedent of a consequential conditional is always an action of a third party.

In the *Conclusion* section of this article, we consider whether the third-person criterion in the definition of consequential conditionals should be relaxed, thus making inducements and means–end statements subclasses of consequential conditionals. Until then, we continue to consider consequential conditionals to feature an action of a third party.

Consequential conditionals are not deontics. Consequential conditionals do not usually fall within the deontic domain, simply because they do not specifically address the issue of what an agent ought to do or what ought to happen as a consequence of his/her actions but what an agent may do and what would happen as a consequence. For example, the statement, "If Sophie takes this drug, she will be cured," is a consequential but not a deontic, for there is no obligation for Sophie to take the drug or to be cured if she does.

Conversely, deontic statements do not usually qualify as consequentials. For example, the deontic statement, "If a patron wants to have a beer, he must be at least 18 years old," does not have an action as its antecedent. The deontic statement, "If the nurse cleans blood, she must wear rubber gloves," does have a third-party action as its antecedent but not a valued outcome as its consequent.

Consequential conditionals are not (mere) causal statements. Consequential conditionals, by definition, embed a causal relation between their antecedent and their consequent (as Outcome Q is a consequence of Action P). Yet, there is more to consequential conditionals than a simple causal relation. Besides the fact that the antecedent of a consequential is always an action (and not, e.g., a state of the world, as in the causal statement, "If the temperature of water is below 0° C, it freezes"), a consequential must have a valued consequent, whereas mere causal statements can feature neutral (nonvalued) consequents.

In other words, causal conditionals that do not have an action as their antecedent or a valued outcome as their consequent will not be recognized as consequential conditionals and, therefore, will not invite consequential-related inferences. On the other hand, a causal conditional that abides to all of the five requirements in the definition of consequential conditionals will be recognized as a consequential and, thus, invite the specific inferences, which we discuss in the next section.

What Inferences Do Consequential Conditionals Invite?

Now that we have provided the list of criteria according to which a conditional is recognized to be of the consequential type, we can proceed to the second step in our research program, that is, to consider the inferences that are pragmatically invited by consequential conditionals; the easiest route is to first define *consequentialism*.

As a philosophical principle, consequentialism holds that rational agents base their actions on their perceived consequences. That is, people avoid actions from which the consequences would hurt and pursue actions that have consequences they deem desirable. Even though it is sometimes possible to observe nonconsequentialist behavior (Baron, 1994), the best predictor of the behavior of others is to assume they will act in accordance with this principle.

Thus, what would we think Cedric will do when provided with the positive consequential, "If Cedric takes this new job, his life will improve in every respect"? Consequentialism tells us that he will take the job. Conversely, when provided with the negative consequential, "If Cedric takes this new job, he will be paid less and be less happy than he is now," reliance on consequentialism leads us to think that he will not take the job. Hence, consequential conditionals ought to invite an inference to whether their antecedent is true or false. Positive consequentials should invite an inference to the truth of their antecedent; negative consequentials should invite an inference to the falsity of their antecedent. Note that this conclusion can be reached in the absence of any additional information other than the conditional itself, in similar fashion than counterfactual conditionals (e.g., "If I had been a dog, I would have been a golden retriever") convey on their own, as their raison d'être, the falsity of their antecedents and consequents.

Thus, our first claim regarding the inferential properties of consequential conditionals is that they invite an inference to the truth (positive consequentials) or the falsity (negative consequentials) of their antecedent. Experiment 1 is an investigation of this claim.

Experiment 1

Method

Participants. A total of 42 communication undergraduates at the Institut Universitaire de Technologie of Tarbes, all native French speakers, participated in this experiment (33 men and 9 women; mean age = 20 years and 6 months).

Materials and design. Each questionnaire featured six conditional statements, according to a 2 (context: job vs. party) × 3 (type of conditional: positive consequential, negative consequential, or neutral outcome conditional) within-subject design. Antecedents were always of the form, "If [agent] goes to the party" (party context) or "If [agent] takes up this new job" (job context), with the agent being identified with a different first name in each statement. In the party context, outcomes were, "[agent] will meet up with all her best friends" (positive), "[agent] will take the bus" (neutral), and "[agent] will only meet up with people he dislikes" (negative). In the job context, outcomes were, "[agent]'s life will improve in every respect" (positive), "[agent] will have new colleagues" (neutral), and "[agent] will be less paid and less happy" (negative).

After reading each conditional statement, participants had to say whether they believed the antecedent of the conditional to be true ("P"), false ("not-P"), or that nothing followed. For example, after reading "If Didier takes up this new job, he will be paid less and less happy," participants had to choose from the response options, "Didier will take up the job," "Didier will not take up the job," or "Nothing follows." The order of statements was reversed in half the questionnaires.

Procedure. Participants filled out the questionnaire at the beginning of a class. Participation was not mandatory. No time limit was imposed, and a quick debriefing took place after the experiment. The experiment was conducted in French.

Results

Participants' answers followed a strikingly clear pattern, especially with respect to the job context (see Table 1). The modal answer for positive consequentials was P for positive consequentials, whereas it was not-P for negative consequentials, and "nothing follows" for neutral outcome conditionals.

In only one case did a participant choose the answer P for a negative consequential in the job context. Similarly, in only one case did a participant choose the answer P for a negative consequential in the party context. In no cases did any participant choose the answer not-P for a positive consequential, be it in job or party context.

The choice of the answer P over the two other answers was significantly more frequent with positive consequentials than with neutral outcome conditionals (sign test, $p < .001$, in job context as well as in party context) or negative consequentials (sign test, $p < .001$, in job context as well as in party context). Similarly, the choice of the answer not-P over the two other answers was significantly more frequent with negative consequentials than with neutral outcome conditionals (sign test, $p < .001$, in job context as well as in party context) or positive consequentials (sign test, $p < .001$, in job context as well as in party context). Finally, the choice of the answer "nothing follows" over the two other answers was significantly more frequent with neutral outcome conditionals than with positive consequentials (sign test, $p < .001$, in job context as

Table 1
Endorsement Rates of Conclusions Not-P, "Nothing Follows," and P From a Consequential "If P Then Q," as a Function of Context and Valence of Outcome Q

Context	Not-P (%)	Nothing follows (%)	P (%)
Job			
Q negative	76.2	21.4	2.4
Q neutral	2.4	95.2	2.4
Q positive	0	21.4	78.6
Party			
Q negative	66.6	31.0	2.4
Q neutral	2.4	81.0	16.6
Q positive	0	40.5	59.5

Note. $n = 42$ in each line.

well as in party context) or negative consequentials (sign test, $p < .001$, in job context as well as in party context).

Discussion

Results of Experiment 1 make it clear that consequential conditionals, contrary to neutral outcome conditionals, have the property of inviting an inference to the status of their antecedent. Consequentials with a positive outcome invite an inference to the truth of their antecedent, whereas consequentials with a negative outcome invite an inference to the falsity of their antecedent. Neutral outcome conditionals do not invite any of these inferences.

These invited inferences were not elicited to the same degree in the two contexts used in Experiment 1. Specifically, they were not as strongly elicited in the party context as they were in the job context. Rather than concluding that inference to the antecedent is context dependent, we would be inclined to see here an effect of the extremity of the outcome, beyond the effect of its valence. That is, outcomes featured in the job context were respectively extremely positive or negative (the agent having every aspect of her life improving vs. the agent being paid less and less happy), possibly more so than the outcomes featured in the party context (the agent meeting up with all her best friends vs. the agent meeting up only with people she dislikes). Extremely positive and negative outcomes should strongly invite the inference to their antecedent, more so than moderately positive or negative outcomes. This hypothesis is the focus of Experiment 2.

Experiment 2

Method

Participants. A total of 48 psychology undergraduates at the University of Toulouse-2, all native French speakers, participated in this experiment (7 men and 41 women; mean age = 19 years and 7 months).

Materials and design. Each questionnaire featured four conditional statements, according to a 2 (type of conditional: positive consequential vs. negative consequential) × 2 (extremity of the outcome: moderate vs. extreme) within-subject design. Context was a between-subject factor (job vs. party). Antecedents were always of the form, "If [agent] goes to the party" (party context) or "If [agent] takes up this new job" (job context). In the party context, outcomes were "[agent] will meet up with all her loved ones" (extremely positive), "[agent] will have a good time" (moderately positive), "[agent] will have to speak to some people he dislikes" (moderately negative), and "[agent] will not make it to the birth of his child" (extremely negative). In the job context, outcomes were "[agent]'s life will improve in every respect" (extremely positive), "[agent] will have more free time" (moderately positive), "[agent] will have a 2-hour commuting time morning and evening" (moderately negative), and "[agent] will be paid less and be less happy" (extremely negative). The order of statements was reversed in half the questionnaires.

Whereas Experiment 1 only used three response options, Experiment 2 featured a finer grained response scale. Participants could choose among the following: "Sure that not-P," "Most certainly not-P," "Probably not-P," "Nothing follows," "Probably P," "Most certainly P," and "Sure that P." The decision to use this scale was made because it was felt that the three response options of Experiment 1 might be too crude a measure with respect to the objective of Experiment 2.

Procedure. Procedure was similar to the one used in Experiment 1 except that the experiment took place during class break.

Results

Participants' answers were coded on an ordinal scale, from –3 (*sure that not-P*) to 3 (*sure that P*), with 0 representing *nothing follows* (see Table 2 for the distribution of participants' answers). With respect to the party context, answers that were related to strongly positive outcomes ranked higher on the scale than did answers that were related to moderately positive outcomes ($Z = –1.79$, $p < .05$, one-tailed), and answers related to strongly negative outcomes ranked lower than did answers related to moderately negative outcomes ($Z = –3.43$, $p < .001$, one-tailed). Answers related to moderately positive outcomes also ranked higher than did answers related to moderately negative outcomes ($Z = –4.05$, $p < .001$, one-tailed). Those results also held with respect to the job context ($Z = –2.70$, $p < .01$; $Z = –3.70$, $p < .001$; $Z = –3.76$, $p < .001$, respectively, all one-tailed).

It is also worth considering to what extent individual responses followed this general pattern. Let us define four possible configurations of answers in a given questionnaire (S+, M+, M–, and S– represent the answer related to the strongly positive outcome, the moderately positive outcome, the moderately negative outcome, and the strongly negative outcome, respectively).

A given questionnaire may feature a *strict ordering* of answers, that is, S+ > M+ > M– > S–. It may also feature some quasi-strict ordering, that is, strict ordering allowing for only one tie: for example, S+ > M+ > M– = S–. As an alternative, a

Table 2
Confidence in P or Not-P From a Consequential "If P Then Q," as a Function of Context and of Valence and Extremity of Outcome Q

Context	Sure that not-P (%)	Most certainly not-P (%)	Probably not-P (%)	Nothing follows (%)	Probably P (%)	Most certainly P (%)	Sure that P (%)
Job							
Q strongly negative	25.0	29.2	29.2	16.6	0	0	0
Q mildly negative	0	12.5	25.0	58.3	4.2	0	0
Q mildly positive	0	0	0	37.5	20.8	16.7	25.0
Q strongly positive	0	0	0	12.5	12.5	20.8	54.2
Party							
Q strongly negative	62.5	12.5	12.5	12.5	0	0	0
Q mildly negative	4.2	8.3	58.3	20.8	4.2	4.2	0
Q mildly positive	0	0	0	16.7	37.5	20.8	25.0
Q strongly positive	0	0	0	16.7	12.5	33.3	37.5

Note. $n = 24$ in each line.

questionnaire could feature a *basic ordering*, that is, S+ ≥ M+ ≥ M– ≥ S–. A final possibility would be for the answers to this questionnaire not even to satisfy basic ordering. (Any set of answers satisfying strict ordering also satisfies quasi-strict and basic orderings, and any set of answers satisfying quasi-strict ordering also satisfies basic ordering.)

At the individual level, our hypothesis was compatible with all three orderings—strict, quasi-strict and basic—and was not compatible with violation of basic ordering. However, the stricter the ordering was, the more support there was for our hypothesis. With respect to the party context, we discovered that strict ordering accounted for 29.2% of response patterns to the questionnaires, quasi-strict ordering accounted for 29.1% more, and basic ordering accounted for an additional 12.5%. Results are even more striking with respect to the job context, with strict ordering accounting again for 29.2% of response patterns, quasi-strict ordering for 50%, and basic ordering for 12.5%.

Discussion

Results of Experiment 2 demonstrate that inference to the antecedent is a function of both the valence and the extremity of the outcome. Outcome valence determines whether the inference is toward the affirmation or the denial of the antecedent. Outcome extremity determines the strength with which this inference is invited: the more extreme the outcome, the stronger the invitation.

It is important to note that this was not only a global trend observed in our sample: Indeed, a large proportion of questionnaires were internally consistent with this hypothesis. This adds strong support to our hypothesis, considering how uncommon it is for researchers to report within-subject consistency in reasoning experiments (see George, 1997, for an example of the discrepancy between global trends and individual protocols in a conditional reasoning task).

Having introduced consequential conditionals, we now want to show how we can apply our knowledge of their previously undocumented properties to predict novel reasoning phenomena. In the next section, we consider a well-known phenomenon (the suppression of modus ponens) and show how consequential conditionals can be used to demonstrate a new variation on this effect.

Consequential Conditionals and the Suppression of Modus Ponens

When lay reasoners are asked what follows from such premises as, "If Mary's TV is broken, then Mary will have it fixed; Mary's TV is broken," they almost unanimously declare that "Mary will have it fixed," in accordance with modus ponens (if A then C; A; therefore, C). Yet, there are some premise sets that reasoners hesitate to apply modus ponens to, for intuitively appealing (if not logically sound) reasons.

During the last decade, research dealing with this suppression of modus ponens phenomenon has been almost exclusively focused on a single kind of such premise sets. From Byrne's (1989) seminal experiment, together with numerous replications and extensions (e.g., Chan & Chua, 1994; Dieussaert, Schaeken, Schroyens, & d'Ydewalle, 2000; Politzer & Bourmeau, 2002; Stevenson & Over, 1995), we can safely assume that a suppression of modus ponens usually occurs with a set of premises of the form

> If A1 then C; if A2 then C; A1,

where (and this is the most important feature of the effect) A2 is not (from general knowledge) a sufficient condition for C but a prerequisite, a necessary condition for C to occur. In other words, although the presence of A2 does not entail the occurrence of C, its absence can prevent the occurrence of C. For example, presented with premises, "If Mary has an essay to write, she will study late at the library; if the library stays open late, Mary will study late at the library; Mary has an essay to write" (where the library staying open late is a prerequisite for Mary to study late there), only a third of participants derived the conclusion, "Mary will study late at the library," in Byrne's (1989) experiment.

The specific nature of A2 in regard to C has been pointed out by most researchers interested in the phenomenon (e.g., Bonnefon & Hilton, 2002; Byrne, 1989; Byrne, Espino, & Santamaria, 1999; Chan & Chua, 1994; De Neys, Schaeken, & d'Ydewalle, 2001; Neth & Beller, 1999; Politzer & Bourmeau, 2002; Stevenson & Over, 1995; Thompson, 1994, 1995). Terminology may vary from one author to another—from Byrne's (1989) "additional antecedent" (p. 67) to Politzer and Bourmeau's (2002) "complementary necessary condition" (p. 365)—and theoretical explanations may differ, but the basic phenomenon is the following: Modus ponens is suppressed with such premise sets as, "If A1 then C, if A2 then C, A1," where A2 is a precondition of C.

From the results of Experiments 1 and 2, we hypothesized that there was another way to suppress modus ponens. The consequential way to suppress modus ponens would make use of a consequential conditional in lieu of the preconditional statement, "If A2 then C." Consider the following premise set:

> If Marie's TV is broken, she will have it fixed;
> If Marie has her TV fixed, she will not be able to pay the electricity bill;
> Marie's TV is broken.

Will Marie have her TV fixed? From a strict logical standpoint, the answer would be yes, she will. One can infer from premises "If A then C; if C then Q; A" not only that C is the case but also Q. Thus, the premise set above entails both conclusions that Marie will have her TV fixed and that she will not be able to pay the electricity bill.

However, we know from Experiment 1 that the second condition in the premise set, as a negative consequential, invites an inference to the falsity of its antecedent. Thus, reasoners presented with this premise set can reach two inconsistent conclusions: On the one hand, modus ponens applied to the first and third premises leads to the conclusion that Mary will have the TV fixed; on the other hand, the second condition invites the inference that Mary will not have the TV fixed. What should reasoners conclude in such a situation?

Even though we cannot predict what conclusion a given individual will reach when presented with this problem, we can predict that the endorsement rate of the conclusion, "Marie will have the TV fixed," should be lower within a group of participants presented with the consequential premise set than it would be within a group of participants presented with straight modus ponens premises, such as, "If Marie's TV is broken she will have it fixed; Marie's TV is broken." In Experiment 3, we tested this prediction.

Experiment 3

Method

Participants. A total of 60 undergraduates at the University of Toulouse-2, all native French speakers, participated in this experiment (21 men and 39 women; mean age = 21 years and 8 months).

Materials and design. Each questionnaire featured three problems, with each problem framed in a different form. The *control* form involved a premise set of the form, "If A1 then C; A1." The *precondition* form involved a premise set of the form, "If A1 then C; If A2 then C; A1." The *consequential* form involved a premise set of the form, "If A1 then C; If C then Q; A1" (see Table 3 for the exact content of each problem). The precondition form was introduced to compare the effectiveness of undesirable outcomes with the effectiveness of preconditions regarding the suppression of modus ponens.

Three different questionnaires were constructed, for each scenario to be framed once in each form. The order of problems was reversed in half the questionnaires. Thus, the form of the premise set can be considered either a three-level within-subject factor (all scenarios being confounded) or a three-level between-subjects factor (if results are considered scenario by scenario).

On the first page of the questionnaire, participants could read that they were about to engage in an experiment about reasoning. They were told that the task was easy, that they should not worry about any trick, and that they should answer logically, without engaging in too many nit-picking considerations about what was the right answer.

Each problem was introduced by an instruction to consider the premises as true. Once participants had considered the premises, they had to say whether Conclusion C could be derived from the premises.

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 (2–6) so that the experimenter could easily observe that participants did not communicate while taking part in the experiment. The experiment was conducted in French.

Results

The endorsement rate of Conclusion C was (across all scenarios) 80% in the control condition, 43% in the precondition condition, and 37% in the consequential condition. Although the endorsement rate in the control condition was arguably lower than what is usually observed in conditional reasoning experiments, the difference between those endorsement rates was still highly significant, Cochran $Q(2) = 24.5$, $p < .001$. In particular, the endorsement rate in the consequential condition was less than half the endorsement rate in the control condition. (The difference between the consequential and the precondition conditions was not significant.)

This same pattern was observed when results were considered scenario by scenario (see Table 4). Endorsement rates in the consequential condition were always significantly lower than in the control condition: $\chi^2(2, N = 40) = 10.724$ for the Marie story; $\chi^2(2, N = 40) = 10.800$ for the Emma story; and $\chi^2(2, N = 40) = 5.759$ for the Lucie story (all ps $< .05$, one-tailed). Endorsement rates in the consequential condition were not reliably different from endorsement rates in the precondition condition.

Discussion

The ability of consequential conditionals to suppress modus ponens inference as do preconditional statements is clearly supported by the results of Experiment 3. Reasoners are reluctant to endorse the conclusion that some agent will take Action C from the premises "If A then C; if C then Q; A," when "If C then Q" is a negative consequential.

We have hypothesized that such reluctance was the product of an invited inference to not-C, for Experiment 1 demonstrated such an inference to be invited by a negative consequential, "If C then Q." Further test of this hypothesis can be derived from the results of Experiment 2. We have demonstrated that the more extreme that the negative outcome Q is, the stronger the invitation is to infer not-C: Hence, if the suppression of modus ponens from the consequential premise set is indeed due to this invited inference, then the more extreme the negative outcome Q, the larger the suppression effect should be. We conducted Experiment 4 to test further this claim.

Experiment 4

Method

Participants. A total of 200 undergraduates at the University of Toulouse-2, all native French speakers, participated in this experiment (52 men and 148 women; mean age = 21 years).

Materials and design. Four different questionnaires were constructed, each of them featuring a different problem, according to a 2 (negativity of Outcome Q: moderate vs. high) × 2 (scenario: Emma vs. Marie) between-subjects experimental design.

The Emma and Marie stories were the same as in Experiment 3 except for the outcome Q of the consequential conditional. In the moderate-Emma problem, Q was "Cedric will not have time for a drink with his friends,"

Table 3
Propositions Used to Create the Problems of Experiment 3

Scenario	A1	C	Q	A2
Marie	Marie's TV is broken	She will have it repaired	She will not be able to pay the electricity bill	The TV can be repaired
Emma	Emma must take the train	Cedric will drive her to the station	He will not be in time for his exam	His car is functioning
Lucie	Lucie goes to the restaurant	She will eat oysters	She will have a terrible allergy	Oysters are available

Note. Problems were in the form "If A1 then C, A1" in the control condition; "If A1 then C, if A2 then C, A1" in the precondition condition; and "If A1 then C, if C then Q, A1" in the consequential condition.

Table 4
Endorsement Rate of Conclusion C as a Function of Scenario and Additional Premise

Scenario	Control (%)	Precondition (%)	Consequential (%)
Marie	85	50	35
Emma	80	35	35
Lucie	75	45	40

Note. $n = 20$ in each cell.

whereas in the high-Emma problem, it was "Cedric will miss his job interview." In the moderate-Marie problem, Q was "Marie will not be able to afford eating at the restaurant every day," whereas in the high-Marie problem, it was "Marie will not be able to pay the rent." Instructions were the same as those in Experiment 3.

Procedure. The procedure was identical to the one used in Experiment 3.

Results

See Table 5 for endorsement rates of C as a function of scenario and negativity of Q. A log linear analysis was conducted to isolate significant associations between the following variables: endorsement rate of C, scenario, and negativity of Q. This log linear analysis resulted in a statistically significant effect of the negativity of Q, $\chi^2(1, N = 200) = 9.742$, $p < .01$, but no effect of scenario or any interaction effect between those two factors. Goodness of fit was excellent, $\chi^2(4, N = 200) = 3.293$, $p = .98$.

Discussion

As expected, the endorsement rate of C was low when Q was highly negative and intermediate when Q was moderately negative. Thus, results support the claim that the more negative the outcome Q was of the consequential, "If C then Q," the larger the suppression was of modus ponens from the premises, "If A then C; if C then Q; A."

Results of Experiment 4 extend results of Experiment 3 in a more comparable way than results of Experiment 2 extended results of Experiment 1. The ability of negative consequentials to suppress modus ponens is a by-product of their property to invite an inference to the falsity of their antecedent, and, in line with the results of Experiment 2, this ability is all the stronger when the inference is itself strongly invited by an extremely negative outcome.

Having identified the chief property of consequential conditionals and having shown how our newly acquired knowledge of this property can enable us to predict novel reasoning phenomena, we now consider the contribution of our series of experiments to the main current approaches to conditional reasoning.

General Discussion

In this article, we investigated consequential conditionals, that is, conditionals with a third-party action as their antecedent and a valued outcome as their consequent. A series of experiments led to four main findings.

1. Consequential conditionals with a negative outcome invite an inference to the falsity of their antecedent, whereas consequential conditionals with a positive outcome invite an inference to the truth of their antecedent.

2. These inferences are all the more strongly invited when the outcome is strongly negative or positive.

3. Modus ponens from premises "If A then C, A" can be suppressed with the introduction of the additional premise "If C then Q," when this additional premise is a consequential conditional with a negative outcome.

4. This suppression effect is all the larger when the outcome is strongly negative.

In this section, we discuss how these findings can inform three recent accounts of conditional inference, namely the mental model approach (Johnson-Laird & Byrne, 2002), the pragmatic account that is based on complementary necessary conditions (Politzer & Bourmeau, 2002), and the conditional probabilities approach (Oaksford & Chater, 2003; Oaksford, Chater, & Larkin, 2000). We consider each of these three accounts and the way they may handle consequential conditionals.

Consequential Conditionals and Mental Models

Johnson-Laird and Byrne (2002) have recently offered a detailed treatment of conditionals within the mental model framework. In particular, they have suggested that conditionals could be interpreted in 10 different ways, which, for the sake of brevity, we do not enumerate here.

Consequential conditionals do not appear to fit in Johnson-Laird and Byrne's (2002) list of possible interpretations, although this list is meant to be exhaustive. However, we can find a way out of this difficulty if we adopt the same perspective toward consequential conditionals that mental model theory adopts toward deontic conditionals. Deontic conditionals do not form 1 of the 10 classes of conditionals in Johnson-Laird and Byrne; instead, they are handled by way of tagging some models as being factual possibilities yet deontic impossibilities.

For example, following Quelhas and Byrne (2003) as well as Johnson-Laird and Byrne (2002), we may represent a deontic conditional such as, "If she drives the car, she must fasten her seatbelt," as a set of four models (referring to four possible factual states of the world), one of them being tagged as a *deontic impossibility*:

Factual possibilities:	drives	fasten	
	not-drives	fasten	
	not-drives	not-fasten	
	drives	not-fasten	:*Deontic impossibility*

Table 5
Endorsement Rate of C as a Function of Scenario and Negativity of Q

	Control (Experiment 3)		Negativity of Q: Moderate		Negativity of Q: High	
Scenario	%	*n*	%	*n*	%	*n*
Emma	80	20	60	50	34	50
Marie	85	20	54	50	36	50

Note that this representation of the deontic conditional makes every factual possibility fully explicit. Some factual possibilities may be left implicit, leading to the following initial representation of the conditional:

Factual possibilities:	drives	fasten	
	drives	not-fasten	:*Deontic impossibility*
	. . .		

Turning to consequential conditionals, we may want to tag some models as being *consequentialist impossibilities* although they are factual possibilities. The tag would apply to models featuring an outcome that is undesirable for the agent or to models that feature the negation of an outcome that is desirable to the agent. For example, the negative consequential, "If Cedric takes up this new job, he will be paid less," may be represented as the following (fully explicit) set of models, with "CSQ impossibility" standing for "consequentialist impossibility":

Factual possibilities:	job	paid less	:*CSQ impossibility*
	not-job	paid less	:*CSQ impossibility*
	not-job	not-paid less	

Some models may be left implicit, though. The first model (featuring a true antecedent and a true consequent) will always stay explicit, and we may want to consider that reasoners keep tagged models in mind. Hence, a simplified representation of the negative consequential would be

Factual possibilities:	job	paid less	:*CSQ impossibility*
	not-job	paid less	:*CSQ impossibility*
	. . .		

When presented with such a conditional and asked what, if anything, follows, reasoners may tentatively eliminate the models tagged as consequentialist impossibilities. When such a strategy is applied to the simplified set of models above, no conclusion follows. However, when applied to the full set of models, it leads to the single model, not-job, not-paid less. From this single model, it follows that Cedric will not take up the new job. Thus, the tendency for negative consequentials to invite an inference to the falsity of their antecedent may be accounted for within mental model theory by introducing a new consequentialist tag.

A positive consequential like, "If Cedric takes up this new job, his life will improve," could be represented as the following set of models:

Factual possibilities:	job	improve	
	not-job	improve	
	not-job	not-improve	:*CSQ impossibility*

Alternatively, the second model may be left implicit, leading to the representation

Factual possibilities:	job	improve	
	not-job	not-improve	:*CSQ impossibility*
	. . .		

This second set of models supports the conclusion, "Cedric will take up this new job." However, this conclusion is no longer supported by the fully explicit set of models. Hence, within the mental model framework, positive consequentials may invite an inference to the truth of their antecedent insofar as their initial representation is not fleshed out, whereas negative consequentials may invite an inference to the falsity of their antecedent only if their initial representation is fleshed out, an asymmetry that can most certainly enable the derivation of some novel experimental predictions.

We have shown so far that mental model theory may account for the results of Experiment 1 by introducing a consequentialist tag along with its deontic tag. If we accept now that the more extreme the outcome is of the consequential conditional, the larger the chance is for its models to get tagged (as mildly positive or negative outcome may not be salient enough to activate the tagging), then mental model theory may also account for the results of Experiment 2.

Results of Experiment 3 can be rather straightforwardly explained using the representation of negative consequentials we have just introduced. Experiment 3 made use of problems such as

> If Marie's TV is broken, she will have it fixed;
> If Marie has her TV fixed, she will not be able to pay the electricity bill;
> Marie's TV is broken.

The first conditional gives rise to the following set of models:

Factual possibilities:	broken	fixed
	not-broken	fixed
	not-broken	not-fixed

The second conditional is a negative consequential, giving rise to the models

Factual possibilities:	fixed	can't pay	:*CSQ impossibility*
	not-fixed	can't pay	:*CSQ impossibility*
	not-fixed	not-unable to pay	

When the third premise is integrated to those models, models featuring not-broken are eliminated. Thus, the set of models representing the negative consequential does not change, but the first conditional is now represented as the single model broken, fixed. Because the models tagged as consequentialist impossibilities are to be tentatively dismissed from the reasoning, reasoners are left with only two models to be conjoined together—broken, fixed—from the first conditional, and not-fixed, not-unable to pay from the negative consequential. Because these models are inconsistent, their combination results in a null model, which does not support the conclusion, "Marie will have her TV fixed."

We have just demonstrated that the suppression of modus ponens by the introduction of a negative consequential (Experiment 3) could be explained within the mental model framework, provided that a consequentialist tag is introduced in the theory. The suppression of modus ponens would then occur when the models featuring the negative outcome are tagged as consequentialist impossibilities. Again, if we accept that the more negative the outcome, the larger the chance for the models to be tagged, then we can also account for the results of Experiment 4: the more negative the outcome, the larger the chance for the models to be tagged as consequentialist impossibilities and the larger the chance for modus ponens to be suppressed.

Thus, the introduction of a consequentialist tag appears to enable mental model theory to account for the results of our four experiments. One should be concerned, however, to limit the number of new tags proposed, to avoid an undue proliferation of ad hoc modifications to mental model theory. Nevertheless, because

of the importance and reliability of consequentialism when it comes to predicting human behavior, we believe consequentialist tags deserve a position within the core of the mental model theory of conditionals.

Consequential Conditionals and Complementary Necessary Conditions

Politzer and Bourmeau (2002) have argued that conditional statements are typically understood to convey the implicit assumption that their complementary necessary conditions (CNCs) are satisfied. For example, the statement, "If the match is struck then it lights," comes with the implicit assumptions that the match is not wet, that there is oxygen in the room, and so forth. More generally, any conditional "If P then Q" would be construed as, "If (P and N) then Q," where N can be any CNC needed for Q to occur.

Results of Experiments 3 and 4 can be quite naturally accounted for in terms of CNCs. Consider the CNCs of the statement, "If Marie's TV is broken, she will have it fixed." We may think that for Marie to have the TV fixed, she must also be able to find someone with the ability to fix TVs; the TV itself must not be broken beyond repair, and so forth. However, we may also think of another class of CNCs: For Marie to have the TV fixed, she must not know of any undesirable consequence of such a decision. In other words, the absence of a negative outcome may be considered a CNC: If we have reasons to think this CNC is not fulfilled, then knowing that Marie's TV is broken is no longer a sufficient condition to conclude that Marie will have it fixed, hence the suppression of modus ponens in Experiment 3.

Politzer and Bourmeau (2002) also noted that CNCs vary in their importance regarding the realization of the consequent, "Some are *sine qua non* conditions, whereas others are less indispensable in the sense that their intervention does not affect the consequent in an all-or-nothing manner; rather, they render the consequent more or less likely to be true" (p. 366). Hence, the results of Experiment 4: that modus ponens is all the more likely to be suppressed than the unfulfilled CNC is important, and a strongly negative outcome is arguably more important as an unfulfilled CNC than a mildly negative outcome.

Politzer and Bourmeau (2002) did not offer a detailed typology of CNCs, as they claimed this task to be beyond the scope of their article. Experiments 3 and 4 in the present article may contribute to such a typology, as they demonstrate the existence of a general CNC subclass, the absence of a negative outcome.

Although the CNC approach appears to deal nicely with results of Experiments 3 and 4, results of Experiments 1 and 2 demonstrated a property of consequential conditionals that is alien to CNCs. Undoubtedly, consequential conditionals have CNCs: For example, the statement, "If Marie has her TV fixed, she will not be able to pay the rent," has many CNCs, from Marie not winning the lottery after having had the TV fixed to her not having the TV fixed for free. Yet, the chief property of consequential conditionals (i.e., the invitation of an inference to the truth or falsity of their antecedent) does not appear to be related to, or at least explained by, their having or not having CNCs. In summary, consequential conditionals have CNCs as any other conditional, but they also manifest a property that sets them apart from standard conditionals and that does not concern CNCs.

Consequential Conditionals and Conditional Probabilities

Oaksford et al. (2000; see also Oaksford & Chater, 2003) have developed a psychological model of conditional inference that is based on conditional probabilities. This model assumes that the conclusion C of a modus ponens argument "If A then C, A" is endorsed in direct proportion to the conditional probability $P(C|A)$. A rule, "If A then C," has an exception parameter, ε, such that $P(C|A) = 1 - \varepsilon$, which is equal to $P(\text{not-}C|A)$.

Our results emphasize both the defeasible (Experiments 3 and 4) and graded (Experiments 2 and 4) nature of human inference. We can thus expect those results to fit nicely into Oaksford et al.'s (2000) approach, which focuses precisely on those two aspects of human reasoning.

A simple way to account for our results within this probabilistic model is to use the following formulation of the consequentialist principle: The probability for an agent to take an action is an increasing function of the expected utility of this action. A consequential conditional, "If P then Q," can be conceived as providing information about the expected utility of Action P: When Outcome Q is strongly positive, Action P has high expected utility, whereas this expected utility is lower when Q is only moderately positive and null when Q is a neutral outcome. Thus, the probability of P (and consequently, its endorsement rate) shall be high when Q is strongly positive, lower when Q is moderately positive, and again lower when Q is a neutral outcome.

The same line of reasoning applies for negative outcomes: The more negative Q is, the higher the expected utility of Action not-P and, consequently, the higher the endorsement rate of Conclusion not-P. Thus, results of Experiments 1 and 2 can be accounted for within a probabilistic model by using the expected utility formulation of the consequentialist principle.

The consequential suppression of modus ponens demonstrated in Experiments 3 and 4 may also be explained in probabilistic terms. From premises "If A then C, A" the probability of C is $P(C|A) = 1 - \varepsilon$, with the exact value of ε depending on the scenario and on participants' background knowledge. Now the premise "If C then Q" (where Q is a negative outcome) also provides information about the probability of C. As we have just considered, the probability of C, say $P(C) = \eta$, is a decreasing function of the expected utility of not-C: The more negative that Q is, the lower η becomes. Hence, from premises "If A then C, if C then Q, A," the probability of C could be anywhere between η and $(1 - \varepsilon)$. We may expect that the lower η is, the lower will be the mean probability granted to C among a given sample of participants. As a consequence, we may expect the endorsement of C to be high from participants only presented with premises "If A then C, A"; lower from participants presented with premises "If A then C, if C then Q, A," where Q is a moderately negative outcome; and lowest from participants presented with premises "If A then C, if C then Q, A," where Q is a strongly negative outcome. Such were the results of Experiments 3 and 4.

Of course, we have not offered here a precise probabilistic model of consequential conditionals and the consequential suppression of modus ponens. Our goal was to sketch how such a model could be conceptualized, to show how our series of experiments on consequential conditionals may enrich the existing probabilistic approach to conditional inference.

Conclusion

We believe consequential conditionals to be extremely pervasive in everyday reasoning and decision making and, as such, well worthy of further study in conditional reasoning research. We are especially interested in the possibility of extending the definition of consequential conditionals, to include inducements (second-person consequentials) and means–end statements (third-person consequentials); future research will tell whether such statements invite the same set of inferences as consequential conditionals, in the same way.

Our purpose in this article was to make the case for the need for further research devoted to consequential conditionals. Accordingly, in addition to our experimental results, we have sketched possible ways for current theories to handle this important class of conditional statements. If the suggestions we have made achieve their goal, they will certainly call for refinements and criticisms, and we are looking forward to both kinds of positive consequent.

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