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Conditional content, explicit information and generating cases: Sources for suppressing inferences

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ABSTRACT

In the present study, we evaluate the suppression effect by asking participants to make inferences with everyday conditionals ("if A, then B"; "if Ana finds a friend, then she will go to the theatre"), choosing between three possible conclusions ("she went to the theatre"; "she did not go to the theatre"; "it cannot be concluded"). We test how these inferences can be influenced by three factors: a) when the content of the conditional induces us to think about disabling conditions that prevent us from accepting the consequent (A and ¬B) or alternative conditions that induce us to think about other antecedents that could also lead to the consequent (¬A and B), b) when explicit information is given about what really happened (e.g. Ana found a friend but they did not go to the theatre; or Ana did not find a friend but she went to the theatre) and c) when participants have to look for concrete disabling (e.g. Ana's friend had to work) and alternative cases (e.g. Ana's sister wanted to go to the theatre) before making the inferences. Previous studies have shown what were called "suppression effects": disabling conditions reduced valid inferences while considering alternatives led to a reduction in fallacies. These two "suppression effects" were shown in Experiment 1: a) in an Implicit condition that included just the content factor of the conditional and b) with a greater magnitude in a second Explicit condition that included the three factors (content, explicit information and search for counterexamples). Experiment 2 compared the same Explicit condition with another in which participants, instead of looking for counterexamples, completed a control task of looking for synonyms. In addition, half the participants looked for a few items (2 cases) and the other half for many items (5 cases). Results again showed the suppressing effect in all the conditions, but the magnitude was greater in the counterexample condition. No relevant differences were obtained according to the number of cases generated; the most relevant result was that the factors provided an additive effect on the suppression.

People draw conclusions from conditionals such as

(1) "if Cristina ran, then she took the train" (if A, then B)

using their knowledge about the world and their logical knowledge. For example, knowing that "Cristina ran", most people choose the valid conclusion "she took the train" when they are given three possible ones (She took the train/She did not take the train/Nothing follows) (e.g. see Evans et al., 1993). However, knowing that "Cristina took the train", most people conclude that "she ran" instead of the valid inference "Nothing follows", from a material implication in propositional logic (e.g. see, Evans et al., 1993). The first inference is a Modus Ponens (MP; If A, then B; A, therefore B) while the second is a fallacy, called Affirmation of the Consequent (AC; If A, then B; B, therefore A). Table 1 shows the two valid inferences (MP and MT) and the two fallacies (AC and DA) resulting from affirming or denying the antecedent and the consequent of a conditional.

Mental logic theories (Braine & O'Brien, 1998; Rips, 1994) have proposed the existence of a mental rule for modus ponens. When reasoners find a propositional argument that matches the MP structure (If A, then B; A), they automatically apply the mental rule to conclude "B," which explains the high proportion of MP endorsements (see Evans et al., 1993 and Nickerson, 2015, for reviews). There has not been a similar rule proposed for fallacies. One explanation for this is that the frequency of fallacies depends on the conditionals' content, while valid inferences do not (e.g., Rumain et al., 1983).

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Table 1
Structure and example of the four logical inferences with the conditional, categorical premise and conclusion. The symbols "¬" and "∴" mean "not" and "therefore", respectively.

Conditional premise If she ran, she took the train		
	Categorical premise	Conclusion
Valid inferences		
Modus ponens (MP) *If A, B; A ∴ B*	She ran	She took the train
Modus tollens (MT) *If A, B; ¬B ∴ ¬A*	She did not take the train	She did not run
Fallacies		
Affirm consequent (AC) *If A, B; B ∴ A*	She took the train	She ran
Deny antecedent (DA) *If A, B; ¬A ∴ ¬B*	She did not run	She did not take the train

Based on the mental model theory, Byrne (1989) demonstrated that the modus ponens inference could be suppressed by adding information to the logical argument. This study demonstrated that the conditional's content also influences the MP inference, and therefore, the existence of a mental rule for valid inferences (MP) but not for fallacies was questioned (Byrne, 1989; Espino & Byrne, 2020).

Since the publication of the original studies of suppression (Byrne, 1989; Cummins et al., 1991), many other studies have been carried out and the main deductive theories have had to be adjusted to explain the suppression effect. Despite many studies on suppression, some doubts remain about the conditions in which suppression occurs and whether the theories can easily explain everything, as shown in recent papers (Cariani & Rips, 2017; Espino & Byrne, 2020; Oaksford & Chater, 2020). In these studies, two conditions are critical and involve the action of *counterexamples* (following the example of conditional (1)):

- Alternative conditions allow another antecedent but the same consequent (e.g. Cristina found a taxi and took the train; she did not need to run)
- Disabling conditions *prevent* the consequent from happening even if the antecedent happens (e.g., a twisted ankle meant that even if Cristina ran, she would be too late to take the train).

This study aims to clarify some factors implicated in the suppression effect.

1. Experimental procedures to produce suppression of inferences

Earlier studies (see Cariani & Rips, 2017) used three procedures to create a suppression effect (the reduction of valid inferences and fallacies):

The first consists of using **Enabling conditions**, also called Additional conditions (see Espino & Byrne, 2020). For example, if after the conditional (1) "if Cristina ran, then she took the train", participants read

(2) "if Cristina's ankle recovered, then she took the train",

they tended to suppress the MP inference "she took the train" when provided with the information that "she ran". When participants consider additional content that may affect the relationship between the antecedent and the consequent of a conditional, they are more likely to suppress valid inferences (Byrne, 1989).

The second procedure uses **Disabling conditionals**, also called Contravening conditions (see Cariani & Rips, 2017). For example, if after the conditional (1) "if Cristina ran, then she took the train", participants read

(3) "if Cristina's ankle is twisted, then she did not take the train";

they were again less keen to make the modus ponens inference that Cristina took the train, knowing that "Cristina ran".

In both cases (1 & 2; 1 & 3), the second conditional suppressed the valid inferences (modus ponens and the modus tollens) but not the fallacies (see Cariani & Rips, 2017; Markovits et al., 2010). In the first case, to accept a conclusion, one must consider an additional condition (a healthy ankle). In the second case, a condition (a twisted ankle) can prevent the conclusion.

The third procedure implies the use of **Alternative conditions**. For example, if after presenting the conditional (1) "if Cristina ran, then she took the train", participants read

(4) "if Cristina found a taxi, then she took the train",

they were less likely, given this information, to accept the Affirmation of the Consequent fallacy, "Cristina took the train; therefore, she ran". The same happened for the Denial of the antecedent, the other fallacy, but not for the valid inferences. This effect can be explained by the fact that people understand the existence of other possibilities (e.g., not only running but also taking a taxi) that allow the same consequent, and therefore, they conclude "nothing follows"[1] (Cariani & Rips, 2017; Cummins, 1995).

In these three procedures, the conditional (1) is followed by another conditional (2, 3, or 4). Cariani and Rips (2017) called the effect obtained with these three procedures "explicit suppression". Later studies showed that the suppression effect did not require the inclusion of a second conditional, just additional information that would lead people to think of disabling conditions or alternative possibilities. For example, after reading conditional (1), when participants were informed that "there were taxis available", they suppressed the conclusion that "Cristina ran", and chose "I cannot conclude whether or not she ran" (because she could have taken a taxi). Some authors (e.g., De Neys et al., 2002, 2003b; Markovits & Quinn, 2002) have long demonstrated these effects of disablers (also called contravening conditions) and alternatives in inferential reasoning, shown even without explicit information of counterexamples (e.g., Cummins, 1995; Markovits, 1986; Thompson, 1995).

It has also been demonstrated that some factors influence these effects, such as the strength of the alternative conditions in memory (Quinn & Markovits, 1998), participants' working memory spans, the strategies used, the options given in the conclusion, whether the conclusions are formulated with a degree of certainty (Geiger & Oberauer, 2007) or in a dichotomic way (Markovit et al., 2012). In general, valid MP inferences are more likely to be reduced when disablers can be easily retrieved from long-term memory (Bonnefond et al., 2014; De Neys et al., 2002, 2003b; Markovits & Quinn, 2002; Simoneau & Markovits, 2003). Recently, Markovits et al. (2017) and Verschueren et al. (2005a, 2005b) have studied how people can be classified depending on their tendency to look for counterexamples, while others seem to have a more probabilistic strategy (Brisson & Markovits, 2020). In any case, using a particular strategy does not increase the overall number of logical responses (see Markovits et al., 2017).

[1] Although the prediction is an increase in "nothing follows" responses, many studies used an indirect estimation, using the reduction of the frequency of endorsed fallacies. The indirect measure is not clear because it includes changes in the frequency of the unexpected third conclusion (e.g. in AC; "if a, b; b, therefore …" the "not a" conclusion is computed as a suppression effect). In both experiments, we compute the "nothing follows" conclusions to test suppression.

2. Theoretical approaches explaining inference suppression

Different theories have tried to explain the results of suppression studies: some of them based on logic (see e.g., Braine & O'Brien, 1998; Rips, 1994), including pragmatic implicatures and context-sensitivity (Cariani & Rips, 2017), others on suppositions (see Evans, 2007), on probability (see e.g., Cruz et al., 2015; Evans, 2012; Pfeifer & Kleiter, 2009) or on mental models (Byrne, 1989; Johnson-Laird & Byrne, 2002).

Probabilistic approaches to deduction with conditionals (if A, then B; e.g. If Cristina runs, she will take the train; see Geiger & Oberauer, 2007) propose that people's confidence in a conclusion (e.g., Cristina took the train) depends on the subjective conditional probability of the consequent, given the antecedent p(B/A) i.e., the probability of Cristina taking the train given that she ran (p(Take-Train/Run)). Instances that alter the conditional probability will also influence inference acceptance, for example, disabling cases such as having a twisted ankle, or an alternative such as taking a taxi instead of running would reduce the acceptance for valid inferences and fallacies, respectively.

The mental model theory (Johnson-Laird & Byrne, 2002; Khemlani et al., 2018) states that people represent conditionals as mental possibilities (a model of reality known as a mental model) that include the case A & B and an implicit mental footnote indicating that other possibilities exist, but are not initially represented. In the conditional (1), the possibility that "Cristina ran, and she took the train" is represented:

She ran	Took the train	(A B)
…		

However, depending on the context, content and knowledge, different instances may also be represented, such as "¬A & ¬B" and "¬A & B" (Johnson-Laird & Byrne, 2002; Quelhas et al., 2010, 2017), and inferences will depend on the possibilities represented:

She ran	Took the train	(A B)
She did not run	Took the train	(¬A B)
She did not run	She did not take the train	(¬A ¬B)

For example, knowing that Cristina can find a taxi (she does not need to run), people represent the alternative model "¬A B". In this case, there are two models in which B is present (the initial model AB and ¬A B), and when we tell participants that Cristina took the train (B), they are less likely to accept the fallacy "she ran" (A) because they have another possibility represented (Cristina did not run, that is, ¬A). This extra model could explain the suppression of fallacies. Similarly, the suppression of valid inferences occurs when participants think of disabling conditions, "A ¬B" cases, such as "Cristina had a twisted ankle". Given A (Cristina ran), they are less prone to conclude B (she took the train), as they have in mind a model with "¬B", which is inconsistent with the model "A B".

Cariani and Rips (2017) proposed a model of suppression related to the mental model theory without assuming mental models where the meaning of a conditional (semantic) is captured by one indicative conditional rather than many, as proposed by the mental model theory (Johnson-Laird & Byrne, 2002). The suppression effect results from conversational pragmatic principles that alter the scope of the context in which people evaluate the argument. For example, participants assume that when they are told conditional (1), it is because there is a common ground knowledge based on typical properties (If you are in a hurry and run, you can catch the train) and this excludes atypical ones (such as your ankle is twisted and you cannot run fast). Participants consider the set of possibilities consistent with an argument. However, when additional information is given (as a contravening condition, e.g., "if Cristina's ankle is twisted, then she did not take the train"), people reevaluate the possibilities. In this case, most participants would not accept that "Cristina ran and took the train".

3. The role of explicit premises and thinking about concrete cases

As we have seen, authors have used different experimental procedures to suppress inferences: using two conditionals, using an additional premise after the conditional or just using alternative or disabling content.

Alternative content induces us to think of alternative conditions that also lead to the same consequent:

(5) "If María studies hard, then she will get good grades".

Some students may think of other ways to get good grades without studying hard, such as cheating in the exam.

Disabling content induces us to think of disabling conditions that could prevent the consequent,

(6) "If Ana finds a friend, then she will go to the theatre".

People can find many circumstances that would prevent Ana from going to the theatre, such as going to a party instead.

Whether the content of the conditional alone can lead to suppression has been brought into question. Cariani and Rips (2017) compared the results from different suppression studies and sustain that suppression effects are more evident with the three traditional procedures (enabling-contravening conditions and alternative conditions). They questioned the robustness of the suppression effect in "Implicit suppression" studies, when participants receive one conditional with content that leads them to think of disabling or alternative conditions. Moreover, they pointed out that most of these studies reporting suppression used a different task: asking participants to give a response on a scale that varies on a continuum between "very sure that I can draw this conclusion" to "very sure that I cannot draw this conclusion" (e.g. Cummins, 1995; De Neys et al., 2003a; Geiger & Oberauer, 2007). As previously mentioned, this could lead participants to make an inference not assuming the truth of the premises, but answering to the degree of confidence that should be placed in the consequent. They cite three other experiments with more traditional conclusions, but find that their effects are unclear and differ from each other (see Cariani & Rips, 2017; p. 582).

In our study, we use an "implicit suppression" procedure referred to by Cariani and Rips (2017), but using a traditional inference task with the three possible discrete conclusions (such as in Table 2). In Experiment 1, we test whether it is the conditional's content leading to thinking about alternatives and disabler conditions that produces the suppression effect. We also test whether the magnitude of suppression is similar to that in a condition with unambiguous and explicit indications of alternatives or disabling conditions. According to theoretical models, such as probabilistic and suppositional approaches and models based on pragmatics, we would expect a maximum suppression effect to be obtained when participants are explicitly informed of the existence of alternative or disabling conditions for a particular conditional (for example, by changing the conditional probability, as mentioned in the previous section). However, if participants represent particular cases (as the model theory proposes), an increase of the suppression effect would be obtained when participants think of different concrete cases in addition to the explicit information. We will test this possibility in Experiment 2. If a participant only needs evidence of the existence of a disabling condition to reduce a modus ponens inference, whatever source provides the effect will be sufficient, and no additional effect should emerge. However, if the sources influence different processes during the inference, we would expect additive effects.

Few studies have tried to test whether the concrete number of alternatives and disabling conditions directly affects the reduction of valid

Table 2
Structure of the suppression trials for a disabling conditional used in Experiment 1 (rows 1 and 2) and Experiment 2 (rows 2 and 3). See text for more details.

Implicit procedure	Experiment 1- example
Control search cases:	*Write two possible synonyms for (big)* ______________________________
Conditional: Minor premise (MP): Conclusions:	If Ana finds a friend, then she will go to the theatre Ana finds a friend, therefore, 1) Ana goes to the theatre 2) Ana does not go to the theatre 3) It cannot be concluded …. (the 3 other inferences follow: AC, DA & MT)
Explicit procedure (with concrete cases)	**Experiments 1 and 2 - example**
Conditional: Explicit information:	If Ana finds a friend, then she will go to the theatre However, we know that Ana found a friend but she did not go to the theatre
Search for alternative or disabling cases:	*Write two possible cases in which that could have happened:* ______________________________
Conditional: Minor premise (MP): Conclusions:	If Ana finds a friend, then she will go to the theatre Ana finds a friend, therefore, 1) Ana goes to the theatre 2) Ana does not go to the theatre 3) It cannot be concluded …. (the 3 other inferences follow: AC, DA & MT)
Explicit procedure (without concrete cases)	**Experiment 2 example**
Conditional: Explicit information:	If Ana finds a friend, then she will go to the theatre However, we know that Ana found a friend but she did not go to the theatre
Control search cases:	*Write two possible synonyms for big* ______________________________
Conditional: Minor premise (MP): Conclusions:	If Ana finds a friend, then she will go to the theatre Ana finds a friend, therefore, 1) Ana goes to the theatre 2) Ana does not go to the theatre 3) It cannot be concluded …. (the 3 other inferences follow: AC, DA & MT)

inferences and fallacies. Markovits and Quinn (2002) in their original model proposed that after successful retrieval of a single counterexample, the search process stops as there would be no advantage in accessing more counterexamples. However, De Neys et al. (2002) had mixed results, testing frequency and processing times. The authors suggested that the number of disabling conditions could influence not only valid inferences but also fallacies. The same authors in another study (De Neys et al., 2003a) manipulated the number of explicit counterexamples (0 or 4 alternatives or disablers) and found the expected effect for affirmative inferences (MP and AC). In contrast, the effect was less evident in the negative inferences (MT and DA). A possible explanation is that the additional processing requirements for these negative inferences burden the counterexample search process.

It is difficult to make specific differential predictions from the deductive theories. They can all integrate different results, and in some cases, opposite results. Probabilistic approaches maintain that people accept a conclusion when it is believable. We could attribute to probabilistic approaches the primary role of factors such as the general probability of the conditional rather than the role of the number of particular cases such as disabling conditions, which is the argument used in some studies (Geiger & Oberauer, 2007). Nevertheless, it seems plausible that if one thinks of many alternatives or disabling cases, the perceived probability will change. Considering Cariani and Rips's (2017) proposal, when participants are told explicitly of alternatives or disabling conditions, we can expect suppression. However, we would not expect an increase in suppression when asking participants to think of concrete instances because there are no semantic or pragmatic changes. On the other hand, because the model theory assumes people consider models of reality, the concrete cases should affect the inferences. But once a critical case (such as "¬A B") has been represented, why would one expect many cases to be more effective than just a few?

4. Experiment 1. Conditional content for the suppression effect

As previously mentioned, Cariani and Rips (2017) maintained that the empirical results of suppression are not precise when only one conditional is presented instead of two. They also questioned whether some suppression effects, found previously in the literature, could be due to not using the traditional inference task with three options for conclusions. In this experiment, we test suppression with one conditional and use the standard inference set of conclusions. We are interested in testing whether the suppression effect is obtained in a simple implicit condition depending on the conditional content. We tested participants with two types of conditional: alternative contents that lead people to think of alternatives to the antecedent (¬A cases that lead to the same consequent). These conditionals should suppress fallacies by increasing the frequency of "nothing follows" conclusions. The second type relates to disabling contents that lead participants to think of disabling conditions (¬B even when A occurs), and should suppress valid inferences. The contents were selected from previous studies (Couto et al., 2010; Cummins, 1995) and from a pilot study conducted to increase the number of conditionals (see the Materials section in Experiment 1 and Appendix A for more details).

Based on the previously reviewed studies, we created an explicit suppression condition to contrast with an implicit suppression condition to test whether the implicit condition can produce suppression and if a difference in the magnitude of the suppression effect exists between the conditions.

The suppression procedure structure in this study is shown in Table 2 (first and second rows). In the implicit condition, in each trial, participants carry out a control task, in which they generate synonyms for a given word. We then present the conditional with disabling or alternative contents (see Appendix B for the conditionals list) followed by the minor premise, and ask participants to make the four inferences (MP, DA, AC, MT). In contrast, in the Explicit condition, we provide participants with disabling or alternative information, stating what happened after the conditional. For example, "we know that A occurred, but B did not." Following this, we ask participants to generate Disablers or Alternatives and then make the four inferences (see Table 2, second row).

Therefore, in the Explicit condition (with concrete cases; as it is which was used in this Experiment), there are two sources of information for alternatives and disablers that are not present in the Implicit condition: the explicit mention of there being disablers/alternatives and the search for specific disablers/alternative cases.

We test an additional factor to determine whether the number of concrete alternatives and disablers represented affects the magnitude of the suppression. Half the participants search for a few particular cases (two), and the other half search for many cases (five). Since executive function activity can influence the inference task, we created the control task for the implicit condition, where participants search for few (two) or many (five) synonyms. The synonyms are neutral words, not related to alternatives or disablers, and therefore not expected to produce any suppression effect.

If the content is enough to produce the predicted suppressing effect, this would appear in both conditions (Implicit and Explicit). However, if the suppression requires participants to consider explicit information, the suppressing effect will only appear in the Explicit condition. Finally, if the number of alternatives or disablers generated is responsible for the suppression effect, we could expect a more significant suppression effect in the many cases group than in the few cases group.

4.1. Participants

Sixty-three adults between 19 and 27 years (*M* = 19.64; *SD* = 1.50) participated in the study. Fifty were women with a mean age of 19.48 years (*SD* = 1.45) and thirteen were men whose mean age was 20.23 years (*SD* = 1.60). The size of each group was determined before data collection and based on effect sizes in the literature. All participants were native Spanish speakers and were recruited in colleges or universities in Granada. They were compensated with course credits. Before starting the experiment, they read a consent form complying with the University Research Ethics Committee guidelines.

4.2. Materials

We used twelve conditionals, half having many alternatives available, the other half many disablers (see Appendix B). We selected these conditionals based on previous studies (Couto et al., 2010; Cummins, 1995) and a pilot study (see Appendix A) to reach the 12 conditional sentences.

Materials test: we asked 33 adults (from 20 to 54 years old) to test 12 conditionals of the same kind, similar to those previously mentioned. We presented six conditionals to each participant (in a disabler or an alternative condition), and they had to write down on a sheet of paper as many counterexamples as possible for each conditional. An example of the alternative condition is:

"If María jumps into a swimming pool, then she will get wet.
However, we know that María did not jump into the pool, but she got wet.
Write down as many explanations as you can think of for this fact."

For the disabling condition, we negated the consequent:

"If Ana finds a friend, then she will go to the theatre.
However, we know that she did not go to the theatre, but she found a friend.
Write down as many explanations as you can think of for this fact."

Of the 12 conditionals tested, we selected three as having many alternatives available but few disablers and three others as having many disablers available but few alternatives. The time spent generating the maximum number of alternatives and disablers was no longer than 2 min.

With the complete set of 12 final conditionals (six from previous studies and six selected in the pilot study), we carried out our experiment using E-prime software v.2.

Participants received the 12 conditionals (6 with many alternatives available and 6 with many disablers available). Participants were randomly assigned to two groups to generate either two or five counterexamples (explicit condition) or synonyms (implicit condition) for each conditional. For each conditional, they also had to make the 4 inferences (MP, MT, AC, DA) in a total of 48 inferences.

The six synonyms trials for the Implicit procedure condition and six counterexample trials for the Explicit procedure condition were presented in block order (Implicit vs Explicit), both blocks being counterbalanced by participants.

4.3. Procedure and design

Participants were tested in a quiet room using a computer to display stimuli and record responses on a keyboard controlled by E-prime software v.2. (Schneider et al., 2002). The sessions lasted between 15 and 30 min. Participants were distributed randomly in two groups depending on the number of elements they had to generate: Few items (two) or Many items (five).

They read the instructions on the screen to ensure comprehension of the "Synonyms" and "Counterexample" tasks. Each participant then performed twelve trials: 6 for the Explicit Procedure condition (with 3 alternatives and 3 disablers in the generation task) and 6 for the Implicit Procedure condition (with 6 synonyms in the generation task).

Implicit condition: The participants started with the generation task, where they had to generate 2 or 5 synonyms depending on their assigned group. For example:

Type 2 synonyms for the word "good" [generation task - synonyms]

After that, a conditional was displayed on the screen, followed by the minor premise and the three response options. Participants had to press one of three keys to select the appropriate conclusion. An example of the Affirmation of the consequent (AC) is:

If Vera turns on the air conditioning, then she will be cold [conditional]
Knowing that Vera was cold, what can you conclude? [minor premise]

1. Vera turned on the air conditioning
2. Vera did not turn on the air conditioning
3. It cannot be concluded

Press 1, 2 or 3 according to your response

For each conditional, they were asked to make all four inferences. Once the participant had completed the inferences, a new generation task would appear, followed by the conditional and inferences.

Explicit condition: In the explicit condition, the participants started with the conditional, followed by explicit alternative or disabler information and the generation task. For example:

If Vera turns on the air conditioning, then she will be cold [conditional]
However, we know that Vera turned on the air conditioning but did not feel cold [explicit information]

Type 2 possible cases in which that could have happened [generation task - counterexamples].

After completing the generation task, they made the four inferences as described above for the implicit condition.

The six synonyms trials for the Implicit procedure condition and six counterexample trials for the Explicit procedure condition were presented in blocks (Implicit vs Explicit); the presentation of the blocks was counterbalanced.

In the "Few items" group, participants had 1.50 min for each generation task (synonyms and counterexamples), meaning that for each word they had 1.50 min to generate two synonyms and for each conditional in the explicit condition they had 1.50 min to generate two counterexamples. In the "Many items" group, participants had 2 min for each generation task. The time was fixed based on the results in a pilot study without a time limit.

In this way, we created a 2 (Group: few items vs. many items) × 2 (Condition: Implicit vs. Explicit) × 2 (Counterexample: Alternatives vs. Disablers) × 2 (Inference: Valid vs. Fallacy) mixed design with the group variable manipulated between participants.

The suppression effect was computed for the traditional, logical and valid conclusions (interpretation of the conditional material implication): endorsed valid inferences and "nothing follows" conclusions for fallacies.

4.4. Results Experiment 1

The data are available at https://sl.ugr.es/0aVB for the two experiments.

As expected, fewer cases were generated in the Few items group than in the Many items group, for both the Explicit Condition (Few items: $M = 1.94$, $SD = 0.11$; Many items: $M = 4.16$, $SD = 0.62$; U-Mann Whitney test $Z = 6.97$, $\eta^2 = 0.74$, $p < .001$) and the Implicit Condition (Few items: $M = 1.71$, $SD = 0.21$; Many items: $M = 3.06$, $SD = 0.88$; $Z = 5.91$, $\eta2 = 0.55$, $p < .001$).

We carried out an analysis of variance (ANOVA) on the frequency of correct answers (valid) in a 2 (Condition: Explicit vs Implicit) by 2 (Counterexample: Alternative vs Disabler) by 2 (Inferences: Valid vs Fallacies) by 2 (Group: Few items vs Many items) design with the first three factors manipulated within-participants and the last between-participants. We computed the affirmation of the consequent for modus ponens, the negation of the antecedent for modus tollens and the "nothing follows" conclusion for the two fallacies (AC and DA) as correct inferences. Note that computing this response directly, as a measure of the suppression effect, is a stricter criterion than just looking for non-acceptance of the fallacies, which is consistent with two possible alternatives (the nothing follows and ¬A in the case of AC and B in the case of DA).

More correct inferences were made with Valid inferences than with Fallacies (72% vs. 42%; $F(1, 61) = 57.46$, $p < .001$, $\eta^2 = 0.49$) and the same happened for Alternatives compared to Disablers (74% vs. 40%; $F(1, 61) = 205.99$, $p < .001$, $\eta^2 = 0.77$) (see Table 3 and Table C1). In general, results reveal a traditional trend that shows that Valid inferences are more frequently accepted than Fallacies. Note again that we compute "nothing follows" responses for Fallacies, which is the correct response from a material implication interpretation of the conditional and the logical response. As expected, considering Alternatives increases the correct inferences in Fallacies and considering Disablers reduces Valid inferences. This suppressing effect was greater for the Explicit Condition than for the Implicit Condition, with fewer Valid inferences in the first (54% vs. 60%; $F(1, 61) = 19.5$, $p < .001$, $\eta^2 = 0.24$). No effect of Group (few items vs many items) was found (58% vs. 56%; $F(1, 61) = 0.34$, $p = .56$, $\eta^2 = 0.01$).

Results also showed a significant interaction between Condition (Explicit vs Implicit) and Counterexample (Alternative vs Disabler) ($F(1, 61) = 61.23$, $p < .001$, $\eta^2 = 0.50$), between Condition (Explicit vs Implicit) and Inference (Valid vs Fallacies) ($F(1,61) = 35.02$, $p < .001$, $\eta^2 = 0.37$) and the interaction of Counterexample (Alternative vs Disabler) with Inference (Valid vs Fallacies) ($F(1,61) = 28.38$, $p < .001$, $\eta^2 = 0.25$).

The interaction showed that different results were obtained in the Implicit condition. The generation of synonyms made before the inference, which acts as a control, should not influence the process. Actually, the analysis for this condition shows no interaction between Counterexample and Inference ($F(1,61) = 1.23$, $p = .27$, $\eta^2 = 0.02$), but more correct responses for Alternatives than Disablers (64% vs. 52% $F(1,61) = 37.12$, $p < .001$, $\eta^2 = 0.37$) and more correct Valid inferences than Fallacies (87% vs. 30%; $F(1,61) = 125.44$, $p < .001$, $\eta^2 = 0.69$). Therefore, the content per se can provide the suppressing effect on inferences (see Fig. 1).

The interaction between Condition and Counterexample shows that the suppressing effect is significant for the Explicit condition ($F(1,61) = 198.54$, $p < .001$, $\eta^2 = 0.77$) and for the Implicit condition ($F(1,61) = 50.13$, $p < .001$, $\eta^2 = 0.45$), but greater for the first. Actually, more correct inferences were made for the Explicit condition than for Implicit with Alternatives ($F(1,61) = 11.69$, $p = .001$, $\eta^2 = 0.16$) but fewer with Disablers ($F(1,61) = 89.50$, $p < .001$, $\eta^2 = 0.60$): which means a greater suppressing effect for the Explicit condition, as expected.

The same happened in the interaction between Condition and Inference. More inferences were endorsed with Valid inferences than with Fallacies in the Explicit condition ($F(1,61) = 8.25$, $p < .01$, $\eta^2 = 0.12$) and also in the Implicit Condition ($F(1,61) = 81.47$, $p < .001$, $\eta^2 = 0.57$). However, more correct valid inferences (fewer suppressing effects) were obtained in the Implicit Condition ($F(1,61) = 64.93$, $p < .001$, $\eta2 = 0.52$) and more correct inferences with Fallacies were obtained in the Explicit condition ($F(1,61) = 8.43$, $p < .01$, $\eta2 = 0.12$).

Finally, the interaction between Inference and Counterexample showed that the difference between Valid inferences and Fallacies was greater for Disabling ($F(1,61) = 97.18$, $p < .001$, $\eta^2 = 0.61$) than for Alternative conditions ($F(1,61) = 21.75$, $p < .001$, $\eta^2 = 0.26$).

4.5. Discussion

Participants made inferences with two kinds of conditionals: contents that induced them to think of disabling conditions and contents that induced them to think of alternative conditionals. Fewer valid inferences were endorsed with disabling-content conditionals and fewer fallacies were accepted when the alternative-content conditionals were presented. Therefore, we could conclude that in the Implicit condition, the content of the conditional per se can create this suppressing effect of fallacies and valid inferences (given more correct fallacies and fewer valid inferences). The magnitude of the suppression of valid inferences and fallacies increased when we informed participants about a "disabling" or alternative condition and asked them to generate two or five explanations. Thus, Experiment 1 shows that the suppression effect was greater in the Explicit condition: when participants were informed that the antecedent happened but the consequent did not follow (or vice versa) and they looked for disabling or alternatives cases. Moreover, it did not make any difference whether participants were asked to generate two or five cases for the inference task.

Therefore, the main result in this study has been to show that the Implicit condition produced suppression effects. Cariani and Rips (2017) questioned whether suppression could happen in an implicit procedure.

Table 3
Experiment 1. Mean percentage of logically valid conclusions in bold (and standard deviations) for Inferences (valid, fallacies), Condition (explicit, implicit), Counterexample (alternative, disabler) and Group (few items, many items).

	Explicit procedure				Implicit procedure			
	Alternatives		Disablers		Alternatives		Disablers	
	Valid	Fallacies	Valid	Fallacies	Valid	Fallacies	Valid	Fallacies
Few items								
Accept	**83 (0.20)**	19 (0.28)	**34 (0.30)**	80 (0.20)	**91 (0.18)**	44 (0.37)	**79 (0.29)**	73 (0.31)
Nothing follows	16 (0.19)	**80 (0.29)**	65 (0.31)	**19 (0.21)**	9 (0.18)	**55 (0.37)**	20 (0.29)	**25 (0.31)**
Many items								
Accept	**82 (0.21)**	26 (0.38)	**42 (0.35)**	78 (0.24)	**86 (0.21)**	51 (0.36)	**80 (0.24)**	77 (0.28)
Nothing follows	15 (0.20)	**71 (0.38)**	57 (0.35)	**19 (0.22)**	13 (0.21)	**48 (0.37)**	18 (0.25)	**20 (0.29)**
Average								
Accept	**83 (0.21)**	23 (0.33)	**38 (0.33)**	79 (0.22)	**88 (0.20)**	47 (0.36)	**79 (0.26)**	75 (0.29)
Nothing follows	15 (0.20)	**75 (0.34)**	61 (0.33)	**19 (0.22)**	11 (0.20)	**51 (0.37)**	19 (0.27)	**23 (0.30)**

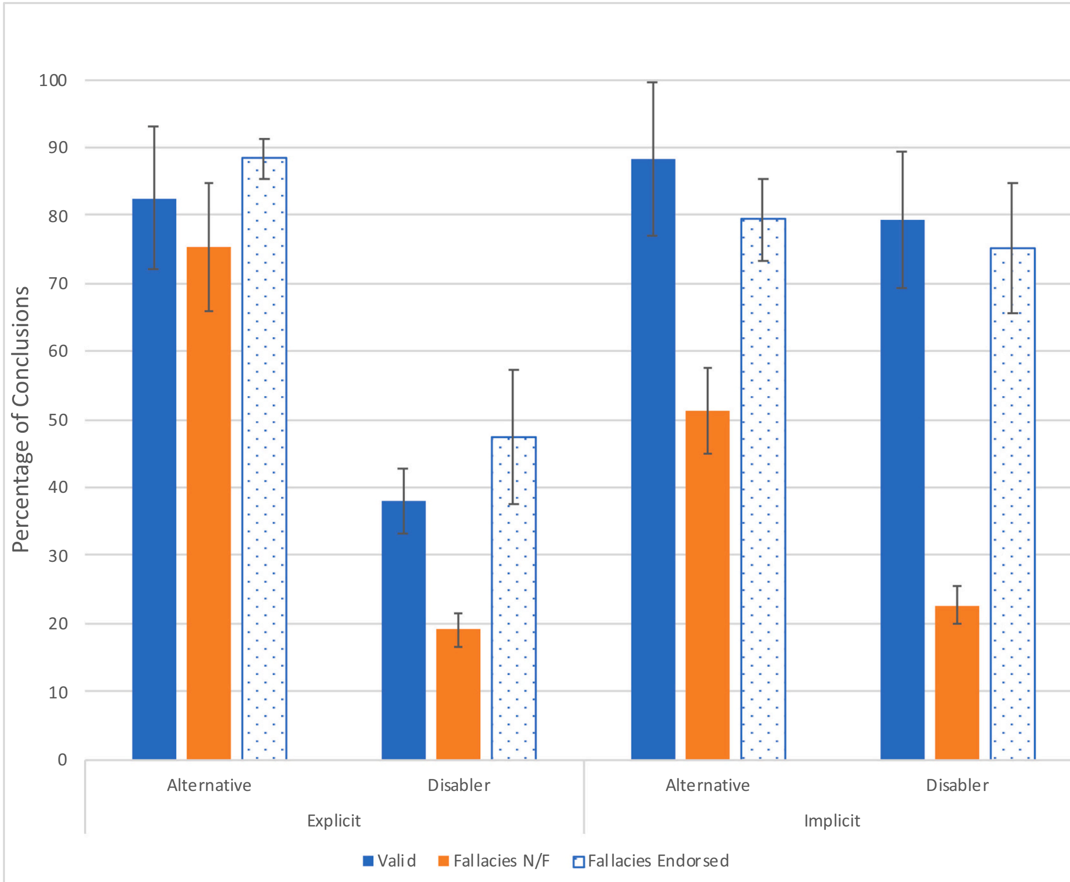

Fig. 1. Mean percentage of logically correct responses for inferences (Valid, Fallacies) and fallacies endorsed (dotted bars), Condition (Explicit, Implicit) and Counterexample (Alternative, Disabler) in Experiment 1.

The suppression effect was greater in the Explicit condition, but we cannot be sure whether this was caused by the explicit information given about the existence of alternatives and disablers or because participants actively looked for those concrete cases, or by both. In Experiment 2 we try to answer this question.

5. Experiment 2. Explicit information vs looking for counterexamples

In this second experiment, participants are always explicitly informed of a general disabling or alternative condition. We test whether asking them to look for disabling or alternative cases increases the suppression effect. We use the same Explicit condition as in Experiment 1 and create a new Explicit condition in which participants do not search for counterexamples; instead, after reading about the disabling or alternative condition, they carry out the control task of looking for synonyms. This control task is necessary because memory retrieval involves additional executive functions that could impact the later inference process. The two procedures' conditions for suppression are presented in Table 2 (second and third rows, respectively). In both conditions, participants are explicitly told that the consequent did not happen but the antecedent did (disabling) or that the consequent happened but not the antecedent (alternative). Therefore, the only difference between the two conditions is the generation task: participants either generate synonyms or counterexamples.

If the explicit information is responsible for the suppression effect, then searching for counterexamples should not increase that effect. As such, the suppression would be the same in both conditions (generating counterexamples or synonyms) since participants have the same explicit information telling them about the existence of counterexamples for the conditional. On the other hand, if thinking of particular cases influences representations, as the model theory maintains, an increase of the suppressing effect will occur in the counterexample condition compared to the synonyms condition. A final question is whether a more significant number of counterexamples will lead to an increase in suppression. Although the results in Experiment 1 did not show this effect, we again asked half the participants to search for many counterexamples (5) and the other half for just a few (2).

5.1. Participants

The sample consisted of sixty-six adults between 18 and 27 years (M = 19.41; SD = 1.73): fifty-eight women with a mean age of 19.40 years (SD = 1.76) and eight men whose mean age was 19.50 years (SD = 1.60). All participants spoke Spanish as their first language and were recruited in colleges or universities in Granada. They were compensated with course credits. Before starting the experiment, they read a consent form complying with the University Research Ethics Committee guidelines.

5.2. Materials

The same as used in Experiment 1 (see Appendix B).

5.3. Procedure and design

The procedure was the same as in Experiment 1 with the following difference: in both conditions, participants were presented with the conditional, followed by explicit information about the alternative or disabling condition (see Table 2). In the Counterexamples condition (explicit condition with concrete cases in Table 2), participants had to write two or five (depending on their group: few items vs. many items) counterexamples that could account for the facts described in the explicit information (see Table 2). By contrast, in the Synonyms condition (see explicit condition without cases in Table 2), participants were presented with a word and they had to write two or five (depending on their group) synonyms of that word. Everything else was identical to Experiment 1. We used a mixed design with Group (Few items vs Many items) manipulated between groups and Condition (Counterexamples vs Synonyms), Counterexample type (Alternative vs Disabler) and Inference (Valid vs Invalid) manipulated within participants. The suppression effect was computed as in Experiment 1.

5.4. Results and discussion

As expected, fewer cases were generated in the Few cases generation group than in the Many cases group for both the Counterexample (Few cases: $M = 1.98$, $SD = 0.06$; Many cases: $M = 4.12$, $SD = 0.82$; U-Mann Whitney test $Z = 6.79$, $\eta^2 = 0.65$, $p < .001$) and the Synonyms condition (Few cases: $M = 1.85$ $SD = 0.21$; Many cases: $M = 3.34$, $SD = 1.05$; $Z = 5.82$, $\eta^2 = 0.50$, $p < .001$) (see Table 4 and Table C2).

We carried out an analysis of variance (ANOVA) on the frequency of correct logical answers in a 2 (Condition: Counterexamples vs Synonyms) by 2 (Counterexample type: Alternative vs Disabler) by 2 (Inferences: Valid vs Fallacies) by 2 (Group: Few items vs Many items) design, with the first three factors manipulated within-participants and the last between-participants.

As in Experiment 1, participants made more correct Valid inferences than Fallacies (68% vs. 30%; $F(1, 64) = 49.16$, $p < .001$, $\eta^2 = 0.43$); also, Disabling conditionals reduced the Valid inferences while Alternative conditionals increased the "nothing follows" correct conclusions. Therefore, more correct conclusions were obtained for the Alternative conditionals compared to the Disabling conditionals (53% vs. 37%; $F(1, 64) = 55.37$, $p < .001$, $\eta^2 = 0.46$). No effect of Group (generating 2 or 5 items) (48% vs. 50%; $F(1, 64) = 0.90$, $p = .35$, $\eta^2 = 0.01$) or Condition (49% vs. 49%; $F(1, 64) = 0.07$, $p = .80$, $\eta^2 < 0.01$) was found.

The results also showed three significant interactions, all with the factor Condition as a component: Condition (Counterexamples vs Synonyms) and Inferences (Valid vs Fallacies) ($F(1, 64) = 7.06$, $p = .01$, $\eta^2 = 0.10$); Condition (Counterexamples vs Synonyms) and Counterexample type (Alternative vs Disabler) ($F(1, 64) = 12.95$, $p = .001$, $\eta^2 = 0.17$); and the same two factors with Group (Few items vs Many items) ($F(1, 64) = 4.67$, $p = .04$, $\eta^2 = 0.07$).

The first interaction shows that participants gave more correct responses to the Valid inferences (MP and MT) than to the Fallacies (DA and AC) in both conditions, as in Experiment 1. However, the suppression was stronger in the Counterexample condition ($F(1, 64) = 26.85$, $p < .001$, $\eta^2 = 0.30$) than in the Synonyms condition ($F(1, 64) = 51.35$, $p < .001$, $\eta^2 = 0.45$).

Condition and Counterexample type show that the suppressing effect is significant for both procedures (see Fig. 2), the Counterexample condition ($F(1,64) = 66.44$, $p < .001$, $\eta^2 = 0.51$) and the Synonyms condition ($F(1,64) = 26.34$, $p < .001$, $\eta^2 = 0.29$), but greater for the first. Again, as expected, the suppressing effect was greater: more correct inferences were made for the Counterexample condition than for the Synonyms condition with Alternatives ($F(1,64) = 10.39$, $p = .002$, $\eta^2 = 0.14$) but fewer with Disablers ($F(1,64) = 6.01$, $p = .017$, $\eta^2 = 0.09$).

To analyse the effect of the Group in the interaction, we analysed the two groups separately. In the Many items group, more correct conclusions were made for Alternatives than for Disablers (64% vs. 37%; $F(1,32) = 20.78$, $p < .001$, $\eta^2 = 0.39$), and participants endorsed more Valid inferences than Fallacies (66% vs. 43%; $F(1,32) = 12.14$, $p < .001$, $\eta^2 = 0.28$). No other significant difference was found. Similarly, in the Few items group, more correct conclusions were made for the Alternatives than for the Disablers (62% vs. 34%; $F(1,32) = 40.32$, $p < .001$, $\eta^2 = 0.56$), and more were endorsed for Valid inferences than for Fallacies (69% vs. 26%; $F(1,32) = 40.24$, $p < .001$, $\eta^2 = 0.56$). The interaction was due to the fact that only in the Few items group was the interaction between Condition (Counterexamples vs Synonyms) and Counterexample type (Alternative vs Disabler) significant ($F(1,32) = 14.28$, $p = .001$, $\eta^2 = 0.31$). The increase of the suppressing effect in the Synonyms condition reached significance only in the Few items group.

6. General discussion

In this research, we tested the suppression effect of valid inferences and fallacies. To do so, we used alternative-content conditionals that induce us to think of alternative antecedents for obtaining a consequent, and disabling-content conditionals that lead us to think of disabling conditions that prevent the consequent. In Experiment 1, those contents that led people to think of alternatives and disabling conditions produced an effect of suppressing fallacies and valid inferences, respectively. This result is particularly interesting because Cariani and Rips (2017) maintained that the suppression of Modus Ponens in studies seems to require an explicit premise for alternative or disabling (contravening) conditions. They questioned the suppressing effect obtained in studies that varied the content of the conditional. Some of these studies used response scales as conclusions, instead of using the standard deduction instructions and response format with the three options (see Table 2). The response scales could encourage participants to treat the inferences as a probabilistic task, regarding the certainty of the conclusion instead of its necessity (p.581–582). Experiment 1 shows that the suppression effect was present in the implicit procedure with the standard deduction instructions and response format.

We also confirmed that the suppression effect was more significant in the Explicit Condition than in the Implicit one. In the Explicit condition, we told participants that there were alternatives or disabling conditions

Table 4
Experiment 2. Mean percentage of logically valid conclusions in bold (and standard deviations) for Inferences (valid, fallacies), Condition (counterexample, synonyms), Counterexample type (alternative, disabler) and Group (few items, many items).

	Counterexample				Synonyms			
	Alternatives		Disablers		Alternatives		Disablers	
	Valid	Fallacies	Valid	Fallacies	Valid	Fallacies	Valid	Fallacies
Few items								
Accept	**83 (0.24)**	41 (0.39)	**44 (0.38)**	83 (0.24)	**82 (0.25)**	63 (0.40)	**68 (0.32)**	87 (0.23)
Nothing follows	15 (0.23)	**50 (0.41)**	49 (0.38)	**12 (0.22)**	17 (0.24)	**32 (0.41)**	22 (0.28)	**11 (0.22)**
Many items								
Accept	**81 (0.24)**	39 (0.39)	**48 (0.35)**	72 (0.31)	**79 (0.28)**	49 (0.46)	**56 (0.38)**	79 (0.31)
Nothing follows	15 (0.20)	**50 (0.40)**	43 (0.35)	**25 (0.30)**	17 (0.27)	**44 (0.47)**	37 (0.39)	**18 (0.31)**
Average								
Accept	**82 (0.24)**	40 (0.39)	**46 (0.36)**	78 (0.27)	**80 (0.26)**	56 (0.43)	**62 (0.35)**	83 (0.27)
Nothing follows	15 (0.21)	**50 (0.40)**	46 (0.37)	**18 (0.26)**	17 (0.26)	**38 (0.44)**	30 (0.33)	**15 (0.26)**

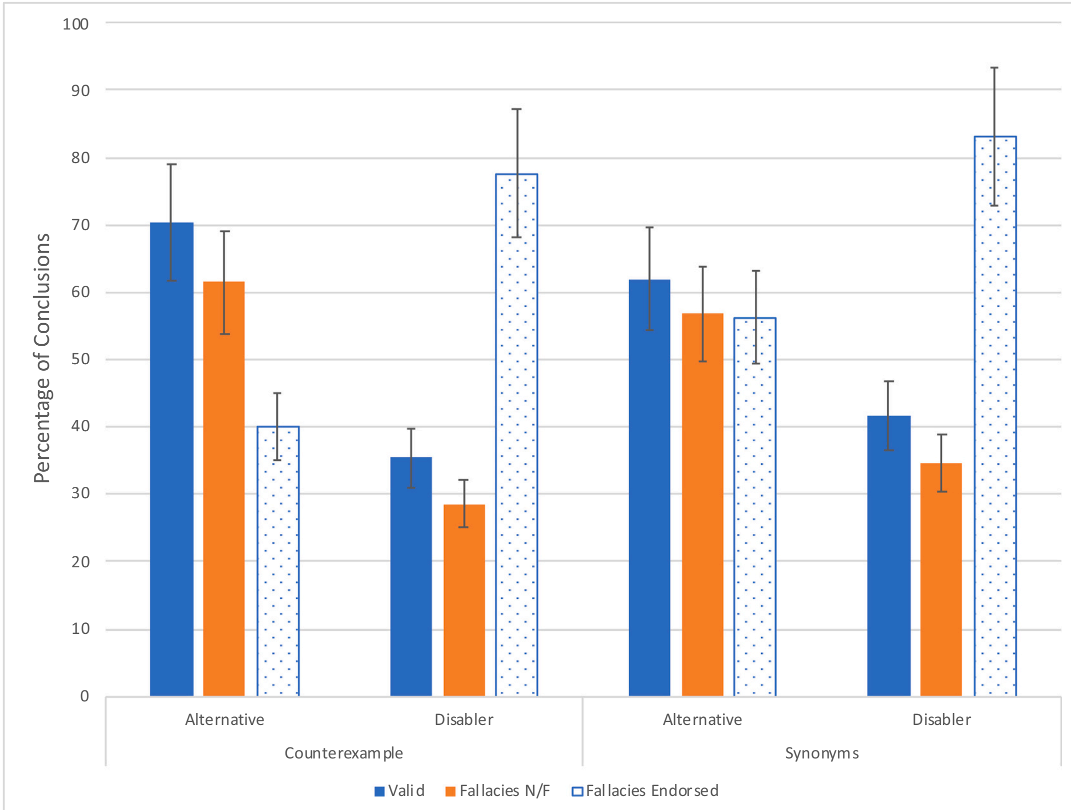

Fig. 2. Mean percentage of logically correct responses for Inferences (Valid, Fallacies) and fallacies endorsed (dotted bars), Condition (Counterexamples, Synonyms) and Counterexamples type (Alternative, Disabler) in Experiment 2.

and asked them to look for counterexamples before making the inference. In this case, the number of generated instances (few or many) did not make a difference. To make the Explicit and Implicit procedure conditions similar in complexity, we created a control condition where participants had to retrieve from memory synonyms instead of counterexamples. In both conditions, participants had a task that required them to retrieve contents from long term memory; however, those contents only related to the inferences in one of the conditions (Explicit condition). In the Implicit condition in Experiment 1, the synonyms generation task preceded the conditional and the inferences. Considering the differences between the Implicit and Explicit conditions in Experiment 1 (see Table 2), one may ask: is it the presence of explicit information that increases the suppression effect or does searching for disabling and alternative cases have an additional suppression effect? In Experiment 2, we compared the Experiment 1 Explicit condition with a new condition. The only difference between the conditions in the second experiment was that in one condition, participants searched for counterexamples (alternatives and disablers), whereas in the other condition, they had to search for synonyms. We created the synonyms task to control the possible effects of retrieving content from long term memory. Once more, results showed the suppression effect in the two Explicit Conditions (Counterexample and Synonyms conditions). However, when participants not only received the explicit information but also had to search for counterexamples (counterexample condition), the endorsement of valid inferences decreased when participants searched for disabling conditions (without affecting fallacies). When participants retrieved alternative cases, the correct conclusions for fallacies increased (without affecting valid inferences). We found that the increased suppression was significant only when participants searched for a few cases and not for many. We had not predicted this lack of improvement in the Many items group. One possibility is that the need to look for many counterexamples would force participants to go outside the mental set of possible related ones and find less prototypical cases, maybe with lower suitability as real counterexamples, thus reducing the benefit obtained when they only have to look for two.

Another possibility is related to the fluency effect: the first counterexamples are easily retrieved in the few items condition because of the greater strength of association, but when participants need to search for additional ones and have difficulty finding them (up to five items), they might get the impression that there are not many counterexamples available for that conditional. In any case, the results clearly show that 1) looking for explicit alternatives and disablers improves the suppression of fallacies and valid inferences, but 2) having many cases does not produce more suppression than having few; actually, the opposite happened. As we mentioned in the introduction, deductive theories from different approaches have attempted to integrate and explain the results of initial studies on the suppression effect. They have tried to explain how disabling information (A & ¬B) and alternatives (¬A & B) influence people's inferences. They should also explain that the suppression effect may arise from different sources:

1. From participants' general knowledge accessed by the meaning of the conditional
2. From the cases explicitly mentioned in the problem
3. From participants actively generating cases

As we have seen, mental rule theories base their explanation on pragmatic effects (see Braine & O'Brien, 1998; Rips, 1994). In their model of suppression, Cariani and Rips (2017) also proposed the pragmatic component as a key to explaining how suppression occurs: semantically, participants consider possibilities from a basic interpretation of the conditional (strict interpretation). In addition, they adjust, adding and discarding possibilities when they acquire new evidence from additional premises (i.e., the second conditional in the traditional suppression procedures). Conversational rules are the base of the pragmatic component. In the description of their model, they do not explicitly say how the content would lead to activation of the pragmatic component when no additional premises are included, as happened in the Implicit Procedure Condition. The model in its present form cannot predict that in Explicit conditions, the suppression effect increases when participants search for concrete cases, as in Experiment 2. One difference between this model and the mental model theory is how the conditional is represented, depending on its meaning.

In the mental model theory, through the modulation effect, a particular set of initial representations is created, depending on the meaning of the conditional (see Johnson-Laird & Byrne, 2002; Quelhas et al., 2010, 2017). For example, as compared to a factual conditional (such as "if she watered the plants, they bloomed"), a counterfactual conditional (such as "if she had watered the plants, they would have bloomed") induces an increase of MT and DA inferences because the initial representation for counterfactuals includes the model of "she did not water the plants and they did not bloom" (Byrne, 2016 for a review). Therefore, participants are willing to accept "she did not water the plants" when they know that the plants did not bloom (MT) or to accept the reverse (DA). Espino and Byrne (2020) demonstrated that the background knowledge conditions can produce a suppression effect even with counterfactual conditionals. They used the traditional explicit procedure of additional conditions to suppress the MT valid inference and the explicit alternative condition to suppress the DA fallacy. They explained the result by the fact that people represent conditionals in the additional procedure as a conjunction of the antecedents of the two conditionals and the alternative procedure as a disjunction. As we used disabling conditions instead of the traditional explicit procedure of additional conditions, we cannot test their proposal.

The model theory assumes that people represent mental models and explains how the content leads them to represent additional information as a new mental model to be integrated by the modulation effect based on their knowledge (Johnson-Laird & Byrne, 2002). Shared knowledge can induce us to think that if we find a friend, our earlier plans might change (for example, after reading "if Ana finds a friend, she will go to the theatre" and knowing that "Ana found a friend", we can suppress the valid conclusion "Ana went to the theatre"). However, the chances of including an explicit negation in the abstract model (found-a-friend and did not-go-to-theatre) increase when we explicitly tell people about this instance. This is what happened in our Explicit condition. The problem with negation is that a mental footnote such as negation can be easily lost (Johnson-Laird & Byrne, 2002). When participants were allowed to create their particular cases, they could obtain a concrete mental model such as "found-a-friend and went to a party," which would help to fix a more permanent mental model (instead of "found-a-friend *not-theatre*", "found-a-friend *party*"). The search for counterexamples has an essential role in the mental model theory because it allows the construction of mental models (De Neys et al., 2003b; Markovits & Quinn, 2002) by fleshing out operations (Johnson-Laird & Byrne, 2002; Khemlani et al., 2018). Given a conditional, considering counterexamples consists of fleshing out the implicit models into explicit ones that can suppress inferences. However, the theory would not predict an advantage for having many concrete mental models since a higher working memory load is not usually helpful (Johnson-Laird & Byrne, 2002). Our results are consistent with this theory.

Theories based on supposition and probabilistic logic explained the suppression effect based on the reduction of believability in a conditional when participants received additional information (Oaksford & Chater, 2020; Over, 2017; Stevenson & Over, 1995). In particular, the Suppositional conditional theory assumes that people understand a conditional "if A, then B" considering only "A" but not "not-A" cases to compute the probability of "B" (Evans, 2007; Evans & Over, 2004). When given new information, people revise the credibility of the first conditional, which explains suppression. From this approach, the suppression effect for our Implicit condition can be explained by the effect of the conditional content. Thus, thinking about a disabling conditional's content leads them to consider the "A *not-B*" case, reducing the probability of their accepting "B" and, therefore, a reduction of MP valid inferences would be expected. On the other hand, the content of an alternative conditional that leads them to think of the "not-A *B*" case does not reduce the probability of their accepting "B". Thus, consequent in conditional (6) is less likely to be accepted than consequent in conditional (5), and therefore in the first case, suppression of MP is predicted. Previous studies have also shown that giving explicit information about the frequency or the existence of disabling or alternative conditions increases the suppression (Geiger & Oberauer, 2007; Markovits et al., 2010). This could explain the increase of suppression in the Explicit condition in Experiment 1 when we explicitly told participants about alternatives or disabling conditions.

However, it is not clear how to explain the results regarding the search for alternatives and disablers; participants had already been explicitly informed of their presence. For example, for disabling conditionals, participants were told that the antecedent happened, but not the consequent. This explicit information should fix the reduction of credibility in the conditional. We expected that later in the trial when participants searched for counterexamples, they would obtain additional evidence that reduced the probability of the conditional. If this happened, why was there no effect of the number of alternatives? There was no more suppression in the Many cases condition than in that of the Few cases, in either experiment.

Differences between probabilistic approaches and the mental model theory could lie in how statistical information is processed (Markovits et al., 2017). Although they might make similar predictions, Brisson et al. (2018) propose that the account based on probability could induce the use of different strategies from those of mental model theories. The mental model theory would explain that the manipulations in the present study (the content of the conditional, given explicit information, and the search for counterexamples) increase the probability that participants will suppress valid inferences by producing counterexamples based on the disabling conditions and reject fallacies when considering alternatives (Byrne et al., 1999; Juhos et al., 2015).

Markovits et al. (2017) maintain that although the probabilistic approach (the p-validity model; see Evans et al., 2015; Singmann et al., 2014) is in many respects very similar to the mental model description of the counterexample, different predictions could be made from it. The probabilistic approach evaluates the likelihood of a conclusion considering the full context of available knowledge. In contrast, the counterexample search approach maintained by the mental model theory implies a narrower focus: a more concrete search for cases. If reasoners base their inferences on statistics, a broader contextual effect would be expected compared to those based on a counterexample search (Markovits et al., 2017; p.1183).

The present study's objective was to test whether the content of conditionals, explicit information, search for cases and search for counterexamples contribute to influencing how inferences are made. We have shown that these factors increase the suppression effects. We believe that these theories can integrate or explain our results ad hoc, but it is challenging to make exact predictions from the beginning. For example, following Markovits et al. (2017), we could attribute the suppression effect to the statistical approaches based on general knowledge and explicit information, but this is clearly not expected from the generated cases. From the model theory, we could expect a suppression effect based on the generated cases and the meaning (based on the modulation effect, Johnson-Laird & Byrne, 2002). Assuming that with the content of the conditionals factor, participants have already established a believability criterion or have created a mental model, both approaches could have predicted the lack of effect of another factor (the explicit information and/or the search for counterexamples). The additive effect found in the three factors we study here provides, in our view, an important empirical fact that could help theories detail in more depth the algorithm for integrating evidence during the process of deduction with conditionals.

CRediT authorship contribution statement

Jesica Gomez. She is finishing her doctoral thesis on developmental reasoning. This research is part of her thesis. Writing-original draft preparation. Design and conduct of experiments, data analysis.

Sergio Moreno Ríos. Jesica's Supervisor and expert on reasoning. Writing-original draft preparation. Conceptualization, Methodology. Writing draft preparation.

Marta Couto. She is an expert on the suppression effect and had some of the original ideas in this research. She also conducted part of a pilot study.

Cristina A. Quelhas. She is an expert on deductive reasoning and co-responsible for the original idea in this study. Also, she participated on the pilot study.

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Appendix A. Mean of counterexamples (alternatives or disablers) generated for each conditional tested for the selection of the 6 conditionals (3 alternatives and 3 disablers) for Experiments 1 and 2

Conditional	Alternatives generated	Disablers generated
1[a]	3.33	1.14
2	1.66	2.14
3	1.83	1.14
4[b]	1	3
5[b]	0.83	2.57
6	1.66	2.57
7[a]	4.43	2.5
8	3.57	3.33
9[a]	3.71	2.66
10[b]	2.42	4.33
11	3.28	2.5
12	3	3.5

[a] Conditionals selected as alternatives.
[b] Conditionals selected as disablers.

Appendix B. Conditionals used in the task (synonyms in brackets) and *the original ones in italic*

Disabler sentences

1. If Ana finds a friend, then she will go to the theatre (big); *Si Ana encuentra una amiga, entonces irá al teatro (grande)***
2. If Sebastian puts the coffee pot on the stove, then the coffee will rise (happy); *Si Sebastián pone la cafetera en el fuego, entonces subirá el café (feliz)***
3. If Rafael goes to the airport by car, then he will arrive in time to catch his flight (sensitive); *Si Rafael va en coche al aeropuerto, entonces llegará a tiempo para coger el avión (sensible)***
4. If you strike a match, then it will be lit (rich); *Si se frota una cerilla, entonces se encenderá (rico)*
5. If you press the right switch, then the light will turn on (tenacious); *Si se pulsa el interruptor correcto, entonces la luz se encenderá (constante)*
6. If Vera turns on the air conditioning, then she will be cold (good); *Si Vera enciende el aire acondicionado, entonces tendrá frío (bueno)*

Alternative sentences

7. If María jumps into a swimming pool, then she will get wet (beautiful); *Si María salta a una piscina, entonces se mojará (bonito)***
8. If Beatriz's phone is dropped, then it will break (kind); *Si a Beatriz se le cae el móvil, entonces se le romperá (simpático)***
9. If Cristina drinks coffee at night, then she will have difficulty sleeping (easy); *Si Cristina bebe café por la noche, entonces tendrá dificultad para dormir (fácil)***
10. If Teresa eats salt, then she will be thirsty (intelligent); *Si Teresa come sal, entonces tendrá sed (inteligente)*
11. If Tiago reads without glasses, then he will have a headache (expressive); *Si Tiago lee sin gafas, entonces tendrá dolor de cabeza (expresivo)*
12. If Daniel pours water on a camp fire, then the fire will go out (calm); *Si Daniel echa agua en la hoguera, entonces el fuego se apagará (tranquilo)*

*As the materials were in Spanish, it is important to take into account that in the case of synonyms, most of them are polysemic, unlike in English.
**Conditionals selected from a pilot study.

Appendix C. Results by inference in the two experiments

Table C1
Mean frequencies of acceptances for each inference (AC,MP,MT,DA) (with "nothing follows" in parentheses) for Condition (explicit, implicit), Counterexample Type (alternatives, disablers) and Group (few items, many items) in Experiment 1. In bold the logically correct response.

	Alternatives				Disablers			
	MP	MT	AC	DA	MP	MT	AC	DA
Explicit								
Few items	**2.69** (0.28)	**2.28** (0.66)	0.53 **(2.47)**	0.59 **(2.31)**	**1.06** (1.94)	**0.97** (1.97)	2.38 **(0.59)**	2.44 **(0.53)**
Many items	**2.55** (0.32)	**2.39** (0.58)	0.81 **(2.06)**	0.77 **(2.19)**	**1.13** (1.84)	**1.39** (1.58)	2.39 **(0.55)**	2.32 **(0.61)**
Average	**2.62** (0.30)	**2.33** (0.62)	0.67 **(2.27)**	0.68 **(2.25)**	**1.10** (1.89)	**1.18** (1.78)	2.38 **(0.57)**	2.38 **(0.57)**
Implicit								
Few items	**2.78** (0.22)	**2.66** (0.31)	1.21 **(1.78)**	1.44 **(1.50)**	**2.50** (0.50)	**2.22** (0.72)	2.19 **(0.75)**	2.19 **(0.75)**
Many items	**2.74** (0.26)	**2.42** (0.52)	1.61 **(1.35)**	1.42 **(1.52)**	**2.42** (0.52)	**2.39** (0.58)	2.42 **(0.52)**	2.23 **(0.71)**
Average	**2.76** (0.24)	**2.54** (0.41)	1.42 **(1.57)**	1.43 **(1.51)**	**2.46** (0.51)	**2.30** (0.65)	2.30 **(0.63)**	2.21 **(0.73)**

Table C2
Mean frequencies of acceptances for each inference (AC,MP,MT,DA) (with "nothing follows" in parentheses) for Condition (counterexample, synonyms), Counterexample Type (alternatives, disablers) and Group (few items, many items) in Experiment 2. In bold the logically correct response.

	Alternatives				Disablers			
	MP	MT	AC	DA	MP	MT	AC	DA
Counterexample								
Few items	**2.97** (0.27)	**2.30** (0.88)	1.39 **(1.67)**	1.18 **(1.70)**	**1.33** (1.12)	**1.24** (1.36)	2.21 **(0.30)**	2.27 **(0.33)**
Many items	**2.85** (0.21)	**2.21** (0.76)	1.21 **(1.64)**	1.15 **(1.58)**	**1.70** (0.91)	**1.21** (1.36)	2.18 **(0.64)**	2.00 **(0.73)**
Average	**2.91** (0.24)	**2.26** (0.82)	1.30 **(1.65)**	1.17 **(1.64)**	**1.52** (1.02)	**1.23** (1.36)	2.20 **(0.47)**	2.14 **(0.53)**
Synonyms								
Few items	**2.39** (0.30)	**2.12** (0.49)	1.85 **(0.82)**	1.82 **(0.70)**	**2.33** (0.67)	**1.91** (1.00)	2.88 **(0.30)**	2.76 **(0.52)**
Many items	**2.48** (0.30)	**2.09** (0.67)	1.42 **(1.27)**	1.39 **(1.24)**	**1.97** (1.00)	**1.73** (1.21)	2.58 **(0.52)**	2.45 **(0.58)**
Average	**2.44** (0.30)	**2.11** (0.58)	1.64 **(1.05)**	1.61 **(0.97)**	**2.15** (0.83)	**1.82** (1.11)	2.73 **(0.41)**	2.61 **(0.55)**

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