Content and Strategy in Syllogistic Reasoning

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Abstract Syllogistic reasoning has been investigated as a general deductive process (Johnson-Laird & Byrne, 1991; Revlis, 1975; Rips, 1994). However, several studies have demonstrated the role of cognitive strategies in this type of reasoning. These strategies focus on the method used by the participants (Ford, 1995; Gilhooly, Logie, Wetherick, & Wynn, 1993) and strategies related to different interpretations of the quantified premises (Roberts, Newstead, & Griggs, 2001). In this paper, we propose that content (as well as individual cognitive differences) is an important factor in inducing a certain strategy or method for syllogistic resolution. Specifically, we suggest that syllogisms with a causal conditional premise that can be extended by an agency premise induce the use of a conditional method. To demonstrate this, we carried out two experiments. Experiment 1 provided evidence that this type of syllogism leads participants to draw the predicted conditional conclusions, in contrast with control content syllogisms. In Experiment 2, we demonstrated that the drawing of conditional conclusions is based on a causal conditional to an agent representation of the syllogism premises. These results support the role of content as inducing a particular strategy for syllogistic resolution. The implications of these results are discussed.

Syllogisms are arguments from two premises to a conclusion. Both premises and conclusion are statements of one of four types or moods: "All of the A are B" (A), "Some of the A are B" (I), "None of the A are B" (E), and "Some of the A are not B" (O). Each statement in the premises contains two terms: One term, the middle term (B), occurs in both premises, while the other two (A and C) are known as the end terms. The syllogistic conclusion relates the end terms by means of the middle term. For example,

All bricklayers are mechanics,
All chemists are bricklayers
Conclusion: *All chemists are mechanics.*

TABLE 1
The Figures of Syllogisms

Premise	Figure 1	Figure 2	Figure 3	Figure 4
1	A-B	B-A	A-B	B-A
2	B-C	C-B	C-B	B-C

The arrangement of the end and middle terms in each of the premises gives rise to a four-way classification known as the figure of the syllogisms (see Johnson-Laird & Byrne, 1991).

The combination of the figure of the syllogisms and its mood gives rise to a great number of different syllogisms of which only a few have a propositionally valid conclusion (logically correct), that is to say, a conclusion necessarily derived from the premises.

Among the several tasks against which theories of reasoning are benchmarked, categorical syllogisms are of considerable importance. Different theories have been proposed to describe the process of syllogistic reasoning. Each one describes a different method for syllogistic resolution. In this respect, it is relevant to distinguish a *heuristic method* as proposed by the probabilistic heuristic model (Chater & Oaksford, 1999). This method suggests that people base their answers on the action of fast and frugal heuristic performing on the surface features of the problems (rather than attempt to reason by representing the information). These heuristics considerably reduce the cognitive demands of the task, but at the expense of resulting in systematic errors. The *mental models method* (Johnson-Laird & Byrne, 1991) requires a multistep process requiring information to be represented and transformed internally by means of mental models. The *spatial method* suggests that syllogisms are represented by means of Euler circles, and the action of the appropriate procedures enables the conclusion to be drawn (Ford, 1995; Stenning & Yule, 1997). In the *rule-based method* (Rips, 1994), the premises are represented as propositions and a group of diverse rules

of inference are applied to them step by step in order to produce the conclusion, or evaluate a given conclusion. The *conditional method* considers that syllogisms are conditional inferences and for any individual conclusion, one premise supplies the conditional and the other the source of the atomic input to the conditional rule (Ford; Stenning & Yule).

More recently, the role of strategies in syllogistic reasoning has reawakened interest in syllogistic reasoning research. In this respect, Ford's (1995) research is relevant. She has demonstrated that reasoners can use two different strategies when they solve syllogisms: a verbal strategy, which implies the use of formal rules (equivalent to conditional rules), and a spatial strategy, which implies the use of Euler circles. However, Johnson-Laird, Savary, and Bucciarelli (2000) conclude that individual differences in syllogistic resolution are compatible with the use of mental models. As they stated, "The strategies and tactics that we have observed both in sentential and quantified reasoning are not easily reconciled with formal rules of inference, but they do seem to be compatible with the unconscious processes that construct and manipulate mental models" (p. 238). Experience has also been suggested as a factor influencing the adoption of a particular strategy for syllogistic resolution. Specifically, Bara and Bucciarelli (1997) have suggested that reasoning over experienced content could be based on rules, while in the case of novel contents it would be based on mental models. These authors argue that "It is possible that previously acquired, well-organized knowledge is expressed in the abstract form of formal rules that might guide reasoning through a process which is straightforward and less costly that the construction and manipulation of models" (p. 67). In addition, there is always the possibility that some motivated individuals will attempt a full logical analysis, with others adopting heuristic strategies instead (Gilhooly, Logie, Wetherick, & Wynn, 1993; Wetherick & Gilhooly, 1990). Finally, individuals may also vary strategies from trial to trial, perhaps discovering effective shortcuts while reasoning (Galotti, Baron, & Sabini, 1986).

Cognitive strategies can affect syllogistic resolution in a different way. In this respect, Roberts, Newstead, and Griggs (2001) have examined the role of different strategies for premise quantifier interpretation in syllogistic resolution. They argue that people may adopt different strategies in order to reduce the demands of the syllogistic reasoning task, but without necessarily dispensing with analytic reasoning process altogether. Some of these strategies would be used by the majority of people so they are "dominant" strategies. These authors evaluated the prediction of different strategies: logical interpretation, Gricean interpretation, reversible interpretation, premise conversion, and reversible Gricean quantifier interpretation for the type of conclusion given to different syllogisms. Roberts et al. (2001) provided evidence supporting the adoption of both reversible interpretation and reversible Gricean interpretation, but not Gricean interpretation on its own. According to these authors the conclusion attained by means of these interpretative strategies would be incorrect from the logical meaning of the quantifier, but a valid conclusion from a modified quantifier interpretation.

In short, cognitive strategies have been suggested to have an important role in the process of syllogistic resolution, and one of the ways strategies influence syllogistic reasoning is related to the adoption of a particular method. The question of what syllogistic method is preferred is open to empirical research. For example, Ford (1995) found that the number of participants adopting either the verbal or the spatial strategy was similar (one-third for each).

In this paper we focus on the method that people adopt for syllogistic resolution, and we examine the hypothesis that the adoption of a certain method is influenced by the content. In order to illustrate the differences between the syllogistic methods, it is relevant here to compare the conditional rule-based method as described by Ford (1995) (in the case of verbal reasoners) with the mental models method (Johnson-Laird & Byrne, 1991). As Roberts (1993, 2000) has argued, the contrast between the mental models and rule-based methods constitutes the core of the most important debate in deductive reasoning.

Ford (1995) has suggested that when reasoners follow a verbal strategy, they manipulate the verbal form of syllogisms as an algebraic problem, and

> Take one premise as having a term that needs to be substituted with another term and the other premise as providing a value for that substitution. The premise that provides the value for substitution acts as a rule relating membership of class C to a property P, while the premise containing the term that needs to be substituted acts as a case of specific objects, O, whose status with regard to either C or P is known. (p. 21)

Subsequently, appropriate rules are applied in order to draw a valid conclusion. The previously shown syllogism is thus represented as follows:

All bricklayers (C) are mechanics (P)
All chemists (O) are bricklayers (C)

O = Specific objects; C = Class; P = Property.

By means of the application of a modus ponens rule-type such as, "If every member of the class C has the property P, and a specific object O is a member of C, then O has the property P," reasoners would draw the conclusion, *All chemists (O) are mechanics (P).*

Mental models theory (Johnson-Laird & Byrne, 1991) bases syllogistic resolution on a semantic process: the building up of mental models. The process of deductive reasoning goes through three stages: comprehension, description, and validation (Polk & Newell, 1995). Comprehension corresponds to encoding the problem into an internal representation. This representation is assumed to take the form of a mental model. A mental model represents a scenario composed of specific tokens and consistent with the problem statement. The description stage involves generating a putative conclusion, which requires formulating a description of some aspect of the mental model that was not explicit in the problem. In the validation stage, participants deal with searching for conclusions compatible with the premises, but contradictory with the informative conclusion just generated. This search is made in order to find the conclusion necessarily derived from the premises. From the mental models approach, reasoners build up a composite mental model of the above syllogism as follows, to attain the same conclusion:

[[ch] b] m
[[ch] b] m
...

ch = chemists; b = bricklayers; m = mechanics.

In this composite mental model, the class relationship described in the premises is represented by means of specific tokens; the square brackets mean that "ch" is exhausted with respect to "b," and "b" is exhausted with respect to "m." The three dots allow for other sorts of individuals yet to be made explicit. For simplicity, the number of individuals is likely to be small. This composite mental model enables the drawing of the affirmative universal conclusion, *All chemists are mechanics.*

As aforementioned, we have proposed that the content (as well as individual differences or experience) is an important factor in order to induce a certain strategy or method for syllogistic resolution. Specifically, we suggest that syllogisms with a causal conditional premise that can be extended by an agency premise induce the use of a conditional method. What we hypothesized is that this type of content causes the conditional method to be the dominant strategy for syllogistic resolution. To examine this proposal, we presented the participants with categorical syllogisms that contained a causal conditional relation in one of the premises that can be extended by the other premise. For example:

All persons who participate in experiments are people who contribute to scientific progress,
All students are persons who participate in experiments,

contains a causal conditional relation in the first premise (participating in experiments → contributing to scientific progress). This causal conditional statement could be extended by the second premise where the term "students" is interpreted as an agent affirming its antecedent. In the case of the syllogism being solved by the conditional method, the participants give the conclusion.

All the case students are persons who contribute to scientific progress, because they make use of a modus ponens conditional rule-type such as, "If every person who carries out the conduct of participating in experiments has the consequence of contributing to scientific progress, and an agent (the students) is found that carries out the conduct, then the students have the consequence of contributing to scientific progress."

This is a conclusion in the C-A direction, so this is a figural conclusion, *Syllogisms in Figure-2 (BA-CB) cause C-A conclusions,* (see Johnson-Laird & Byrne, 1991). In addition, this conclusion is the type of conclusion predicted by the relevant syllogistic reasoning models, although each model proposes a different method in order to attain this. In order to make a more robust contrast, we also used syllogisms where the predicted conditional conclusions were neither figural nor predicted by syllogistic reasoning models. This occurs when we reverse the order of the terms in both premises as follows:

All persons who contribute to scientific progress are persons who participate in experiments, and
All persons who participate in experiments are students.

This syllogism is presented in Figure-1 (AB-BC), and this figure causes conclusions in the A-C direction such as, *All persons who contribute to scientific progress are students.* This is also the conclusion predicted by the different models of syllogistic reasoning for this type of syllogisms. However, if the causal-agency content is the most relevant, then reasoners realize that the premises contain a conduct (to participate in experiments) and a contingent social consequence (to contribute to scientific progress), and a reference to an agent (the students) who carries out the conduct,

respectively. Therefore, they make use of the conditional method in spite of this reversal. In this case, they gave the (not figural) conclusion: *All students are persons who contribute to scientific progress*.

This manipulation followed Cosmides's (1989) experimental logic using the Wason selection task. She manipulated the presentation of a conditional statement representing a social contract, that could appear either in standard form ("If you take the benefit, then you pay the cost") or in switched form ("If you pay the cost, then you take the benefit"). According to Cosmides (1989), if the participants make the same card selection in both versions, this suggests that they are basing their reasoning on the content rather than the (explicit) form of the conditional statement. Likewise, if we find that the participants give the same conclusion to the normal and reversed conditional order syllogisms, we can conclude that the content rather than the (explicit) form of syllogisms is guiding the deductive process, that is, that the participants are using a conditional method.

Furthermore, we introduced a control content. The content of these syllogisms moved away from the pragmatic agent-conduct-consequence structure by suppressing causality as follows:

All persons who participate in experiments are persons who drink beer,
All students are persons who participate in experiments.

As can be seen, in the first premise of this control syllogism the original consequence (contributing to scientific progress) has been replaced by a term (to drink beer) unrelated to the conduct of participating in experiments. Moreover, the verbal expression that acts as a goal indicator or points out a result ("to contribute") was suppressed. As a result, a causal interpretation of the premise (and therefore of the syllogism) would be improbable.

The predictions, if participants made use of the conditional method driven by the content, are a universal conclusion, starting with the term "students" (C-A), to both Figure-2 (normal conditional order) and Figure-1 (reversed conditional order) syllogisms, but only in the case of causal content syllogisms. Otherwise, in the control content syllogisms, the conclusions given by the participants are those predicted by the relevant syllogistic reasoning models. That is, universal affirmative C-A conclusions to Figure-2 syllogisms and universal affirmative A-C conclusions in the case of Figure-1 syllogisms.

Experiment 1

In this experiment we tested the hypothesis that the participants solve syllogisms with a causal content by means of a conditional method.

We carried out two pretests. One evaluated the suitability of a causal interpretation of the first premise of causal and control content syllogisms. The other tested the degree of believability of conditional-type and alternative conclusions in causal and control syllogisms. The believability effect is related to participants' tendency to accept or to draw believable but invalid conclusions or, conversely, to reject or not to draw valid but unbelievable conclusions (Cherubini, Garnham, Oakhill, & Morley, 1998; Newstead, Pollard, Evans, & Allen, 1992; Oakhill, Jonhson-Laird, & Garnham, 1989; Santamaría, García-Madruga, & Carretero, 1996). As the believability effect is a potential source of biasing syllogistic conclusions, we need to discard it as an alternative explanation of our experimental hypothesis.

Pretests

Evaluation of the plausibility of the causal premise. Twenty participants evaluated the plausibility of a causal interpretation of the 16 first premises of experimental and control syllogisms. The 16 questions were presented in a booklet with 10 filler questions and a brief instruction about the nature of the task. After the presentation of a premise, its causal interpretation appeared, and the raters were asked to evaluate its plausibility. For example:

All persons who participate in experiments are persons who contribute to scientific progress.
Causal interpretation: Those persons who participate in experiments contribute as a consequence to scientific progress.
( )APPROPRIATE ( )NOT APPROPRIATE.

We found that raters considered the causal interpretation of the causal premises as appropriate 80% of the time (95% confidence interval = 70%, 90%), the item range being from 70% to 95%. However, in the case of the control syllogisms, we found that the raters considered the causal interpretation as not appropriate 90% of the time (95% confidence interval = 83%, 97%), the item range being from 80% to 100%. The Appendix contains the results for each causal and control item.

Evaluation of conclusion believability. Forty raters evaluated the believability degree of both the (C-A) conditional-type conclusions and their (A-C) alternative syllogism conclusions (20 raters evaluated the causal syllogisms and the other 20 evaluated the control content syllogisms). We considered as alternative conclusions those which had the same mood (universal affir-

mative) as the conditional conclusions, but which presented the end terms in the alternative order. Syllogisms with universal quantifiers in both premises favour the drawing of universal conclusions, the affirmative conclusion if both syllogism premises are affirmative (Begg & Denny, 1969; Wetherick & Gilhooly, 1990; Woodworth & Sells, 1935). If the participants had the possibility of choosing between the two possible universal affirmative conclusions then they could select the one that seemed more believable to them.

Both conclusion versions (C-A and A-C conclusions) were presented in pairs. Participants were simply asked to rate the plausibility of the conclusions as statements. Their task was to rate each statement on a scale of 1 (completely unbelievable) to 7 (completely believable). The Appendix contains the results for each causal and control item.

In the case of causal syllogisms, we found that the believability degree of C-A conditional-type conclusions and alternative A-C conclusions was close and between the "a little believable" and "moderately believable" degrees (M = 3.50, 95% confidence interval = 3.28, 3.72, and M = 3.30, 95% confidence interval = 3.08, 3.52, respectively). In the case of the control content syllogisms, we found that the believability of both conclusions was low, and closer to the "hardly believable" degree (M = 2.45, 95% confidence interval = 2.17, 2.73 and M = 2.10, 95% confidence interval = 1.89, 2.32, respectively). As can be seen, the conditional-type and the alternative conclusions were evaluated as similarly believable. It is difficult to argue that the participants had the possibility of choosing between the two conclusions and selected the C-A conditional-type conclusion because it was believable and the alternative conclusion was not. In other words, it is difficult to explain a bias towards the conditional-type conclusion in terms of a believability effect.

Method

Participants. Fifty first-year Pedagogy students at the University of La Laguna participated for course credit.

Design. The design had a within-subjects factor "Form of syllogisms" with two conditions: Figure-2 and Figure-1, and a between-subject factor "Type of content" with two conditions: causal and control content. In the case of causal conditional content, Figure-2 syllogisms had the normal conditional order while Figure-1 syllogisms had the reversed conditional order. The dependent variable was the frequency of C-A conclusions.

Material. Four booklets were provided, two corresponding to the causal content condition and the other two to the control content condition. The experimental within-subjects condition, "Form of syllogisms," was counterbalanced so that if a certain syllogism appeared in one of the booklets in Figure-2 then it appeared in the other booklet in Figure-1 (and vice versa) within the same between-subject condition. On the first page of each booklet, standard instructions were given about how to solve the task, with two completed examples. The following four pages contained 16 syllogisms, the 8 experimental syllogisms alternating with the 8 filler syllogisms (4 syllogisms for each). Below each syllogism there were three lines for the participants to write the conclusion(s). The filler syllogisms had different forms.

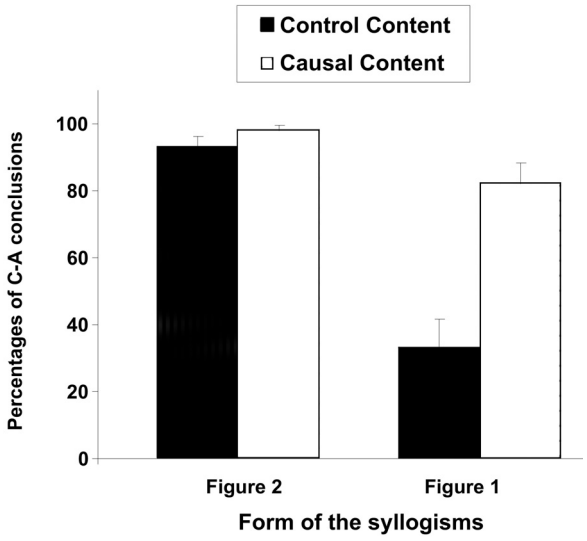

Figure 1. Mean percentages of C-A conclusions and between-subject standard errors for causal and control content syllogisms in Figure-2 and Figure-1 (Experiment 1).

In the case of causal syllogisms, the first premise contained a generic agent ("All persons") carrying out a conduct and a term referring to a behavioural consequence. The interpretation of these terms as consequences was reinforced by means of verbal expressions that pointed out a result, specifically, to promote, to encourage, to show (two items), to get, to make, to contribute, and to help to improve. In the case of control syllogisms, causality was suppressed in that the terms referring to consequences were replaced by terms that were not related to the conduct, and the verbal consequence indicators were suppressed.

Procedure. The different booklets were randomly given out to the students during regular class time without a time limit being imposed. Twenty-six partici-

pants were given the causal content condition while 24 participants received the control content condition. Within each between-subject condition, half of the participants received one of the booklets and the other half the other booklet.

Results

In Figure 1 are shown the (mean) percentages of C-A conclusions (the complementary percentages corresponded to the alternative A-C conclusions) for causal and control content syllogisms, with both Figure-2 and Figure-1 (the Appendix contains the results by each causal and control item). Four participants (two from the causal content condition and two from the control content condition) were excluded because a substantial number of their conclusions were not acceptable. This was because they included the middle term, or the conclusion was a mere repetition of one of the premises, with their terms usually inverted.

We carried out an analysis of variance, with a within-subjects factor, "Form of the syllogisms," and a between-subject factor, "Type of content." The interaction form of the syllogism and type of content was significant, $F(1,44) = 18.89$, $p < 0.001$. As shown in Figure 1, the percentage of C-A conclusions was high in both Figure-2 and Figure-1 syllogisms in the case of the causal content condition (98% and 82%, respectively), while the percentage of C-A conclusions was comparatively low in Figure-1 control content syllogisms (33%). The effect of the form of syllogisms was significant, $F(1,44) = 55.51$, $p < 0.000$. The percentage of C-A conclusions was higher in Figure-2 than in the Figure-1 condition (96% and 59%, respectively). This effect is related to the effect of the figure (see Jonhson-Laird & Byrne, 1991). While C-A conclusions are facilitated by the figure in Figure-2 syllogisms (syllogisms with Figure-2: BA/CB, facilitate the drawing of C-A conclusions), the alternative conclusion is facilitated in the Figure-1 syllogisms (syllogisms with Figure-1: AB/BC, facilitate the drawing of A-C conclusions). Finally, the effect of the content was also significant, $F(1,44) = 19.88$, $p < 0.000$. The causal content (90%) produced a greater percentage of C-A conclusions than the control content (63%).

The significant effects of both the interaction between form of the syllogism and type of content and the content support our predictions: The preferred conclusion to syllogisms with a causal content was the universal C-A conclusion to both Figure-2 (normal conditional order) and Figure-1 (reversed conditional order). Otherwise, in the control content syllogisms the conclusions given by the participants were those predicted by the relevant syllogistic reasoning models. That is, universal affirmative C-A conclusions to Figure-2 syllogisms and universal affirmative A-C conclusions in the case of Figure-1 syllogisms. Therefore, these results support the hypothesis that causal content syllogisms strongly induce a conditional strategy for syllogistic resolution.

Experiment 2

The results of Experiment 1 uphold the idea that syllogisms with a causal content are frequently solved by means of a conditional method. This conditional method consists of identifying the causal premise as a conditional statement to be applied on the second premise. In our experimental syllogisms, the term "students" is interpreted as an agent affirming its behavioural antecedent, and a C-A conclusion is attained by applying a modus-ponens rule-type. In this context, we suggest that the participants had to return the reversed conditional order syllogisms to the normal order to obtain a syllogism representation that enables them to draw a conditional conclusion.

The goal of this experiment was to provide evidence that participants carry out the cognitive operation of returning the content to the normal causal conditional order when they draw a conditional conclusion to the reversed conditional order syllogisms. Specifically, we tested, using a reading-time technique, whether drawing the conditional conclusion took more time in the case of syllogisms presented in the reversed order than in the normal conditional order. If the participants take more time to give the conditional conclusion to the reversed conditional order syllogisms then this would suggest that they swapped the terms of each premise around in working memory to restore the normal conditional direction.

In addition, in this experiment we manipulated the disposition of the premises as a between-subject factor so that the syllogisms could appear in the two possible premise orders. One of the premise dispositions was that of the Experiment 1 causal syllogisms: conduct-consequence, first premise; agent-conduct, second premise (henceforth, disposition A). The other disposition presented the inverted premise order: agent-conduct, first premise; conduct-consequence, second premise (henceforth, disposition B). This experimental factor explores the effect of the presentation order of the causal and the agency premises.

Method

Participants. Fifty-four first-year Pedagogy students at the University of La Laguna participated in exchange for course credit.

Design. The design had a within-subjects factor, "Form of the syllogisms," with two conditions: normal

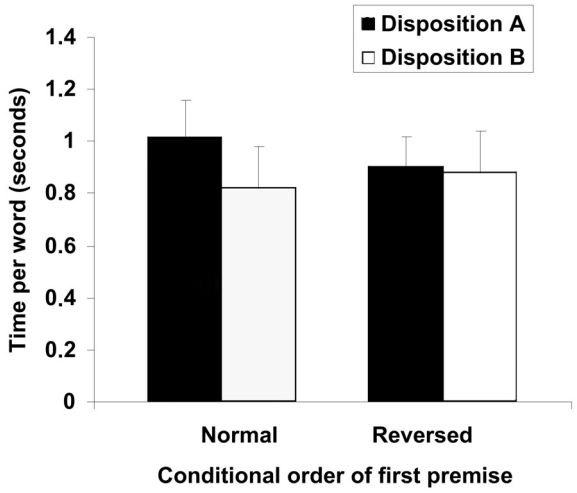

Figure 2. Mean reading times per word with the between-subject standard errors of the first premise of normal and reversed conditional order syllogisms in dispositions A and B when the given conclusion was the conditional conclusion (Experiment 2).

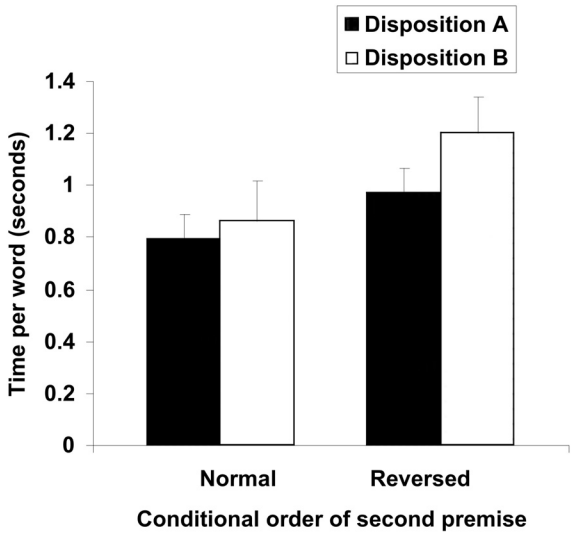

Figure 3. Mean reading times per word with the between-subject standard errors of the second premise of normal and reversed conditional order syllogisms in dispositions A and B when the given conclusion was the conditional conclusion (Experiment 2).

and reversed conditional order, and a between-subject factor, "Disposition of the premises": disposition A and B. There were two dependent measures, the (reading) time per word of the first and the second premise of syllogisms with a conditional conclusion.

Material. Four lists of syllogisms were constructed, two for each premise disposition. The within-subjects condition was counterbalanced: If a certain syllogism appeared on one of the lists in the normal order then it appeared on the other list in the reversed conditional order (and vice versa). Each list consisted of 20 syllogisms, 8 experimental (4 normal and 4 reversed conditional order syllogisms), 8 filler, and 4 practice syllogisms. The experimental and filler syllogisms were the same as in Experiment 1. Two instructional sheets also formed part of the material. One of these explained how to solve the task as in Experiment 1, and the other explained how to use the computer appropriately.

Procedure. The participants were tested individually by computer. The presentation of the problems was as follows: At the beginning, the prompt, "Press the return key to continue," appeared on the screen. Once the participant pressed the key, the first premise was displayed. A further press erased the first premise and displayed the second premise. A third press erased the second premise and then the request, "Please write the conclusion(s)," appeared. Participants were instructed to make this last press when they were ready to give the conclusion and then to use the keyboard. Once the conclusion was written, a press displayed a new syllogism. The first four syllogisms were for practice purposes. The end of the practice session was indicated by the prompt, "End of the Examples." The computer recorded the participants' reading times for both premises of the syllogisms.

The within-subjects form of the syllogism condition was counterbalanced. The syllogisms that appeared in one of the presentations in the normal conditional order appeared in the other presentation in the reversed conditional order and vice versa. Half of the participants received one of the presentations and the other half the other. Twenty-four participants received disposition A and 30 participants received disposition B.

Results

We found that the (mean) percentage of the conditional conclusions was very high in the normal conditional order syllogisms in both syllogism premise dispositions (97%, disposition A; 92%, disposition B). The (mean) percentage was also high, although smaller, in the reversed conditional order syllogisms in both dispositions (79%, disposition A; 69%, disposition B). Six participants were excluded because they gave a substantial number of incorrect conclusions. This was because they included the middle term, or the conclusion was a mere repetition of one of the premises, with their terms usually inverted.

In order to analyze the time taken to draw a condi-

tional conclusion, we selected the participants who gave at least three conditional responses for the group of four experimental syllogisms, both in the normal and the reversed conditional order. Four participants were rejected because their latencies were extremely high (more than three standard deviations). Once counterbalanced, the sample comprised 26 participants (10 corresponding to Disposition A and 16 corresponding to B). The reading times of each premise of the syllogisms were divided by the number of words of the premise, and we obtained a reading time per word. This reading time per word was the dependent measure. Figures 2 and 3 show the mean reading times per word of the first and second premises in the different conditions.

We carried out analyses of variance of the first and the second premises, with a within-subjects factor, "Form of the syllogisms," and a between-subject factor, "Premise disposition."

With reference to the first premise, we found that neither the interaction form of the syllogisms and premise disposition, nor the form of the syllogisms, nor the premise disposition had significant effects ($p > .10$).

In relation to the second premise, we found that the form of the syllogisms was significant, $F(1,24) = 23.99$, $p = 0.000$. The time per word was higher in the reversed conditional order syllogism (Disposition A, $M = 0.97$ s, $SD = 0.30$; Disposition B, $M = 1.20$ s, $SD = 0.57$,) than in the normal conditional order syllogisms (Disposition A, $M = 0.79$ s, $SD = 0.31$; Disposition B, $M = 0.86$ s, $SD = 0.65$).

Neither the interaction form of the syllogisms and premise disposition, nor the premise disposition had significant effects ($p > .10$).

As we predicted, the reversion of the conditional order made the process of drawing a conditional conclusion more difficult. This effect of reversion is robust as it affected both dispositions of the premises. The difficulty associated with reversion of the conditional order would be related to the operation of returning the content to the normal conditional order. In short, this experiment supports the idea that the process of drawing a conditional conclusion is based on a causal conditional to an agent representation of the syllogism premises.

General Discussion

One aim of syllogistic reasoning research has been the establishment of one theory as fundamental to all reasoning. As a result, debates such as that confronting mental models and deductive rules theories are difficult to resolve. One possible solution to this state of affairs is the idea that deductive reasoning (and syllogistic reasoning in particular) could be based on different strategies. Some studies have demonstrated that the methods that people adopt to solve syllogisms can vary, depending on several factors: individual differences (Ford, 1995; Gilhooly et al., 1993; Roberts, 2000), experience and practice (Galotti et al., 1986; Gilhooly et al., 1999; Roberts). The methods described in the different syllogistic reasoning models are varied and we can distinguish the following: The heuristic method, the mental models method, the spatial method, the rule-based method, and the conditional method.

In this paper, we propose that content is a relevant factor in influencing the strategy people adopt for syllogism resolution. Strategy can be conceived as any procedure that is goal directed and nonobligatory (Siegler & Jenkins, 1989). Specifically, we suggest that if we present participants with syllogisms where one premise contains a causal conditional that can be extended by the other (agency) premise, they will adopt a conditional method to solve the syllogisms. This type of content makes the conditional method more suitable and sometimes easier than the other methods. According to Van Dijk and Kintsch (1983), "strategy" refers to a set of actions all aimed at satisfying a goal (in this case drawing a syllogistic conclusion that seems rational) in the simplest, quickest, and therefore most economical way, in other words, in a way that minimizes the demands on cognitive resources and reduces the load on working memory. Gámez and Marrero (2000) have shown that the conditional conclusion, when facilitated by causal content presented in the normal conditional order, was made more quickly than the alternative conclusion facilitated by the syllogism figure. Another relevant result in this respect is that of Experiment 2, which showed that the drawing of the conditional conclusion is effortful when the content is presented in the reversed conditional order. In this case, the conditional method may not be the quickest way of drawing the syllogistic conclusion. However, we suggest that this conditional conclusion would continue to be the simpler way of drawing a conclusion that seems rational, insofar as rationality is here bounded by the content.

In general, our results have demonstrated that the participants showed a clear preference for the conditional (C-A) conclusion when they solved causal syllogisms. Therefore, our suggestion was confirmed: The dominant strategy to solve this type of syllogisms was the conditional method.

This conclusion can be discussed in terms of an alternative explanation. Our pretest results suggest that the manipulation of the content is confounded with the believability of the conclusion insofar as conclu-

sions were evaluated as more believable in the causal than in the control syllogisms. The alternative interpretation is that participants were more likely to use a heuristic process leading to C-A conclusions when the content of the conclusion is more plausible, that is, when the content of the conclusion was causal. This heuristic process would be aimed at avoiding an overload of working memory at the stage of deciding the ordering of the terms. However, this explanation is problematic, in that it requires to be explained in its turn: Why does this heuristic process bias the conclusion towards the C-A direction instead of towards the A-C? An appropriate explanation is that the causal content heuristically induced a conditional strategy for syllogism resolution. In addition, we have to take into account that the result of Experiment 2 showing that drawing the C-A conclusion was more effortful in the reversed conditional than in the normal conditional order syllogisms, did not support the action of a heuristic process "blind to the content." A "blind to the content" heuristic process would mean that drawing a C-A conclusion to causal syllogism was equally easy in both syllogism forms.

It is relevant here to ask about the characteristics of the conditional method as a deductive strategy. Several authors (Evans, 2000; Jonhson-Laird et al., 2000; Shaeken, De Vooght, Vandierendonck, & Ydewalle, 2000) have proposed that a deductive strategy must fulfil the requisite of being conscious to some extent to be qualified as such. However, other authors propose that strategies can also be unconscious processes. In this respect, García-Madruga, Moreno, Carriedo, and Gutierrez (2000) distinguished between explicit (conscious) strategies and implicit (unconscious strategies). Likewise, Johnson-Laird et al. differentiated four levels of thinking, varying in their level of consciousness: at the top, meta-cognitive thinking, which can yield novel strategies for reasoning; at the second level, strategies; at the third level are the components of the strategies, constituted by a variety of tactics; and finally at the fourth level are the unconscious processes that underlie the tactics. In the Johnson-Laird et al. conceptualization, the conditional method constitutes a strategy, so this method is made up of different steps (tactics).

Johnson-Laird et al. (2000) have stated that the strategies and tactics that they have observed in quantified reasoning are compatible with the unconscious processes that construct and manipulate mental models. Our results contradict their claim to some extent, inasmuch as they showed that participants made use of a method compatible with the unconscious processes of representing and manipulating the information in a conditional way.

Is it possible to generalize an effect of the type of content in the method that people adopt to solve syllogisms? We consider that it is, and suggest that when the content refers to well-specified and closed categories such as pilots, chemists, etc., this content facilitates the adoption of a mental models method due to this being basically a semantic procedure that maps appropriately the term relations as a set of tokens. On the other hand, if the content is arbitrary we suggest that people do not show a preference for any of the syllogistic methods, for example, between mental models or formal rules. Moreover, if the content is presented in a way that makes comprehension difficult, this would facilitate the adoption of a heuristic strategy. Finally, if the content can be interpreted in a conditional way, the conditional method is preferred.

Experiment 2 supported the idea that drawing the (invalid and nonfigural) conditional conclusion to reversed conditional order syllogisms requires the operation of returning the content to the normal conditional direction. Therefore, this experiment supports the idea that the process of drawing a conditional conclusion is based on a causal-conditional-to-an-agent representation of the syllogism.

However, it can be argued that the bias towards the C-A universal conclusion caused by causal syllogisms is no more the result of a conditional strategy than an effect of premise conversion. What the results effectively showed was that some statements might, when certain kinds of contents are used, tend to be converted and thus may tend to produce C-A conclusions when more neutral content would lead to A-C conclusions. Revlis (1975; Revlin & Leirer, 1978) have advocated that there is a tendency to incorrectly convert universal premises by means of a process of direct verbal conversion from "All A are B" to "All B are A." Furthermore, these authors have claimed that conversion is more likely with some kinds of contents than with others. With certain kinds of material, conversion of the premises is blocked by the content.

We consider that this premise conversion explanation presents several difficulties. For example, how to explain that participants converted causal content when this content is presented in the reversed conditional order, while they do not do this when causal content is presented in the normal conditional order. This implies that it is not the causal content itself that is responsible for the premise conversion, but the order and direction of the causal terms. Therefore, the conversion in this case would seem to be driven by the goal of restoring a certain order of the terms in the premises. The triggering of this goal is appropriately explained if the participants interpreted the content as a conditional that can be extended by the other

premise. However, the conditional content interpretation is not the only explanation for this premise conversion. It can be argued that the order that the participants try to restore is related to the conceptual relation of the terms. In the case of our syllogism example, the term "persons who participate in experiments" in the first premise can be conceived as a category included in the category of the other term "persons who contribute to scientific progress." The latter would also include "persons who design experiments," "persons who give funds to scientific experiments." The conceptual relation of inclusion is appropriately expressed when the premise is "all" quantified (see Santamaría et al. 1996). If the terms are presented in the reversed order, firstly, "persons who contribute to scientific progress" and, subsequently, "persons who participate in experiments," then the participants could be tempted to restore by conversion the direction of the conceptual relation of inclusion. It is, however, more problematic to explain the conversion of the agency premise in this way. The conceptual relation between the terms "students" and "persons who participate in experiments" is the intersection, so the appropriate quantifier is the existential quantifier ("some students are persons who participate in experiments" or vice versa). Therefore, the use of a universal quantifier for this premise is equally inappropriate in any term presentation order. As a result, there is no need to convert this premise. At this point, we can conclude that the suggested operation of restoring the conceptual relation of the terms cannot explain the bias towards the C-A conclusion in causal syllogisms, as the drawing of this conclusion requires the conversion of both premises.

Moreover, the process of a (blind) conversion of universal premises has been criticized in several ways. On the one hand, the more extreme position taken by Revlis (1975) in which it was suggested that participants always reasoned with the converted premises first, only returning to the correct interpretation when no valid conclusion could be found, has received little support (Evans, Newstead, & Byrne, 1993). Moreover, this type of premise conversion seems somewhat perverse because it involves participants implementing additional processing steps with the sole consequence of sabotaging performance (Roberts et al., 2001). Although evidence for some kind of conversion exists, it does not seem to be the dominant strategy in premise interpretation (Roberts et al.). Finally, some authors have considered that the conversion hypothesis (Chapman & Chapman, 1959) can be discarded as an explanation of mistakes in syllogistic reasoning, due to the evidence of the figural effect (Johnson-Laird & Byrne, 1991). However, this argument cannot be applied to premise conversion in causal syllogisms mainly because the result of this conversion is a conclusion opposed to the effect of the figure.

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Appendix

Causal Interpretation and Believability Ratings, and the Results of Experiment 1 for Each Causal and Control Syllogism in Figures 2 and 1

	Plausibility Report	Believability Report	Results of Experiment 1
Items	First Premise Causal Interpretation Rating (%)	Conclusion Believability Rating (C-A/A-C)	Percentage of C-A Conditional-type Conclusions
1. All persons who defend their families are persons who show they are loyal. All students are persons who defend their families. (causal, Figure-2)	75	3.70/3.15	100
2. All persons who defend their families are persons who listen to sports news. All students are persons who defend their families (control, Figure-2)	0	2.30/1.95	100
3. All persons who show they are loyal are persons who defend their families. All persons who defend their families are students. (causal, Figure-1)		3.70/3.15	64
4. All persons who listen to sports news are persons who defend their families. All persons who defend their families are students. (control, Figure-1)		2.30/1.95	27
5. All persons who share their experiences are persons who promote comradeship. All students are persons who share their experiences. (causal, Figure-2)	85	3.20/3.45	91
6. All persons who share their experiences are persons who use calculators. All students are persons who share their experiences. (control, Figure-2)	20	2.35/2.15	100
7. All persons who promote comradeship are persons who share their experiences. All persons who share their experiences are students. (causal, Figure-1)		3.20/3.45	83
8. All persons who use calculators are persons who share their experiences. All persons who share their experiences are students. (control, Figure-1)		2.35/2.15	49
9. All persons who help with the housework are persons who encourage family life. All students are persons who help with the housework. (causal, Figure-2)	95	3.60/3.35	100
10. All persons who help with the housework are persons who practice swimming. All students are persons who help with the housework. (control, Figure-2)	0	2.15/1.75	89
11. All persons who encourage family life are persons who help with the housework. All persons who help with the housework are students. (causal, Figure-1)		3.60/3.35	82
12. All persons who practice swimming are persons who help with the housework. All persons who help with the housework are students. (control, Figure-1)		2.15/1.75	18
13. All persons who stand out in their studies are persons who get to be valued by their tutors. All students are persons who stand out in their studies. (causal, Figure-2)	90	3.50/3.30	91
14. All persons who stand out in their studies are persons who drive fast cars. All students are persons who stand out in their studies. (control, Figure-2)	20	2.20/1.90	100
15. All persons who get to be valued by their tutors are persons who stand out in their studies. All persons who stand out in their studies are students. (causal, Figure-1)		3.50/3.30	78
16. All persons who drive fast cars are persons who stand out in their studies. All persons who stand out in their studies are students. (control, Figure-1)		2.20/1.90	56
17. All persons who co-operate with humanitarian associations are persons who make themselves socially responsible. All students are persons who co-operate with humanitarian associations. (causal, Figure-2)	70	3.25/3.05	100
18. All persons who co-operate with humanitarian associations are persons who drink stimulating hot drinks. All students are persons who co-operate with humanitarian associations. (control, Figure-2)	20	2.35/2.00	100
19. All persons who make themselves socially responsible are persons who co-operate with humanitarian associations. All persons who co-operate with humanitarian associations are students. (causal, Figure-1)		3.25/3.05	73
20. All persons who drink stimulating hot drinks are persons who co-operate with humanitarian associations. All persons who co-operate with humanitarian associations are students. (control, Figure-1)		2.35/2.00	27
21. All persons who participate in experiments are persons who contribute to scientific progress. All students are persons who participate in experiments. (causal, Figure-2)	85	2.90/2.85	100
22. All persons who participate in experiments are persons who drink beer. All students are persons who participate in experiments. (control, Figure-2)	20	2.60/2.15	100
23. All persons who contribute to scientific progress are persons who participate in experiments. All persons who participate in experiments are students. (causal, Figure-1)		2.90/2.85	92

Appendix (con't)

24. All persons who drink beer are persons who participate in experiments. All persons who participate in experiments are students. (control, Figure- 1)		2.60/2.15	67
25. All persons who make suggestions in the classroom are persons who help to improve the quality of teaching. All students are persons who make suggestions in the classroom. (causal, Figure-2)	70	3.70/3.50	100
26. All persons who make suggestions in the classroom are persons who wear sports clothes. All students are persons who make suggestions in the classroom. (control, Figure-2)	0	2.65/2.45	100
27. All persons who help to improve the quality of teaching are persons who make suggestions in the classroom. All persons who make suggestions in the classroom are students. (causal, Figure-1)		3.70/3.50	92
28. All persons who make suggestions in the classroom are persons who wear sports clothes. All students are persons who make suggestions in the classroom. (control, Figure-1)		2.65/2.45	27
29. All persons who solve intelligence tests correctly are persons who show they are competent. All students are persons who solve intelligence tests correctly. (causal, Figure-2)	70	4.15/3.75	100
30. All persons who solve intelligence tests correctly are persons who wear jeans. All students are persons who solve intelligence tests correctly. (control, Figure-2)	0	3.00/2.50	91
31. All persons who show they are competent are persons who solve intelligence tests correctly. All persons who solve intelligence tests correctly are students. (causal, Figure-1)		4.15/3.75	92
32. All persons who wear jeans are persons who solve intelligence tests correctly. All persons who solve intelligence tests correctly are students. (control, Figure-1)		3.00/2.50	33

Sommaire

Le raisonnement syllogistique a été l'objet d'enquêtes à titre de processus général de déduction (Revlis, 1975; Johnson-Laird & Byrne, 1991; Rips, 1994). Cela dit, des études ont illustré le rôle joué par les stratégies cognitives dans ce type de raisonnement. Les stratégies précitées sont centrées sur la méthode employée par les participants (Ford, 1995; Gilhooly, Logie, Wetherick & Wynn, 1993) et sur d'autres stratégies, celles-là se rapportant à diverses interprétations des prémisses quantifiées (Roberts, Newstead & Griggs, 2001). Dans le présent article, nous avançons que le contenu (aussi bien que les différences cognitives individuelles) est un facteur déterminant de l'induction d'une stratégie ou d'une méthode donnée aux fins de la résolution syllogistique. Notamment, nous proposons que les syllogismes reposant sur une prémisse conditionnelle causale susceptible d'être étendue par une prémisse d'agence induisent le recours à une méthode conditionnelle. À preuve, les résultats de nos deux expériences. La première établit que cette forme de syllogisme conduit les participants à tirer les conclusions conditionnelles prévues, au contraire des syllogismes à contenu contrôlé. La seconde fait la preuve que le fait de tirer des conclusions conditionnelles repose sur une prémisse causale conditionnelle à une représentation par agent des prémisses du syllogisme. Les résultats susmentionnés tendent à confirmer le rôle du contenu dans l'induction d'une stratégie particulière aux fins de la résolution syllogistique. Nous discutons des conséquences des résultats obtenus.