

Cahiers de Psychologie Cognitive (2000), 19, 487-512

***THE ROLE OF THE MIDDLE TERMS CONTIGUITY IN PRAGMATIC
SYLLOGISTIC REASONING***

E.Gámez & H. Marrero

University of La Laguna. Spain.

Keywords: Syllogistic reasoning; pragmatic inferences; Content; Middle term contiguity; Agency; Causality; Behaviour

Abstract

Bringing the middle terms into contiguity is proposed by mental models (Johnson-Laird and Byrne, 1991) as a cognitive operation involved in syllogistic reasoning. However, a causal-agency behavioural content has been demonstrated to bias the deductive process towards a pragmatic conclusion in opposition to the figural effect (Marrero and Gámez, 1999). In this paper we examine if bringing the middle terms into contiguity remains as a cognitive operation in the process of drawing a pragmatic conclusion. We carried out two experiments.

In Experiment 1 we examine both if the middle terms contiguity presentation facilitates the drawing of the pragmatic conclusion, and if in syllogisms with the causal-agency direction reversed the subjects carried out two cognitive operations: returning the content to the standard causal-agency direction and, subsequently, placing the middle terms into contiguity. In Experiment 2 we compared the latency of drawing a formal conclusion facilitated by the middle terms contiguity and a pragmatic conclusion facilitated by the standard causal-agency direction presentation.

In general, the results did not support the idea that bringing the middle terms into contiguity is a cognitive operation involved in the process of drawing a pragmatic conclusion. The implications for syllogistic reasoning research are discussed.

One of the phenomena within syllogistic reasoning that has awoken interest in research is the so-called figural effect (Johnson-Laird & Steedman, 1978). This effect consists of the direction of the conclusion tending to be different depending on the figure in which the syllogism is expressed; the asymmetry in the direction of the conclusion of the syllogisms in figure 1 (AB-BC) and figure 2 (BA-CB) being particularly representative. Specifically, the predominant direction in figure 1 syllogisms is $A \rightarrow C$, while in figure 2 syllogisms it is $C \rightarrow A$. The frequency of both directions is shared with syllogisms in figures 3 and 4. Johnson-Laird and Steedman (1978) found that in figure 1 syllogisms the $A \rightarrow C$ direction of the conclusion took place 70% of the time, while in figure 2 syllogisms the $C \rightarrow A$ conclusion direction was predominant with a similar percentage. The frequency of both types of conclusion directions was similar in figures 3 and 4.

The figural effect can be defined as a result of the subjects' tendency to formulate the conclusion beginning with the end term which acts as a grammatical subject in one of the two premises (Johnson-Laird & Steedman, 1978). The grammatical subject in the case of figure 1 syllogisms (AB-BC) appears in the first premise biasing the conclusion towards the $A \rightarrow C$ direction. In the case of figure 2 syllogisms (BA-CB) the grammatical subject appears in the second premise so that it biases the conclusion towards the direction $C \rightarrow A$.

This figural effect has received different explanations (Wetherick and Gilhooly, 1990; Polk and Newell, 1995; Ford, 1995; Stenning and Yule, 1997) and one of the more convincing is that based on the role of the contiguity of the middle term, within the mental model framework. According to Johnson-Laird and Bara (1984) reasoners need to carry out mental operations on syllogistic premises in order to bring the two middle terms into contiguity in order to facilitate the building-up of a composite mental model. Figure 1 (AB-BC) presents the middle terms into contiguity so that there is no need for any operation to bring them into contiguity. Figure 2 (BA-CB) yields contiguous occurrences of the middle term provided that their initial interpretation is based on the second premise and the interpretation of the first premise is then renewed in order to add this information to the model. On the assumption of the principle that the first information

into working memory is the first information out of it (Broadbent, 1958), figure 1 produces conclusions in the direction $A \rightarrow C$, while figure 2 produces conclusions in the direction $C \rightarrow A$. As figure 2 requires a mental operation in order to bring the two middle terms into contiguity it is slightly more difficult than figure 1 as is shown in the percentage of correct responses and latencies. Figures 3 (AB-CB) is more difficult insofar as it requires the operation of switching round the representation of the second premise in order to bring the two middle terms into contiguity. Figure 4 (BA-BC) is the most difficult in as much as it is necessary either to renew the interpretation of the first premise in order to swap it around or to switch round the interpretation of the second premise and then renew the interpretation of the first premise.

As can be seen, mental models (Johnson-Laird and Byrne, 1991) proposes that bringing the middle terms into contiguity is a basic cognitive operation in syllogistic reasoning.

The influence of the content constitutes another topic of interest in syllogistic reasoning research. The effects of beliefs in syllogistic reasoning has been clearly demonstrated (Oakhill, Johnson-Laird & Garnham, 1989; Newstead, Pollard, Evans & Allen, 1992; Santamaría, García-Madruga and Carretero, 1996; Cherubini, Garnham, Oakhill and Morley, 1998). Such belief effects refer to the tendency to give (or to accept) believable conclusions, although they are invalid; and, conversely, to not give (or to reject) conclusions that, although valid, could seem unbelievable. However, the content could also have a pragmatic influence on syllogistic reasoning. This is the case of behavioural causal-agency content which biases the conclusion towards the direction agent \rightarrow goal (Marrero & Gámez, 1999). This bias was evident in syllogisms with figure 1 where the agent \rightarrow goal conclusion corresponded to the $C \rightarrow A$ directed conclusion which is non-valid and in opposition to the figural effect. An implication of this finding is that the subjects did not take advantage of the fact of the contiguity of the middle terms so that it can be concluded that such a disposition is less relevant than the causal-agency behavioural content in the drawing of a syllogistic conclusion.

The importance of practical reasoning has been emphasised by Cheng and Holyoak (1985) and Cosmides (1989). Both Cosmides (1989) and Cheng and Holyoak (1985) have pointed out that conditional reasoning depends on the content, and that it is based on inferences which are specific-domain or context-sensitive and aimed at pragmatic purposes. These authors have proposed that such inferences depend on rules. More specifically, Cosmides (1989) has proposed that reasoning about social exchanges is domain-specific. In this respect, she has suggested that human beings represent social exchanges in the following terms: "If someone obtains a benefit, then he/she should pay the corresponding cost". Cosmides (1989) proposes that such a rule leads subjects to try to find the cheaters (people who take the benefit without having paid the cost) a process she has demonstrated using the Wason selection task.

Similarly, Cheng and Holyoak (1985 and also Cheng & Nisbett, 1993) have proposed that reasoning about permission, obligation and causation is aimed at pragmatic purposes. These authors noted "Although a syntactically based system tell us which inferences are valid, it does not tells us which inferences are useful among the potentially many that are valid" (p. 395) and illustrated the point with an example. Given the statement "If I have a headache then I should take some aspirin", a logic-based reasoning system permits its contra-positive transformation to "If it is not the case that I should take some aspirin, then I do not have a headache". However, this is hardly a useful inference to make. The fact of having a problem creates the goal of finding a remedy to it, but the absence of the need for a remedy does not imply the absence of the problem.

Cheng and Holyoak (1985) proposed that reasoning about permission, obligation and causation is regulated by pragmatic schemas which... "consist of a set of generalized, context-sensitive rules which are defined in terms of classes of goals (such as taking desirable actions or making predictions about possible future events) and relationship to these goals (such as cause and effect or precondition and allowable action) (pg. 395)". In the case of causal reasoning Cheng and Nisbett (1993, p.208) point out that "causal deduction cannot be subsumed under rules of natural logic associated either with the connective *if* or with the condition relations of necessity and

sufficiency". These authors argue that causal deduction is aimed at the goals of prediction and explanation and is appropriately explained by means of pragmatic reasoning schemas. Cheng and Nisbett (1993) contend that informative prediction is mainly based on the relation of contingency conceived as a difference between the probabilities of the effect given the presence versus the absence of the cause.

Below we explain the characteristics of the causal-agency content which are relevant to syllogistic reasoning, and we also explain the case when the pragmatic agent→goal conclusion is invalid and opposing the figural effect.

The following is an example of a causal-agency behavioural syllogism:

"All people that defend their families are people that show they are loyal".

"All students are people that defend their families".

As can be seen, the syllogism is presented as relating to the membership of different classes of people. However, we find that the first premise implicitly refers to a causal condition (the conduct of defending the family) and its consequence (to show loyalty), and the second premise makes a reference to an agent (students) involved in the causal condition (to defend the family). If reasoners focused on the causal-agency implicit content, then they would realise that the first premise is causally relating the fact of carrying out a certain conduct to reaching a potentially desirable social goal, and the second premise is referring to an agent who carries out the conduct. Therefore they would reason towards a drawing of the pragmatic conclusion *"all students are people that show they are loyal"*, which evaluates the consequence (reaching the goal of showing loyalty) for the agent (the students) of carrying out the conduct of defending the family. The syllogism above is presented with the standard causal-agency direction and illustrates the case where the pragmatic conclusion coincides with the formally valid conclusion. The standard direction in the causal premise is from the cause to the consequence, so that both the temporal and conditional direction of the causation are respected. In the agency premise the direction is from

the agent to the causal condition, respecting the pragmatic requirement that the subject of the proposition is the agent.

The syllogism could be also presented with the reversed causal-agency direction as follows:

"All people that show they are loyal are people that defend their families ".

"All people that defend their families are students".

As can be seen in the reversed causal-agency direction the consequence (goal) appears before the causal condition (conduct) in the first premise, and the causal condition (conduct) appears before the agent (students) in the second premise. As aforementioned, a relevant characteristic of the reversed causal-agency direction syllogisms is that the agent→goal (C→A) conclusion is invalid and in opposition to the figural effect. This agent→goal conclusion also implies that reasoners ignore the relevance of the middle terms contiguity in order to facilitate the syllogism resolution, and focus on the causal-agency content.

We posit that the drawing of the pragmatic conclusion in the reversed causal-agency direction syllogisms requires the operation of returning the content to the standard causal-agency direction. In order to do this reasoners have to swap around the entire interpretation of the two premises. Assuming that reversed causal-agency syllogisms are interpreted in the standard causal-agency direction, either a mental model procedure or a pragmatic rule-type procedure could explain the drawing of the conclusion in the direction agent→goal.

Once the reversed causal-agency syllogisms have been restored to the standard causal-agency direction, a mental model procedure implies the mental operation of placing the two middle terms into contiguity if necessary. We assume that reasoners are methodical in the process of reversing the syllogism terms' order so that they respect the order of the entrance of premises. In fact, the instructions explicitly referred to the premises as the first and second premises. Therefore, the first premise is swapped around first and, subsequently, the second premise. This operation produces the following interpretation of the syllogism previously shown:

"All people that defend their families are people that show they are loyal"

"All students are people that defend their families".

In this case reasoners need to place the middle terms into contiguity and get it provided that their initial interpretation is based on the second premise and the interpretation of the first premise is then renewed in order to add this information to the model. Once this operation is performed, the composite mental model according to Johnson-Laird & Byrne (1991) is:

[[S] D] L

...

S=Students ; D=people that defend their families; L= people that show they are loyal.

In this composite mental model the class relationship described in the premises is represented by means of specific tokens, and the square brackets around S mean that the set of people that are students have been exhaustively represented in the model. Assuming the principle that the first information into working memory is the first information out of it (Broadbent, 1958), this model would lead subjects to the conclusion: *"All S (students) are L (people that show they are loyal)."*

As aforementioned, the drawing of the pragmatic conclusion could be also explained by means of the application of a pragmatic rule. The first operation is the same as in the mental model procedure, that is, to interpret the reversed causal-agency syllogisms in the standard causal-agency direction. Subsequently the pragmatic conclusion agent→goal would be drawn by means of the application of modus ponens (Cheng and Holyoak, 1985; Ford, 1995; Stenning and Yule, 1997) as follows: "if a rule exists related to carrying out the conduct C to attain the goal G, and an agent that carries out the conduct C is found, then it can be concluded that the agent attains the goal G; that is" *all students are people that show they are loyal*". In contrast to the mental model procedure, the application of the pragmatic rule would not be influenced by the contiguity of the two middle terms. What is relevant in this case is the identification of the rule and the case in which the rule is applied, and this identification would depend on the full processing of the syllogism content.

Cosmides (1989) has proposed that making decisions about social exchanges is indifferent to the presentation of the terms in the social contract statement in the Wason selection task. Specifically, she found that selections coincided with logical selections in the standard form of the social contract statement, while they were non logical in the case of the rotated form. She concluded therefore that reasoning about social exchanges is not a process which merely facilitates the drawing of logical selections. As in Cosmides (1989) the presentation of causal-agency content in the syllogisms in standard and reversed direction in our research has an effect on the validity of the conclusion. Following our example, the pragmatic conclusion "*all students are people that show they are loyal*" coincided with the logical conclusion in the standard causal-agency direction, while it was illogical in the case of the reversed direction. The purpose behind presenting the material in standard and rotated form is to demonstrate that the subjects are making a selection (or drawing a conclusion) pragmatically aimed. If reasoners make the same selection (or, in our case, draw the same conclusion) to the same content problem but presented in different form, it is revealing that it is the content that is the factor determining the process of deduction (Cosmides, 1989; Brown and Moore, 2000). In the case of causal-agency behavioural syllogisms, if the subjects are reasoning logically then they draw the valid agent→goal conclusion to syllogisms with the standard causal-agency direction. However, if the subjects are evaluating the consequence for the agent of carrying out a certain conduct, then they also draw the invalid agent→goal conclusion to syllogisms with the reversed causal-agency direction.

In this paper we examine the role of the operation of bringing the middle terms into contiguity in the process of drawing a causal-agency pragmatic conclusion. In Experiment 1 the subjects could receive the syllogism terms in the standard or the reversed causal agency direction, either in figure 1 (middle term contiguity) or figure 2 (non middle term contiguity). We firstly examine if the subjects give the invalid agent→goal conclusion to the reversed causal-agency direction syllogisms (at the same time that they give the valid agent→goal conclusion to the standard causal-agency direction syllogisms) suggesting that the subjects are reasoning pragmatically with

this behavioural content; and, subsequently, we test, a) if the middle terms contiguity presentation facilitates the drawing of the pragmatic conclusion in syllogisms with the standard causal-agency direction, and b) if in the syllogisms with the causal-agency direction reversed the subjects carried out these two following cognitive operations: returning the content to the standard causal-agency direction and, subsequently, placing the middle terms into contiguity. In Experiment 2 we compare the latency of formal conclusions to figure 1 syllogisms, facilitated by the middle terms' contiguity, with that of pragmatic conclusions to figure 1 syllogisms facilitated by the standard causal-agency presentation. If we find that the formal $A \rightarrow C$ conclusion to figure 1 syllogisms is drawn more quickly than the pragmatic agent \rightarrow goal conclusion to figure 2 syllogisms then it is suggested that the process of drawing the pragmatic conclusion involves the operation of bringing the middle terms into contiguity.

Experiment 1.

The aim of this experiment was to examine the role of the middle terms contiguity in the process of drawing a causal-agency pragmatic conclusion. To this end, we manipulated the causal-agency content so that it could be presented either with the standard or the reversed causal-agency direction, or in figure 1 or figure 2. Below an experimental syllogism in the different conditions is shown:

"All students are people that participate in experiments"

"All people that participate in experiments are people that contribute to scientific progress".

(figure 1, standard causal-agency direction)

"All people that participate in experiments are people that contribute to scientific progress"

"All students are people that participate in experiments".

(figure 2, standard causal-agency direction)

"All people that contribute to scientific progress are people that participate in experiments"

"All people that participate in experiments are students".

(figure 1, reversed causal-agency direction)

"All people that participate in experiments are students"

"All people that contribute to scientific progress are people that participate in experiments"

(figure 2, reversed causal-agency direction)

In order to examine the role of the middle terms contiguity in the process of drawing a causal-agency pragmatic conclusion, we firstly have to confirm the bias towards the conclusion agent→goal produced by the causal-agency content. This bias would be evident in figure 1 and 2 reversed causal-agency syllogisms inasmuch as the agent→goal conclusion is invalid and opposing the figural effect in both. As aforementioned, if the subjects are reasoning logically they would draw the valid agent→goal conclusion to syllogisms with the standard causal-agency direction. However, if the subjects are evaluating the consequence for the agent of carrying out a certain conduct, they would also draw the invalid agent→goal conclusion to syllogisms with the reversed causal-agency direction.

Once this confirmation is made, we can examine the role of the middle terms contiguity in the process of drawing an agent→goal pragmatic conclusion in two different ways. On the one hand, we compared the time taken by the subjects to draw the agent→goal conclusion in figure 1 and figure 2 syllogisms with the standard causal-agency direction. If the subjects carry out the cognitive operation of bringing the middle terms into contiguity, we expect that the drawing of the pragmatic conclusion takes more time in figure 2 than in figure 1 syllogisms. Figure 1 presents the middle terms into contiguity, while figure 2 requires the cognitive operation of starting the interpretation in the second premise and then renewing the interpretation of the first premise in order to add this information to the model.

Furthermore, we made another test by comparing the time taken to draw the agent→goal conclusion in figure 1 and figure 2 syllogisms with the reversed causal-agency direction. As we previously explained, the drawing of the pragmatic agent→goal conclusion in the reversed causal-agency content syllogisms requires that reasoners carry out the operation of returning the content to the standard causal-agency direction. According to mental models (Johnson-Laird and Byrne,

1991), this operation would be followed by the cognitive operation of placing the middle terms into contiguity. We have assumed that reasoners are methodical in the process of returning the content to the standard causal-agency direction.

In the cases of the previously shown reversed causal-agency syllogisms the operation of returning the content to the standard causal-agency direction gives place to the following interpretations for figure 1 and 2, respectively:

"All people that participate in experiments are people that contribute to scientific progress"

"All students are people that participate in experiments".

"All students are people that participate in experiments"

"All people that participate in experiments are people that contribute to scientific progress".

As can be seen, the figure 1 reversed causal-agency syllogism would adopt the figure 2, and the figure 2 reversed causal-agency syllogism would adopt the figure 1.

In this context, we predict that drawing an agent→goal conclusion would take more time in the reversed than in the standard causal-agency syllogisms in both figures. And, if the operation of bringing the middle term into contiguity is necessary to draw a pragmatic conclusion, then it also could be predicted that the time taken for drawing an agent→goal conclusion would be larger in figure 1 than in figure 2 reversed causal-agency syllogisms.

Method.

Subjects. Fifty eight first year pedagogy students.

Design. The design had a within-subjects factor the Figure of the Syllogism: Figure 1 vs Figure 2, and a between-subjects factor The Causal-Agency Direction: Standard vs Reversed. The dependent variables were the frequency of the agent→goal conclusion, and the resolution latency that is equal to the sum of reading times of the first and second premises.

Materials. The subjects solved a group of 24 syllogisms, 8 were experimental (4 with figure 1 and 4 with figure 2), 12 filler and 4 practice syllogisms. There were two versions of the

experimental syllogisms, that is, those with the standard causal-agency direction and with the reversed causal-agency direction.

As was previously shown, the premises of the experimental syllogisms had mood A (universal affirmative) so half of the syllogisms were of form AA1 and the other half of form AA2. AA1 syllogisms have a valid quantified "all" conclusion in the $A \rightarrow C$ direction, while AA2 syllogisms have a valid "all" quantified conclusion in the $C \rightarrow A$ direction (Johnson-Laird & Byrne (1991).

The filler syllogisms had different forms: AA4, AE4, EO4, AE3, IA3, EA3, AA1, II1, IA1, IA2, AI2, AI4, and different contents. As follows, a filler syllogism is displayed:

"All people that practise water sports are people that enjoy the sea"

"All people that practise water sports are students".

Procedure. The subjects 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 subject 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. Subjects 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 4 syllogisms were for practice purposes. The end of the practice session was indicated by the prompt "End of the Examples". The computer recorded the subjects' reading times for both premises of the syllogisms.

The within-subjects figure of the syllogism condition was counterbalanced. The syllogisms that appeared in one of the presentations in figure 1, appeared in the other presentation in figure 2 and vice-versa. Half of the subjects received one of the presentations and the other half the other. Twenty eight subjects received the syllogisms with the standard causal agency direction version and thirty subjects received the reversed causal-agency direction version of the syllogisms.

Results

Table 1 shows the percentages of the agent→goal conclusion for figure 1 and figure 2 syllogisms both with the standard and the reversed causal-agency direction.

PLEASE, INSERT TABLE 1 ABOUT HERE

With reference to table 1, we found that practically all the correctly given responses to the standard causal-agency syllogisms were agent→goal conclusions in both figure 1 (96%) and figure 2 (100%). In relation to the reversed causal-agency syllogisms, we also found a high percentage of agent→goal conclusions which was similar in both figure 1 (71%) and figure 2 (69%). This result confirms that the behavioural causal-agency content had biased the deductive process towards the conclusion agent→goal. As we previously mentioned, if the subjects are reasoning logically they would draw the valid agent→goal conclusion to the syllogisms with the standard causal-agency direction. But if the subjects are evaluating the consequence for the agent of carrying out a certain conduct, they would also draw the invalid agent→goal conclusion to the syllogisms with the reversed causal-agency direction. This invalid agent→goal conclusion to the syllogisms with the reversed causal-agency direction is in opposition to the figural effect, which implies that the subjects ignored the utility of the contiguity of the middle terms in order to facilitate the syllogism resolution.

Moreover, the fact that the percentage of agent→goal conclusions was lower in the reversed than in the standard causal-agency syllogisms suggests that the formal presentation was sometimes taken into account by the subjects (and, therefore, they gave the valid conclusion to the former syllogisms). The reversal of the causal-agency direction would have rendered the identification of the causal-agency nature of the content difficult to some extent and, as a consequence, the likelihood of a formal resolution of the syllogisms increased.

Once we confirmed that the subjects were reasoning pragmatically with the causal-agency behavioural content we went on to investigate the influence of the operation of bringing the

middle terms into contiguity in the time taken to draw an agent→goal conclusion for the figure 1 and figure 2 syllogisms in both the standard and the reversed causal-agency direction.

In order to analyse the time taken to draw an agent→goal conclusion, we selected the subjects who gave at least three agent-goal responses to the group of four experimental syllogisms both in figure 1 and figure 2. Once counterbalanced, the sample was composed of 26 subjects in the case of the standard causal-agency syllogisms, and 12 subjects in the case of the reversed causal-agency syllogisms.

The extreme cases in the resolution latency of each premise were substituted by the mean of the group plus two standard deviations in the corresponding condition once these cases were removed, and comprised 6.97 % of the observations in the case of standard causal-agency syllogisms, and 3.12% in the case of reversed causal-agency syllogisms. The missing values were substituted by the mean of the group in the corresponding condition after removal of extreme cases, and were 13 (6.25%) in the case of standard causal-agency syllogisms and 9 (9.37%) in the case of the reversed causal-agency syllogisms. 3 cases of non agent→goal conclusion remained (2 in the standard causal-agency syllogisms and 1 in the reversed causal-agency syllogisms) which were considered as blanks and substituted as missing values.

Table 2 shows the mean and standard deviations of the time taken to draw an agent→goal conclusion (in seconds) for figure 1 and figure 2 syllogisms both with the standard and the reversed causal-agency direction.

PLEASE, INSERT TABLE 2 ABOUT HERE

We carried out an analysis of variance with a within-subject factor, the figure of the syllogisms (figure 1 vs figure 2) and a between-subjects factor, the causal-agency direction, (standard vs reversed).

We found that the effect of the figure of syllogisms was significant, $F(1,36):11.49$ $p<0.002$. The time taken to draw an agent→goal conclusion for figure 1 syllogisms (17.67 secs) was lesser than that taken to draw an agent→goal conclusion for figure 2 syllogisms (21.45 secs).

The interaction figure of the syllogisms and causal-agency direction was also significant, $F(1,36)=9.82$, $p<0.003$. As can be seen in table 2, the figure of the syllogisms had an effect in the time taken to draw an agent→goal conclusion, but only in the case of the standard causal-agency direction condition where figure 1 produced a great facilitation.

The effect of the causal-agency direction was significant, $F(1,36)=5.64$, $p<0.023$. The time taken to draw an agent→goal conclusion was smaller in the standard than in the reversed causal-agency direction syllogisms ($M= 18.07$ and $M=22.80$, respectively).

In relation to our predictions, these results suggest that the subjects took advantage of the contiguity of the middle terms presentation in the standard causal-agency direction syllogisms. With regard to the reversed causal-agency direction syllogisms, the main effect of the causal-agency direction supports the idea that the subjects made the cognitive operation of returning the reversed causal-agency syllogisms to the standard direction. However, the fact that the figure did not facilitate the drawing of the agent→goal conclusion, does not support the view that the subjects made the subsequent operation of bringing the middle terms into contiguity. As aforementioned, if we assume that the subjects are methodical in the process of returning the reversed causal-agency syllogisms to the standard direction, we would expect that figure 2 produces facilitation insofar as that, after the operation of returning the causal-agency content to the standard direction, the figure 2 syllogisms adopt the figure 1 where the middle terms are in contiguity.

With regard to the role of the middle terms contiguity in the process of drawing an agent→goal response we can conclude that in the case of the standard causal-agency syllogisms it is supported the idea that the subjects made the operation of bringing the middle terms into contiguity (facilitation of figure 1 in comparison to figure 2). But in the case of the reversed causal-agency syllogisms we did not find any evidence that the subjects made the cognitive operation of bringing the middle terms into contiguity, subsequent to the operation of returning the content to the standard causal-agency direction. Therefore, we can conclude that we have not

found evidence that the subjects systematically made the operation of bringing the middle terms into contiguity in the process of drawing an agent→goal conclusion.

How can these contradictory results in the two tests be explained? We suggest that the facilitation associated with the middle terms contiguity presentation found in the syllogisms with the standard causal-agency direction, is not due to the operation of bringing the middle terms into contiguity (necessary to figure 2 but not to figure 1). This facilitation could be attributed to the contiguity producing a quicker causal-agency interpretation of the syllogisms. Specifically, we suggest that the fact of the figure 1 standard causal-agency syllogisms presenting the causal condition (the conduct) into contiguity creates a continuity in the causal-agency argument which is responsible for the facilitation.

Experiment 2.

The aim of this experiment was to find out which conclusion took more time to be drawn. Would it be an agent→goal conclusion to syllogisms in figure 2 with the standard causal-agency direction, which would be not facilitated by the contiguity of the middle terms, or a formal A→C conclusion to syllogisms in figure 1 which would be facilitated by the contiguity of the middle terms?. If the formal A→C conclusion to figure 1 syllogisms was drawn more quickly than the pragmatic agent→goal conclusion to figure 2 syllogisms then this would suggest that the process of drawing the pragmatic conclusion involves the operation of bringing the middle terms into contiguity. Conversely, if the agent→goal conclusion to figure 2 syllogisms was drawn more quickly than the formal conclusion to figure 1 syllogisms, it would uphold the idea that this conclusion does not require the operation of bringing the middle terms into contiguity. As consequence, this would suggest that the pragmatic conclusion is produced by means of a quick and specialised procedure such as a pragmatic rule. In this respect, it would be expected that such a rule would operate more quickly than a mental models procedure due to the former being a specialized mechanism.

The content of the experimental syllogisms was a version of a previous experiment in which the causal and agency relations between the terms were weakened in order to obtain more formal conclusions to figure 1 reversed causal-agency syllogisms. Marrero and Gámez (1999) found that the tendency to give a formal conclusion increased in syllogisms where the behavioural content was presented in the reversed direction and had weaker causal and agency relations. As follows an experimental syllogism in the different conditions is shown:

"All people that contribute to the increase of the sample are people that participate in experiments"

"All people that participate in experiments are waiters". **(Figure 1)**

"All people that participate in experiments are people that contribute to the increase of the sample"

"All waiters are people that participate in experiments". **(figure 2)**

The experimental syllogisms had the figures 1 and 2. The agent→goal conclusion in figure 2 syllogisms had the C→A direction and would be facilitated by the behavioural content being presented in the standard causal-agency direction. The formal conclusion in figure 1 syllogisms where the behavioural content is presented in the reversed direction, had the A→C direction and would be facilitated by the adjacent presentation of the middle terms.

Method

Subjects. 36 first year psychology students.

Design. The design had a within-subjects factor the Figure of the Syllogism: Figure 1 vs Figure 2. The dependent variables were the frequencies of the A→C and the agent→goal directed conclusions, and the time taken to process the first and the second premises of the syllogisms.

Materials and procedures. The experimental syllogisms contained two changes with respect to the content of Experiment 1 syllogisms. The term "students" was replaced by professional agents; and the goals were replaced with others goals more weakly related to the conduct. As follows, we present the figure 1 and figure 2 versions of one of the experimental syllogisms.

"All people that show they are home loving are people that defend their families"

"All people that defend their families are chemists" (figure 1).

"All people that defend their families are people that show they are home loving"

"All chemists are people that defend their families" (figure 2).

As can be seen, the goal was weakly related to the conduct. Likewise, the agent appeared weakly related to the conduct and the goal, both being distant from the agent's characteristic interests and activities.

In figure 1 syllogisms the behavioural content was presented in the reversed causal-agency direction, while in figure 2 syllogisms it was presented in the standard direction.

The agent→goal conclusion for figure 2 syllogisms was an "all" quantified conclusion with the C→A direction, and coincided with the valid conclusion. The formal and valid conclusion for figure 1 syllogisms was an "all" quantified conclusion with the A→C direction.

Results

Table 3 shows the percentages of the agent→goal (C→A) conclusion and the A→C conclusion for figure 1 and figure 2 syllogisms.

PLEASE, INSERT TABLE 3 ABOUT HERE

As can be seen, the percentage of the agent→goal conclusion to figure 2 syllogisms is high and similar to the percentage associated with figure 2 standard causal-agency syllogisms in Experiment 1. On the other hand, and as we expected, the percentage of the agent→goal conclusion to the figure 1 syllogisms was lower in this experiment than in the figure 1 reversed causal-agency syllogism in Experiment 1 (56% and 71% respectively). This lessening would be a consequence of the weakening of the causal and the agency relations, and produced a greater number of formal A→C conclusions to figure 1 syllogisms, which was our purpose.

In order to compare the time taken to draw a formal A→C conclusion to figure 1 syllogisms with the time taken to draw an agent→goal conclusion to the figure 2 syllogisms, we selected the subjects who gave at least three A→C conclusions to the four figure 1 syllogisms and, at the same

time, they gave at least three agent→goal conclusions to the four figure 2 syllogisms. Once counterbalanced, the resulting sample was composed of 10 subjects.

The extreme cases in the resolution latency of each premise were substituted by the mean of the group plus two standard deviations in the corresponding condition once these cases were removed, and comprised 3.12 % of the data. The missing values were substituted by the mean of the group in the corresponding condition after removal of extreme cases, and were 3 (3.75%). There were 5 cases (12.5% of the data of the corresponding condition) where an agent→goal conclusion was given for figure 1 syllogisms. They were considered as blanks and substituted in the same way as the missing values.

Table 4 shows the mean (in seconds) and standard deviations of the time taken to draw an agent→goal conclusion for figure 2 syllogisms and the formal A→C conclusion for the figure 1 syllogism.

PLEASE, INSERT TABLE 4 ABOUT HERE

We carried out an analysis of variance with two within-subject factors, the figure of the syllogisms (figure 1 vs figure 2), and the premise (premise 1 vs premise 2), taking as dependent variable the latency of processing the premise.

We found that the effect of the premise was marginally significant, $F(1,9)=5.00$, $p=0.052$. The second premise latency ($M=10.55$) was smaller than the first premise latency ($M=12.63$), $Dif=2.08$. The effect of the figure was significant, $F(1,9)=15.44$, $p<0.003$. The latency of figure 2 syllogisms ($M=10.58$) was smaller than the latency of figure 1 syllogisms (13.00), $Dif.=2.82$.

The interaction figure and premise was not significant, $F(1,9)=0.57$, $p>0.20$.

These results support the idea that drawing an agent→goal conclusion to figure 2 syllogisms which presented the facilitating standard causal-agency direction was quicker than drawing a formal A→C conclusion to figure 1 syllogisms which presented the facilitating contiguity of the middle terms. Table 4 shows that the advantage of the standard causal-agency presentation affected the two premises, although it was greater in the second premise ($Dif=2.26$, first premise

and $Dif=3.38$, second premise; $t=1.71$, $p=0.121$, and $t=5.30$, $p<0.000$, respectively). The conduct→goal causal direction of the first premise of figure 2 syllogisms had facilitated the premise processing. The fact of the facilitation of the causal-agency presentation being focused on the second premise is relevant in order to evaluate the role of the contiguity of the middle terms in the process of drawing the agent→goal conclusion. The reading time of the second premise represents the moment where all the information contained in the syllogisms has been processed in order to make a conclusion. This is the moment when the effect of the contiguity of the middle terms facilitating the drawing of the formal conclusions to figure 1 syllogisms (and, conversely, slowing the drawing of the agent→goal conclusion) would be evident. However, as we have seen, the results showed the opposite pattern.

Therefore, and with the caution that the size of the sample implies, the results of this experiment did not uphold the idea that the operation of bringing the middle terms into contiguity is involved in the process of drawing a pragmatic agent→goal conclusion. In a different way, the results suggest that the agent→goal conclusion was produced by means of a quick deductive procedure attuned to the processing of the causal-agency content. This procedure could be well represented by a pragmatic rule which applied to the figure 1 standard causal-agency syllogisms as a modus ponens; that is, “if a rule exists related to carrying out the conduct C to attain the goal G, and an agent that carries out the conduct C is found, then it can be concluded that the agent attains the goal G.

GENERAL DISCUSSION

Several findings of interest to syllogistic research have been found in this investigation. On the one hand, it was demonstrated that the subjects solved the behavioural syllogisms focusing on the (causal-agency) content, and ignored the obvious advantage of the middle terms contiguity presentation (syllogisms with the reversed causal-agency direction). This result emphasises the role of the content in syllogistic reasoning, and that this type of reasoning is biased towards the drawing of realistic or practical conclusions. Causal-agency content and believability affects

sylogistic reasoning in a different way. However both effects illustrate how prior knowledge influences the deductive process in order to give useful and realistic conclusions which are relevant to adaptation in everyday life. Deduction is aimed at an adaptation which to some extent precludes the making of arbitrary conclusions. While the belief effect is mainly focused on the drawing of realistic conclusions, the causal-agency content effect is related to the making of practical conclusions.

On the other hand, our research focused on the role of the operation of bringing the middle terms into contiguity in drawing a pragmatic agent→goal conclusion to behavioural causal-agency syllogisms. Mental models (Oakhill, Johnson-Laird & Garnham, 1989; Love and Kessler, 1995; Manktelow, Fairley, Kilpatrick and Over, 2000) proposes that the content and the context could affect the interpretation of the premises stage and consequently would bias the deductive process, as in the case of the behavioural causal-agency content. Once the content-dependent interpretation is made, at a subsequent stage the subjects have to carry out the cognitive operations necessary to build up a composite mental model as is the case in the operation of bringing the middle terms into contiguity.

We gave three different tests to find out if the subjects brought the middle terms into contiguity when they drew an agent→goal conclusion. We tested firstly if the subjects took advantage of the contiguity of the middle terms presentation in the syllogisms with the standard causal-agency direction, secondly, if the subjects carried out the operation of bringing the middle terms into contiguity after they had made the operation of returning the reversed causal-agency syllogisms to the standard direction, and thirdly, what conclusion took more time to be drawn?, whether it would be an agent→goal conclusion to syllogisms in figure 2 with the standard causal-agency direction, which is not facilitated by the contiguity of the middle terms, or a formal $A \rightarrow C$ conclusion to figure 1 syllogisms which is facilitated by the contiguity of the middle terms.

In Experiment 1, we found that the subjects took advantage of the contiguity of the middle terms presentation in the case of the syllogisms with the standard causal-agency direction but, at

the same, we did not find favourable evidence related to the subjects making the cognitive operation of bringing the middle terms into contiguity subsequent to the operation of returning the reversed causal-agency direction syllogisms to the standard direction. These results did not support the view that subjects systematically carried out the cognitive operation of bringing the middle terms into contiguity in the process of drawing an agent→goal conclusion. We suggest that what these results support is that the time taken to draw a pragmatic conclusion depended on the factors which help or hinder the causal-agency interpretation of the behavioural syllogisms. As was shown, the reversal of the causal-agency direction made the drawing of the agent→goal conclusion more difficult. Moreover, we suggest that figure 1 standard causal-agency syllogisms facilitated the drawing of this conclusion due to the contiguity of the middle terms (the causal condition) creating a continuity in the causal-agency argument (which facilitates the interpretation).

In Experiment 2 we found that the agent→goal conclusion to figure 2 syllogisms (facilitated by the standard causal-agency direction and not facilitated by the contiguity of the middle terms presentation), was given more quickly than the formal conclusions to figure 1 syllogisms, facilitated by the contiguity of the middle terms presentation. This result demonstrates that the operation of bringing the middle terms into contiguity was not involved in the process of drawing an agent→goal conclusion. On the other hand, we consider this result as showing that drawing an agent→goal conclusion that depends on a specialised deductive procedure is faster than a mental model procedure. A context-sensitive pragmatic causal-agency rule is one such specialised deductive procedure. The application of this rule would not need the systematic operation of bringing the middle terms into contiguity, and only requires the identification of the rule and the case where the rule applied, which would be realised when the entire syllogism has been processed. However, these results should be treated with caution. Additional items analyses would be necessary in order to confirm the effect of the causal-agency content. However, the

sample size for items in both experiments, which was even smaller than the sample size for subjects in Experiment 2, dissuaded us from carry out them.

The operation of bringing the middle terms into contiguity has been proposed by mental models (Johnson-Laird and Bara, 1984; Johnson-Laird & Byrne, 1991) as the appropriate explanation of the figural effect. This operation is considered as a general cognitive operation involved in syllogistic reasoning. However, our results suggest that the application of such cognitive operation to syllogistic reasoning is dependent on the content; and, more specifically, on the nature of the reasoning process involved, as is the case if it is aimed at drawing a pragmatic conclusion.

Causal-agency behavioural reasoning is shown as a type of practical reasoning which is based on a biased interpretation of the content orientated to drawing a particular conclusion. Therefore causal-agency pragmatic reasoning constitutes a specialised and efficient type of specific-domain cognition. Several authors have pointed out that reasoning that is efficient in certain domains of cognition would be based on rules (and the results of this research supports this position to some extent). Rules could result in a more efficient deductive procedure than mental models when the inferences are pragmatic and goal-directed (Cheng and Holyoak, 1985, Cosmides, 1989). Within the framework of mental models, 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 than the construction and manipulation of models (p. 67).

The supporters of the pragmatic and domain-specific nature of human reasoning (Cheng and Holyoak, 1985; Cosmides, 1989; Cosmides and Tooby, 1992; Cheng and Nisbett, 1993) claim that although human beings lack a general logical competence, they do have specific-domain cognitive deductive competence. However, the authors that propose that human reasoning is

based on natural rules (Braine, Reiser & Romain, 1984; Rips, 1994), or on building up mental models (Johnson-Laird and Byrne, 1991) consider that human deductive competence is of a general purpose. In the context of syllogistic reasoning, and in the light of our results, we suggest that the fact of reasoners being involved in either a pragmatic or a formal way of reasoning would depend on the content. In syllogisms with a content such as a behavioural causal-agency content, the deductive procedure would be based on rules, but in syllogisms such as the following:

"All pilots are hunters"

"All teachers are pilots".

C:*"All teachers are hunters",*

in which the content does not induce a practical conclusion, a mental model procedure would constitute an appropriate way to explain the process by which subjects reach a conclusion. In this type of content the operation of bringing the middle terms into contiguity would be relevant.

REFERENCES.

- Bara, B.G., & Bucciarelli, M. (1997). The reasons we reason. *Cahiers de Psychologie Cognitive*, 16 (1-2), 63-69.
- Braine, M.D.S., Reiser, B.J., & Rumain, B. (1984). Some empirical justification for a theory of natural propositional logic. In G.H. Bower (Ed), *The psychology of learning and motivation* (Vol. 18, pp. 313-371). New York: Academic Press.
- Broadbent, D.E. (1958). *Perception and communication*. New York: Pergamon Press.
- Brown, W.M. & Moore, C. (2000). Is prospective altruist detection an evolved solution to the adaptive problem of subtle cheating in cooperative ventures?. Supportive evidence using the Wason selection task. *Evolution and Human Behaviour*, 21, 25-37.
- Cheng, P.W. & Holyoak, K.J. (1985). Pragmatic Reasoning Schemas. *Cognitive Psychology*, 17, 391-416.
- Cheng, P., & Nisbett, R.E. (1993). Pragmatic constraints on causal deduction. In R. E. Nisbett (Ed), *Rules for reasoning* (pp. 207-227). N.J: Lawrence Erlbaum Associates.
- Cherubini, P., Garnham, A., Oakhill, J., & Morley, E. (1998). Can any ostrich fly?: some new data on belief bias in syllogistic reasoning. *Cognition*, 69, 179-218.
- Cosmides, L. (1989). The logic of social exchange: has natural selection shaped how humans reason? Studies with Wason selection task. *Cognition*, 31, 187-276.
- Cosmides, L. & Tooby, J. (1992). Cognitive adaptations for social exchange. In J.H. Barkow, L. Cosmides, & J. Tooby (Eds). *The Adapted Mind: Evolutionary Psychology and the Generation of Culture* (pp. 163-228). Oxford: Oxford University Press.
- Evans, J. St.B.T., Newstead, S. and Byrne, R.M.J. (1993). *Human reasoning: The psychology of deduction*. Hillsdale: Erlbaum.
- Ford, M (1995). Two modes of mental representation and problem solution in syllogistic reasoning. *Cognition*, 54, 1-71.

- Johnson-Laird, P. N., & Steedman, M. (1978). The psychology of syllogisms. *Cognitive Psychology, 10*, 64-98.
- Johnson-Laird, P. N., & Bara, B. G. (1984). Syllogistic Inference. *Cognition, 16*, 1-62.
- Johnson-Laird, P. N., & Byrne, R. M. J. (1991). *Deduction*. Hillsdale, New Jersey: LEA.
- Love, R.E. & Kessler, C.M. (1995): Focusing in Wason's selection task: Content and instruction effects. *Thinking and Reasoning, 1*, (2), 153-182.
- Marrero, H. and Gámez, E. (1999). Pragmatic effects in syllogistic reasoning. Internal report presented in May in the research seminar of the Department of Cognitive Psychology of the University of La Laguna .
- Manktelow, K.I., Fairley, N., Kilpatrick, S.G. and Over, D.E. (2000). Pragmatics and strategies for practical reasoning. In Schaeken, W. & De Vooght, G. (Eds). *Deductive reasoning and strategies* (pp. 111-130). Mahwah, NJ, US: Lawrence Erlbaum Associates.
- Newstead, S.E., Pollard, P., Evans, J.St. B.T., & Allen, J.L. (1992). The source of belief bias effects in syllogistic reasoning. *Cognition, 45*, 257-284.
- Oakhill, J.V., Johnson-Laird, P. N. & Garnham, A. (1989). Believability and syllogistic reasoning. *Cognition, 31*, 117-140.
- Polk, T. A., y Newell, A. (1995). Deduction as verbal reasoning. *Psychological Review, 102*, 533-566.
- Rips, L.J. (1994). *The psychology of proof: Deductive reasoning in human thinking*. Cambridge, MA: M.I.T. Press, Bradford Books.
- Santamaría, C, García-Madruga, J.A., & Carretero, M. (1996). Beyond belief bias: Reasoning from conceptual structures by mental models manipulation. *Memory & Cognition, 24* (2), 250-261.
- Stenning, K., & Yule, P. (1997). Image and language in human reasoning: A syllogistic illustration. *Cognitive Psychology, 34*, 109-159.

Wetherick, N., & Gilhooly, K. (1990). The figural effect in syllogistic reasoning. In K. Gilhooly, M. T. G. Keane, R. Logie, & G. Erdos. *Lines of thought: reflections on the psychology of thinking*, Vol. 1, London: Wiley.

Table 1.

Percentages of the agent→goal conclusions for figure 1 and figure 2 syllogisms with the standard and the reversed causal-agency direction (Experiment 1).

	Figure 1	Figure 2
Standard causal-agency direction	96%	100%
Reversed causal-agency direction	71%	69%
N	28	30

Table 2.

Mean latencies (seconds), standard deviations (between brackets) of the agent→goal conclusion for figure 1 and figure 2 syllogisms with the standard and the reversed causal-agency direction

(Experiment 1).

	Figure 1	Figure 2
Standard causal-agency direction	15.35 (3.56)	20.79 (6.24)
Reversed causal-agency direction	22.70 (8.44)	22.91 (7.89)

Table 3.

Percentages of the $A \rightarrow C$ conclusion and the agent \rightarrow goal conclusion for figure 1 and figure 2 syllogisms (Experiment 2).

Conclusion	Figure 1	Figure 2
$A \rightarrow C$	44%	3%
Agent \rightarrow Goal	56%	97%

Table 4.

Premises mean latencies (seconds) and standard deviations (between brackets) of the formal $A \rightarrow C$ conclusion for figure 1 syllogisms and the agent \rightarrow goal conclusion for figure 2 syllogisms

(Experiment 2).

	Fig 1	Fig 2
Conclusion	$A \rightarrow C$	Agent \rightarrow Goal
First Premise	13,76 (2,95)	11,50 (2,75)
Second Premise	12,24 (2,16)	8,86 (1,97)
Global latency	26,00 (3,52)	20,36 (2,96)