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**The Effect of Pragmatic Content on Syllogistic Reasoning: Stronger than Atmosphere
and Believability**

Hipólito Marrero and Elena Gámez.

Department of Cognitive and Social Psychology.

University of La Laguna. Spain

Abstract

A part of the process of drawing a syllogistic conclusion is choosing its quantifier. This choice has been explained as influenced by the atmosphere of the mood of the premises (Woodworth and Sells, 1935), and several models have described the process (Chater and Oaksford, 1999; Johnson-Laird and Byrne, 1991; Stenning and Yule, 1997). The content can also influence it depending on the conclusion believability (Cherubini, Garnham, Oakhill & Morley, 1998).

We propose that the process of drawing a syllogistic conclusion could depend on the type of material given to reason with. Thus, syllogisms where the two end-terms are a class of agents and a class of goals, while the middle term is a class of actions the agent could engage in order to reach the goal, cause agent→goal conclusions. A main prediction in our study is that the conclusion quantifier is the quantifier of the agency premise. In our experiment, participants were presented with IA syllogisms. There were four conditions, three of which gradually moved the content of the syllogisms away from the pragmatic actor-behaviour-goal structure. The results showed that participants preferred unbelievable universal agent→goal conclusions when pragmatic content while this preference was gradually removed as the content moved away from the actor-behaviour-goal structure.

The process of choosing a syllogistic conclusion quantifier

The choice of the conclusion mood in syllogistic reasoning has been earlier described as a superficial process by Woodworth and Sells (1935). These authors explained it as a result of the "atmosphere" created by the mood of the premises. Whenever at least one premise is negative, reasoners choose a negative conclusion; whenever at least one premise contains the existential quantifier "some", they choose an existential conclusion; otherwise, they choose an affirmative and universal conclusion. Renewed versions of this atmosphere hypothesis have been presented (Begg and Denny, 1969; Wheterick and Gilhooly, 1990). For example, Wheterick and Gilhooly (1990) have suggested that the atmosphere effects are the consequence of a matching process which implies that: "where the logic of the situation is not immediately apparent to a subject, he or she may generate a response that has at least the appearance of rationality by selecting a logical form corresponding to that of the more conservative premise; that is, the premise asserting the smaller proportion of members of the class designated by the subject term" (pg. 107).

On the other hand, several syllogistic reasoning models have described the cognitive process of choosing the conclusion mood. Especially relevant in this respect are the source premise grounding of conclusions explanation (Stenning and Yule, 1997), the probability heuristic model explanation (Chater and Oaksford, 1999) and the mental models explanation (Jonhson-Laird and Byrne, 1991).

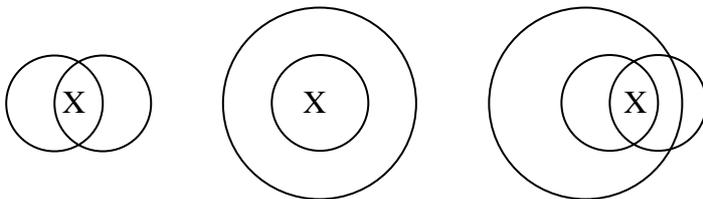
According to Stenning and Yule (1997), syllogism has the model theoretic property of *case-identifiability*: only those syllogisms entailing the existence of a fully specified (by combination of properties) type of individual have a valid conclusion. If reasoners make use of a graphical method for syllogistic reasoning (Stenning and Oberlander, 1995; see the diagram below) the process is as follows: A representation of each premise is constructed where individual types are represented as regions in a diagram defined by circles, an *x* marks the regions of this diagram which corresponds to types of individuals which must exist if the premise is true. Then, a new diagram is constructed by "registering" two premise diagrams by superimposing the middle term circles. The

result is the *registration diagram*, which represents the maximal model of the premises pair. Now each critical region deriving from the original premises diagram will either have been bisected by the third circle or not; if the critical region is bisected, then the mark is removed. The attempt to overlap the end-circles ensures that all possible fully specified types are represented by the resulting diagram. So if a critical region is not bisected and consequently remains marked in the registration diagram, the corresponding fully specified type must exist which enables the conclusion to be drawn. The drawing of the conclusion follows the individual description starting from the source premise, that is, the premise that contains the individuals identified as necessary. Below is the application of this model to the following syllogism:

"Some bee-keepers are physicists"

"All physicists are chemists". (figure 1).

First premise diagram Second premise diagram Registration diagram



Some b are ph + All ph are ch → Some b are ch.

b=bee-keepers; ph=physicists; ch=chemists.

As can be seen, the individuals identified as necessary in the registration diagram are from the first premise so that this is the "source" premise. The conclusion is drawn from the descriptions of critical individuals *b-ph-ch*, which is essentially an existentially quantified conjunction of properties, by merely removing the middle term; that is, *"some bee-keepers are chemists"*.

Stenning and Yule (1997) claimed that syllogisms can be solved by means of either a graphical or a sentential method, but both methods are equivalent at the abstract level. At this level syllogisms have to be considered as conditional inferences. So for any individual conclusion, one

premise supplies the conditional and the other the source of the atomic input to the conditional rule. The above conclusion would be attained by means of application of modus ponens from the conditional second premise to the source first premise.

Mental models theory (Johnson-Laird and Byrne, 1991) bases syllogistic resolution on a semantic process: the building up of mental models. The process of deductive reasoning passes through three stages: comprehension, description and validation (Polk and 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:

b [[ph] ch]

b [[ph] ch]

...

b=bee-keepers; ph=physicist;ch=chemists.

In this composite mental model the class relationship described in the premises is represented by means of specific tokens; the square brackets around "ph" mean that the set of physicists has been exhaustively represented in the model. The three dots allow other sorts of individuals to be made explicit. For simplicity, the number of individuals is likely to be small. In this composite mental model the set of bee-keepers has not been exhaustively represented, which enables the existential conclusion "*some bee-keepers are chemists*".

Chater and Oaksford (1999) have proposed a probabilistic heuristic model for syllogistic

reasoning. Reasoners solve syllogisms by means of simple probability-based heuristics suggested by an informational ordering over quantified statements. These authors argue that a set of fast and frugal heuristics (in the words of Gigerenzer and Goldstein, 1996) generate likely syllogistic conclusions. Moreover, reasoners may use test processes for assessing whether generated conclusions are valid. All these heuristics rely on an ordering in the informativeness of quantified statements that serve as premises of syllogistic arguments. This ordering in categorical syllogisms is as follows: All>some>none>some are not. There are two main generation heuristics. The *min*-heuristic fixes the conclusion quantifier by suggesting choosing that quantifier that matches the least informative (the *min*-premise) of the two premises. The *attachment*-heuristic acts subsequently to the *min*-heuristic and fixes the conclusion order. If the *min*-heuristic has an end-term as its subject, then use this as the subject of the conclusion. Otherwise, use the end-term of the *max*-premise as the subject of the conclusion. If we apply this model to the solution of the above syllogism, we find that the *min*-premise is the existential first premise. The action of both, the *min*-heuristic and the *attachment*-heuristic, generates a conclusion which is existential (as the *min*-premise) and has as its subject the end-term of the *min*-premise and as its predicate the other end-term, that is, "*some bee-keepers are chemists*".

The different explanations of the process of choosing the conclusion quantifier revisited herein, either heuristically-based (the atmosphere explanation: Woodworth and Sells, 1935, the matching explanation: Wheterick and Gilhooly, 1990, and the probability heuristic model explanation: Chater and Oaksford, 1999) or deductively-based (the source premise founding of conclusions explanation: Stenning and Yule, 1997; and the mental model explanation: Johnson-Laird and Byrne, 1991) constitute general-purpose processing descriptions of this process.

The role of the content in syllogistic reasoning has been investigated as the effect of beliefs. The believability effect is related to subjects' tendency to accept or to draw believable but invalid conclusions or, conversely, to reject or not to draw valid but unbelievable conclusions (Oakhill, Jonhson-Laird & Garnham, 1989). Content believability may affect the process of choosing the

quantifier. For example, in the case of the following syllogism (taken from Cherubini et al., 1998):

“every tree is a plant”

“some trees are oaks”,

subjects could give the invalid conclusion “every oak is a plant” instead of the valid but unbelievable conclusion “some oaks are plants”.

Cherubini et al. (1998) have suggested that prior knowledge could facilitate the conclusion process “ if the relations between the end terms could be recovered from general knowledge before the modelling of the premises, this recovered information would provide a single believable conclusion which could be accepted without considering other possible conclusions (pg. 181)”. According to Cherubini et al. (1998) the belief bias is due to the retrieval of prior knowledge relating the end terms, then checking that the premises are compatible with that knowledge, and then accepting the previous knowledge as a true conclusion from the premises.

At this point it is relevant to take into account that the believability content effect is not related to the processing specificities of different types of syllogism content, but is the result of the interaction between the content and the reasoner’s prior beliefs. In this paper we propose that the type of material for reasoning syllogistically strongly influences the process of syllogism resolution. We hypothesise that different structures are at work and different processes work on these depending on the type of material given to reason with. So we predict that different contents with the same (explicit) form may produce different types of conclusions without an influence of prior beliefs. Specifically, we suggest that reasoning with a causal-agency content implies a particular deductive process. As we (Gómez and Marrero, 2000) have demonstrated, this content induces the drawing of a practical conclusion.

Reasoning with syllogisms with a behavioural causal-agency content

We propose that syllogisms where the two end-terms are a class of agents and a class of goals, while the middle term is a class of actions the agent could engage in order to attain the goal, cause agent → goal conclusions. For example, in this syllogism:

“Some persons who participate in experiments are persons that contribute to scientific progress”,

“ All students are persons who participate in experiments”,

we found that the first premise entails the existence of persons that carry out the conduct of participating in experiments and contribute (as a consequence) to scientific progress. This premise acts as a causal conditional premise which relates the conduct to the goal of contributing to scientific progress. The second premise contains an agent (the students) who carry out the conduct. As aforementioned, this causal-agency argument causes an agent→goal conclusion as *“ All students contribute to scientific progress”* . This is a practical conclusion because it constitutes a predictive agency consequence to the students from participating in experiments. This conclusion would be made by means of the application of a conditional rule such as a modus ponens rule-type: "If persons that carry out the conduct of participating in experiments have the consequence of contributing to scientific progress, and an agent (the students) is found that carries out the conduct, then *-the students-* has the consequence of contributing to scientific progress".

We suggest that this causal-agency reasoning is used in daily life with the goals of predicting and explaining the consequences of what happens to us (and others) as agents. This could apply to oneself as agent, or to others as agent. Agents could either be individual or collective. This type of reasoning would be at the service of behavioural planning and, in general, at the service of the goal of obtaining information about agents which is relevant to our social world knowledge.

Moreover, the goal of prediction could be related either to positive or negative consequences. For example, in the case of a negative consequence, the conduct would be placed in the planning context of avoiding that oneself as the agent, or others in whom one could be interested, carry it out. For example, the argument:

"Some persons who smoke cigarettes a lot are persons exposed to lung cancer", and

"My father is a person who smokes cigarettes a lot ",

leads to the conclusion *"My father is a person exposed to a lung cancer"* which warns me about a potential danger to my father if he continues to carry out the conduct.

In general, the presentation of a causal premise, with adaptively relevant information, joined to a premise containing an agency supposition is enough to trigger a reasoning process aimed at the goal of drawing a practical conclusion.

In the above examples, causal-agency reasoning is used with the goal of anticipating consequences in a behavioural planning context. This type of reasoning could also have the goal of explaining the agent's achievements and characteristics. For example, let us suppose that someone meets a man, John, and becomes intrigued by his peace-loving personality. He/she could ask himself/herself about this appealing personality trait and then elaborate the following syllogistic argument:

“Some persons who have been brought up in a violent family are persons who have an aggressive personality”,

“John is a person who does not have an aggressive personality”, so that:

“John is a person who has not been brought up in a violent family”,

which constitutes an explicative conclusion about John's personality.

Causal-agency effect in the process of choosing a conclusion quantifier

As we have described above, the different explanations of the process of choosing the conclusion quantifier involve reasoners contrasting the mood of both syllogism premises. However, they describe this selection by means of different processes. Let us take into consideration the syllogism previously shown:

“Some persons that participate in experiments are persons that contribute to scientific progress”

“All students are persons that participate in experiments”.

According to the source premise founding of conclusions explanation (Stenning and Yule, 1997) there is not in the registration diagram a region that is not bisected by the third circle in the process of superimposing the middle terms circles, so that there is not an identification of the type of individuals necessary and the response must be *“there is not a valid conclusion”*.

The Mental Models explanation (Johnson-Laird and Byrne, 1991) predicts two different responses to this syllogism. Reasoners initially build up the following mental model:

$$\begin{array}{c} [s] p c \\ [s] p c \\ \dots \end{array}$$

c=persons that contribute to scientific progress; p=persons that participate in experiments; s=students.

Reasoners can give the informative conclusion following this composite mental model as valid and then respond "*Some students are persons that contribute to scientific progress*". But if reasoners continue the deductive process of searching for conclusions that are contradictory with the informative conclusion but compatible with the premises, they draw the "there is not a valid conclusion" response. Mental models, as a theory aimed at explaining mistakes in syllogistic reasoning, proposes the first conclusion as more frequently given than the second conclusion.

According to the probability heuristic model explanation (Chater and Oaksford, 1999) the action of the *min*-heuristic causes the quantifier of the conclusion to be that of the end-term of the *min*-premise (the existential syllogism first premise). The subsequent action of the *attachment*-heuristic causes the subject of the conclusion to be students: if the *min*-heuristic has an end-term as its subject then use this as the subject of the conclusion. Otherwise, use the end-term of the *max*-premise as the subject of the conclusion. So this model predicts the conclusion "*some students are persons that contribute to scientific progress*" which is a probabilistically valid conclusion.

The atmosphere hypothesis explanation (Woodworth and Sells, 1935) and the matching hypothesis (Wheterick and Gilhooly, 1990) propose that reasoners choose an existential conclusion quantifier when they find one existential premise in the syllogism; so that these explanations predict an existential quantified conclusion such as "*some students are persons that contribute to scientific progress*".

On the other hand, the causal-agency reasoning explanation proposes that reasoners identify the first syllogism premise as the causal conditional premise and the second premise as the agency premise and then they draw an agent→goal conclusion. Reasoners draw a conclusion about which

quantifier is the quantifier of the agency premise such as "*all students are persons that contribute to scientific progress*".

As can be seen, the different content general explanations of syllogistic reasoning predict either the "*there is not a valid conclusion*" response or (and more frequently) the existential "*some students are people that contribute to scientific progress*" conclusion. In a different way, the (causal agency) content-specific explanation predicts the universal conclusion "*all students are persons that contribute to scientific progress*".

One relevant question in our research refers to the semantic of the syllogistic statements quantifier. Here the semantic of the existential quantifier "*some*" particularly in relation to the quantifier "*all*" is relevant. From a logical point of view, the interpretation of the existential quantified statement "*some A are B*" is "*at least one A is B, and possibly all A are B*". So this interpretation is compatible with the quantifier "*all*". However, the Gricean conversational principle that in normal circumstances people will be maximally informative (they will not withhold information) upholds that "*some*" is generally taken to denote an indeterminate proportion, but not an entire set. So if a person knows that *all A are B*, then he/she will say so (Newstead, 1995; Roberts, Newstead and Griggs, 2001). Moreover, some research has demonstrated that both quantifiers are related to different interpretations of statements (Glass and Holyoak, 1974; Holyoak and Glass, 1978).

On the other hand, various syllogistic models have given a basic role to the semantic of the premise quantifiers. According to mental models, the premise quantifier (either universal or existential) determines whether or not a certain term is exhaustively represented, which is decisive in the process of choosing the conclusion quantifier. From a different perspective, the probabilistic heuristic model considers the semantic of quantifiers in terms of their informativeness which is the basis of the actuation of the *min*-heuristic in the process of choosing the conclusion quantifier (Chater and Oaksford, 1999; Oaksford, Roberts and Chater, 2002). Likewise the source premise founding of conclusions explanation (Stenning and Yule, 1997) confers an important role to both

quantifiers. The quantifier "*all*" facilitates the interpretation of the premise as a conditional, while an existential premise is chosen as the source premise (see the sentential method for syllogistic reasoning described by these authors). Likewise, several rule-based models of syllogistic reasoning have proposed that universal "*all*" quantified premises are interpreted in a conditional way, but this does not occur with the existential quantifier "*some*" (Rips, 1994; Ford, 1995; Stenning and Yule, 1997).

The causal-agency explanation of the choice of a conclusion quantifier involves a different semantic of the quantifier "*some*". As we have seen, this quantifier when used in a behavioural conduct-and-goal premise enables its interpretation as a causal conditional conduct→goal. This quantifier is representative of the real world fact that the persons that carry out a certain conduct are "*some*" (not every person in the world carries out a certain conduct) but every person that carries out the conduct attains the goal associated with it. For example, it does not seem plausible that the action of participating in experiments causes some persons to contribute to scientific progress but not other persons. In this context we suggest that the quantifiers "*some*" and "*all*" are both compatible with a conditional interpretation of a behavioural conduct and goal premise.

The role of content in interpreting quantifiers has been emphasised by several researchers (Moxey and Sanford, 1993; Newstead and Coventry, 2000; Roberts, Newstead and Griggs, 2001). In this respect, Moxey and Sanford (1993) have suggested that quantifiers are mental operators that control the pattern of inferences in the linguistic situation in which they occur but do not map onto any precise numerical interpretation. Several contextual factors have been pointed out as influencing the interpretation of quantifiers and we would like to suggest that social world knowledge is also an important contextual factor when the content is about socially relevant actions. This world knowledge is the framework giving significance to quantifiers when the content is this type of social content.

The causal-agency bias is supposed to be different to the belief effects that constitute a main content effect demonstrated in syllogistic reasoning. The question is, which of the two, the

"content general" or the pragmatic agent \rightarrow goal conclusion, is facilitated by believability? With reference to the previous example, the pragmatic conclusion "*All students are persons that contribute to scientific progress*" seems empirically unbelievable. This would be the result of this conclusion having the universal quantifier when the conceptual relation between the end terms ("*students*" and "*persons that contribute to scientific progress*"), which would be the intersection, permits only the use of the existential quantifier (see Santamaría, García-Madruga and Carretero, 1996). In a different way, we found that the existential quantifier is the quantifier of the content general (and driven by the explicit form) conclusion: "*Some students are persons that contribute to scientific progress*". Therefore this would be the conclusion facilitated by believability.

There is another test of the capacity of the causal-agency content to influence the process of choosing the conclusion quantifier. This test consists of presenting the content in the reversed causal-agency direction so that the drawing of the pragmatic conclusion implies the removal of the figural effect (Johnson-Laird and Bara, 1984). This effect constitutes a strong structural conclusion bias and is related to the subjects' tendency to formulate the conclusion beginning with the end term which acts as a grammatical subject in one of the two premises. This is especially clear when we compare the conclusions given to syllogisms in figure 1 and figure 2. The former clearly biases the conclusion towards conclusions in the $A\rightarrow C$ direction, while the latter biases the conclusion towards the $C\rightarrow A$ direction.

Here, the syllogism displayed above is presented in the reversed causal-agency direction:

"Some persons that contribute to scientific progress are persons that participate in experiments"

"All persons that participate in experiments are students".

As can be seen, in the causal first premise the consequence (to contribute to scientific progress) is presented before the contingent conduct, and in the agency premise, the conduct appears before the agent. This is a syllogism with the form IA1 so that the (pragmatic) conclusion "*All students are persons that contribute to scientific progress*" is non-figural in addition to being an invalid conclusion. If the participants think based on the structure or the form of the syllogism

then they will give the existential and figural conclusion "*Some persons that contribute to scientific progress are students*". As we described earlier, the different explanations of the process of choosing the conclusion quantifier suggest that syllogisms with the form IA (in the example: "*Some bee-keepers are physicists*" / "*All physicists are chemists*") result in an existential $A \rightarrow C$ conclusion such as that previously shown. However, if the participants reason based on the causal-agency content then they will draw the universal agent \rightarrow consequence conclusion "*All students are persons that contribute to scientific progress*". We suggest that drawing the pragmatic agent \rightarrow goal conclusion requires the cognitive operation of returning the content to the standard direction. 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 is respected. In the agency premise the direction is from the agent to the causal condition and respects the pragmatic requirement that the subject of the proposition is the agent. Previously, we have found evidence that subjects carry out this operation (Gámez and Marrero, 2000).

EXPERIMENT

We have suggested that different structures are at work and different processes work on these depending on the type of material given to reason with syllogistically. Specifically, we propose that syllogisms where the two end-terms are a class of agents and a class of goals, while the middle term is a class of actions the agent could engage in order to reach the goal, cause agent \rightarrow goal conclusions. A main prediction of this proposal is that the conclusion quantifier is the quantifier of the agency premise, and we have carried out an experiment in order to test this. We compared four content conditions as a between-subject factor: the causal-agency content and three control content conditions, gradually moving the content of the syllogisms away from the pragmatic actor-behaviour-goal structure. Moreover, the experimental IA syllogisms could be presented either in figure 1 or figure 2 as a within-subjects factor. The main hypothesis is that there

will be a monotonic decline in the percentage of universal agent→goal conclusion as the content of syllogism moves away from the pragmatic actor-behaviour-goal structure.

Below, we describe the different experimental conditions with an example of the type of conclusion predicted when the drawing of the syllogistic conclusion is driven by the (explicit) form (as described by the different explanations of the process of choosing the conclusion quantifier here considered), and when this is a pragmatic-type conclusion:

Causal-agency content

"Some persons that defend their families are persons that show they are loyal"

"All students are persons that defend their families". (**figure 2**)

Form-driven conclusion: *"Some students are persons that show they are loyal"*

Pragmatic-type conclusion: *"All students are persons that show they are loyal"*.

"Some persons that show they are loyal are persons that defend their families"

"All persons that defend their families are students". (**figure 1**).

Form-driven conclusion: *"Some persons that show they are loyal are students"*.

Pragmatic-type conclusion: *"All students are persons that show they are loyal"*.

The first premise of the causal-agency syllogisms was the causal premise and contained an unspecified agent ("Some persons") carrying out a conduct and a term referring to an agency behavioural consequence. The interpretation of these terms as consequences was reinforced by means of the following verbal expressions: to promote, to encourage, to show (two items), to get, to make, to contribute and to help to improve. The second premise contained a reference to an agent and a conduct in which the agent could engage.

The pragmatic-type conclusion is figural in figure 2 but against the figural effect in figure 1. Moreover, in figure 1 the causal-agency syllogisms were presented in the reversed causal-agency

direction so we predict less pragmatic-type conclusions to this type of syllogisms in comparison with the figure 2 standard causal-agency syllogisms.

Control content 1: weakening causality and agency

"Some persons that defend their families are persons that show they are home-loving".

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

Form-driven conclusion: *"Some chemists are persons that show they are home-loving".*

Pragmatic-type conclusion: *"All chemist are persons that show they are home-loving".*

"Some persons that show they are home-loving are persons that defend their families"

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

Form-driven conclusion: *"Some persons that show they are home-loving are chemists".*

Pragmatic-type conclusion: *"All chemists are persons that show they are home-loving".*

As can be seen, the term referring to the consequence of showing loyalty was replaced in the control content 1 syllogisms by a term of less relevance as a goal (being home-loving) so that it would be more difficult to relate it to the conduct. Likewise, "students" was substituted by professional roles (e.g. chemists) more distant from the conducts and goals so that the relation agent→conduct in the second premise was weakened. As a result, the recognition of the causal-agency content is made more difficult to some extent and so the bias towards the pragmatic-type conclusion will be weakened.

Control Content 2: Supressing causality

"Some persons that defend their families are persons fond of gambling "

"All chemists are persons that defend their families". (Figure 2).

Form-driven conclusion: *"Some chemists are persons fond of gambling".*

Pragmatic-type conclusion: *"All chemists are persons fond of gambling".*

"Some persons fond of gambling are persons that defend their families"

"All persons that defend their families are chemists". (**Figure 1**).

Form-driven conclusion: *"Some persons fond of gambling are chemists"*.

Pragmatic-type conclusion: *"All chemists are persons fond of gambling"*.

As can be seen, in the first premise of this control syllogism the original goal (to be loyal) has been replaced by a term (to be fond of gambling) unrelated to the conduct of defending the family. Moreover, the verbal expression that acts as a goal indicator ("to show") was suppressed. As a result, a causal interpretation of the premise (and therefore of the syllogism) would be improbable. Thus, we predict that the bias towards the pragmatic-type conclusion will considerably be reduced.

Control content 3: Removing the behavioural content

"Some persons that are physicists are persons that are bee-keepers"

"All chemists are persons that are physicists" . (**figure 2**).

Form-driven conclusion: *"Some chemists are persons that are bee-keepers"*.

Pragmatic-type conclusion: *"All chemists are persons that are bee-keepers"*.

"Some persons that are bee-keepers are persons that are physicists"

"All persons that are physicists are chemists". (**figure 1**).

Form-driven conclusion : *"Some persons that are bee-keepers are chemists"*.

Pragmatic-type conclusion: *"All chemists are persons tha are bee-keepers"*.

As can be seen, in this control content the behavioural content was removed and replaced by the usual type of content used in syllogistic reasoning research. We predict that this type of content causes the suppression of the bias towards the pragmatic-type conclusion.

Method.

Subjects. 116 first-year Pedagogy students at the University of La Laguna participated in the experiment in exchange for course credit.

Design. The design had a within-subjects factor "Form of syllogisms" with two conditions: figure 1 and figure 2, and a between-subjects factor "Type of content" with four conditions: causal-agency, and control content 1, control content 2 and control content 3. The dependent variables were the frequencies of the pragmatic-type conclusion and the form-driven conclusion.

Material. Eight booklets were provided, two corresponding to the causal-agency content condition, and two to each of the three control content conditions. The experimental within-subjects condition "Form of syllogisms" was counterbalanced so that if a certain syllogism appeared in one of the booklets in figure 1 it then appeared in the other booklet in figure 2 (and vice versa) within the same between-subjects condition. On the first page of each booklet, 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 8 filler syllogisms (four syllogisms for each). Below each syllogism there were three lines for the participants to write the conclusion(s). The filler syllogisms had different figures and their moods were varied. The experimental syllogisms had the form IA1 (figure 1) and the form IA2 (figure 2). IA 1 syllogisms have an existential valid conclusion in the $A \rightarrow C$ direction, while IA2 syllogisms do not have a valid conclusion, according to Johnson-Laird & Byrne (1991).

Fourteen raters evaluated the degree of contingency between the conducts and the socially relevant positive consequences (henceforth, goals). We found that the percentage of positive responses (those responses where the conduct was evaluated as related to the goal to a medium or a high degree) was 74%.

Moreover, 48 raters evaluated the believability of universal and existential affirmative conclusions both in the $A \rightarrow C$ and $C \rightarrow A$ direction (12 raters evaluated the causal-agency syllogisms and 36 raters evaluated each of the three types of control content syllogisms-12 for

each). Specifically, they were asked to choose the real world true statement between the universal (unbelievable) and the existential (believable) affirmative versions of the syllogism conclusion in a given direction. In the case of the causal-agency syllogisms, we found that the existential conclusion version was chosen 93% of the time both in the $A \rightarrow C$ direction and $C \rightarrow A$ direction. That is, the existential conclusion (either in the $A \rightarrow C$ or $C \rightarrow A$ direction) was evaluated as believable in comparison to the pragmatic-type conclusion (universal affirmative $C \rightarrow A$ conclusion). In the case of the control content 1 syllogisms we found that the existential conclusion version was chosen 94% of the time in the $A \rightarrow C$ direction and 93% of the time in the $C \rightarrow A$ direction. Similar results were obtained in the case of control content 2 and 3. As can be seen, the universal affirmative $C \rightarrow A$ conclusion was also evaluated as unbelievable in the control syllogisms in comparison to the corresponding existential conclusion versions.

Procedure. The different booklets were randomly given out to the students during regular class time without a time limit being imposed. Twenty six subjects were given the causal-agency content condition, thirty subjects received the control content 1 condition, thirty six subjects received the control content 2 condition and twenty four subjects received the control content 3 condition. Within each between-subjects condition half of the subjects received one of the booklets and the other half the other booklet.

Results

In Table 1 the percentages of different type of conclusions given by the participants for causal and control content syllogisms in figure 1 and figure 2 are shown. The pragmatic-type conclusion is a $C \rightarrow A$ universal affirmative conclusion, while the form-driven conclusion is an existential conclusion and has the $C \rightarrow A$ direction in the case of figure 2 syllogisms and the $A \rightarrow C$ direction in the case of figure 1 syllogisms.

Ten subjects (three from the agency-content condition, one from the control content 1 condition, four from the control content 2 condition and two from the control content 3 condition) were excluded because they gave many of the conclusions in an unacceptable way. 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.

PLEASE INSERT TABLE 1 ABOUT HERE

We carried out two separate analyses of variance, one for each dependent measure, with a within-subject factor, "Figure of the syllogisms", and a between-subjects factor "Type of content".

In relation to the dependent measure of the frequency of the $C \rightarrow A$ universal affirmative conclusion (the pragmatic conclusion in the case of causal-agency syllogisms), we found that the effect of the figure was significant, $F(1,102)=43$, $p=0.000$. The percentage of $C \rightarrow A$ universal affirmative conclusion was higher in figure 2 (54%) than in figure 1 (28%). The effect of the content was also significant, $F(3,102)=9.02$, $p=0.000$. There was a progressive decrease in the percentage of $C \rightarrow A$ universal affirmative conclusions across the different content conditions (causal-agency content: 60%; control content 1: 52%; control content 2: 35% and control content 3: 15%). We carried out several t-tests in order to compare which of the mean differences were significant. The following mean differences were significant: causal-agency content-control content 2: dif(25%), $t(53)=2.67$, $p=0.010$; causal-agency content-control content 3: dif(44%), $t(43)=5.00$, $p=0.000$; control content 1-control content 2: dif(17%), $t(59)=1.97$, $p=0.05$; control content 1-control content 3: dif(36%), $t(49)=4.42$, $p=0.000$; control content 2-control content 3: dif(20%), $t(52)=2.33$, $p=0.024$. The only contrast that was not significant was causal-agency content-control content 1: dif(8%) $t(50)=0.89$, $p>0.10$.

Finally, the interaction figure*content was not significant, $F(3,102)=1.94$, $p>.10$.

The main effect of the content confirms our hypothesis: there has been a monotonic decline in the percentage of pragmatic-type conclusions as the content of syllogism away from actor-behaviour-goal structure. Only the contrast causal-agency content-control content 1 was not significant, but the means showed the expected pattern. The effect of the figure shows that figure 2 causes more universal $C \rightarrow A$ conclusions than figure 1. This effect would be due to this conclusion being facilitated by the figural effect as well as the fact that causal-agency syllogisms

in this figure have the standard causal-agency direction. This disposition could have facilitated a conditional and agency interpretation of behavioural syllogisms. As we can see in table 1, the universal affirmative $C \rightarrow A$ conclusions presented higher percentages in the three behavioural content conditions (causal-agency, control content 1, control content 2).

In relation to the dependent measure of the form-driven conclusion (existential affirmative conclusions in the $A \rightarrow C$ direction in figure 1 and in the $C \rightarrow A$ direction in figure 2), we found that the effect of the figure was significant, $F(1,102)=8.12$, $p=0.005$. The percentage of the form-driven conclusion was higher in figure 1 (50%) than in figure 2 (33%). The effect of the content was also significant, $F(3,102)=7.88$, $p=0.000$. There was a progressive increase in the percentage of form-driven conclusions across the different content conditions (causal-agency content: 27%; control content 1: 34%; control content 2: 44% and control content 3: 64%). We carried out several t-tests in order to compare which of the mean differences was significant. The following mean differences were significant: causal-agency content-control content 2: dif(17%), $t(53)=2.26$, $p=0.03$.; causal-agency content-control content 3: dif(37%), $t(43)=4.55$, $p=0.000$; control content 1-control content 3: dif(29%), $t(49)=3.88$, $p=0.000$; control content 2-control content 3: dif(20%), $t(52)=2.61$, $p=0.012$. There were two non-significant contrasts: causal-agency content-control content 1: dif(7%), $t(50)=1.05$, $p>0.10$. and control content 1-control content 2: dif(10%), $t(59)=1.33$, $p>0.10$.

As was expected, the effect of the content on the frequency of the form-driven conclusions showed the opposing pattern to that of the pragmatic-type conclusions: there has been a monotonic increase in the percentage of form-driven conclusions as the content of the syllogisms moves away from actor-behaviour-goal structure. The effect of the figure (more form-driven conclusions in figure 1 than in figure 2) is explicable in terms of the form-driven conclusion being figural when given to figure 1 syllogisms; in addition, the presentation of the terms in figure 1 syllogisms hindered a conditional-agency interpretation of the syllogisms with a behavioural content (causal-agency content, control content 1 and 2).

GENERAL DISCUSSION

The choice of conclusion quantifier is a central process in syllogistic reasoning. This process has been given different explanations, and we have considered the most representative of these in this paper: the atmosphere explanation, Woodworth and Sells, 1935, the matching explanations Wheterick and Gilhooly, 1990; the probability heuristic model explanation, Chater and Oaksford, 1999; the source premise founding of conclusions explanation, Stenning and Yule, 1997; and the mental model explanation, Johnson-Laird and Byrne, 1991. Although these explanations refer to different types of processes, they have in common that they are content general explanations; that is, explanations that do not take into account the role of the relevant processing specificities of the content that, in the case of reasoning, would affect both the representation of the problem and the type of inferences that operate on this representation.

On the other hand, the effect of the content in syllogistic reasoning has been investigated as an effect of believability (mainly related to the believability of syllogistic conclusions). Prior beliefs can affect the choice of the conclusion quantifier as a result of the reasoners' goal of drawing conclusions appropriate to what is true in the real world. However, the hypothesis that the content itself (out of prior reasoners' beliefs) could determine the conclusion to be drawn has not been considered in syllogistic reasoning research.

In a different way, this suggestion has been extensively examined in conditional reasoning research. Several investigations have supported that different structures are at work and different processes work on these depending on the type of material given to reason; for example, deontic or causal contents have been demonstrated to have a particular logic (Cheng and Holyoak, 1985; Cosmides, 1989; Mantkelow and Over, 1995). In this paper, we have suggested that syllogistic reasoning is also suitable to be driven by the content. Specifically, we have proposed that syllogisms with a causal-agency content (the two end-terms are a class of agents and a class of goals, while the middle term is a class of actions the agent could engage in order to reach the goal)

cause agent→goal conclusions, and we examined the effect of this causal-agency reasoning in the process of choosing the conclusion quantifier. The experiment that we carried out confirmed our hypothesis: the participants showed a bias towards the universal $C \rightarrow A$ (agent→goal) conclusion in syllogisms with a causal-agency content, and this bias declines progressively as the content moved away from the pragmatic agent-conduct-goal structure. At the same time, the decline of pragmatic-type conclusions was parallel to an increase of the (existential) form-driven conclusions, such as those predicted by the different content-general explanations of the process of choosing the conclusion quantifier.

In short, the process of drawing a universal $C \rightarrow A$ conclusion to causal-agency syllogisms can not be explained in terms of the the source premise founding of conclusions explanation (Stenning and Yule, 1997); or by the (informative) conclusion given from the composite mental models of the premises (either this is a valid conclusion- to figure 1- or an invalid conclusion-to figure 2-), or by the action of the *min* and *attachment* heuristics, or by the influence of the atmosphere of the premises. However, drawing this type of conclusion is appropriately explained if the participants made use of causal reasoning to solve the syllogisms. Moreover, this result is robust, as we used two different tests of the effect of the content by using two types of syllogisms: syllogisms where the pragmatic-type and the form-driven conclusion were both figural (syllogisms in figure 2) and syllogisms where the pragmatic-type conclusion was not figural, in addition to being universal instead of existentially quantified.

It could be argued that the effect of the content in drawing universal affirmative conclusions is not necessarily causal as much as conceptual. In the example "*some persons that defend their families show that they are loyal*", -defending one's family is an example of what loyalty means. It is rather difficult to construe this as anything other than universal: is it possible to defend one's family without thereby being loyal?. A universal interpretation of this premise is plausible on general knowledge grounds. As a consequence, the IA experimental syllogisms are possibly represented by the participants as AA syllogisms, which leads them to choose a universal

affirmative quantifier for the conclusion. We consider that this explanation really competes with the causal explanation in the case of the syllogisms in figure 2 (syllogisms that presented the terms in the first premise in the standard conduct-goal direction). However, the conceptual explanation has difficulties in explaining the preference towards the universal C-A conclusion in the figure 1 experimental syllogisms (in these syllogisms half of the responses were this type of conclusion). The terms in the first premise of figure 1 syllogisms were presented in the reversed goal-conduct direction, that is, as an *"inversed"* inclusion insofar as the second term is included in the first term (see Santamaría et al, 1996). Santamaría et al. (1996) argued that different conceptual relations are appropriately expressed by different syllogistic quantifiers. For example, the direct inclusion (that is, the conceptual relation between the conduct and the goal in the first premise in figure 2 syllogisms) is appropriately expressed by an "all" quantified premise. In a different way, the inversed inclusion (that is, the conceptual relation between the goal and the conduct in the first premise in figure 1 syllogisms) is conveniently expressed by an existential quantified premise, in our example, indicating that some members of the category of persons that show loyalty are members of the category of persons that defend their families.

In short, the conceptual relations of the terms in the first premise of the experimental syllogisms suggest a universal interpretation of this premise in the figure 2 syllogisms, but an existential interpretation in the figure 1 syllogisms. The predicted effects of these conceptual relations on the preferred conclusion quantifier would be the universal quantifier to figure 2 syllogisms (as they are represented as AA syllogisms), and the existential quantifier to figure 1 syllogisms (as syllogisms are represented as IA syllogisms). In contrast, the causal-agency explanation predicted that the preferred quantifier would be the universal affirmative in both types of syllogisms, as this is the quantifier of the agency premise and the results supported this prediction.

Cheng and Holyoak (1985) considered causal conditional deductive reasoning as a type of pragmatic reasoning, joined to reasoning about social permissions and obligations. More

specifically, Cheng and Nisbett (1993) have proposed that causal deductive reasoning is pragmatically aimed at the goals of informative prediction and explanation. These authors noted that neither causal deduction nor deontic deduction can be subsumed under rules of natural logic, and in the case of causal deduction it cannot be subsumed under rules of natural logic associated either with the connective *if* or with the condition relations of necessity and sufficiency. They argue that natural rules perform in human deduction, but specific domain rules have prior activation when the content is relevant to the deductive process (see also the principle of preemptive specificity, Fiddick, Cosmides and Tooby, 2000). Moreover and focusing on prediction, they claim that deductions based on a causal conditional will elicit assumptions about contingency which cannot be represented in propositional logic. Contingency is related to the difference between the probabilities of the effect, given the presence versus the absence of the cause. Contingency predicts that "A is a sufficient cause of B" implies not only "if A occurs then B always occurs" but also "if A does not occur then B is less likely to occur (p. 215). These authors also pointed out that temporal directionality (the cause happening before the effect) is also taken into account in causal reasoning.

Causal-agency syllogistic reasoning constitutes a type of causal deductive reasoning. It clearly demonstrates the goals of prediction and explanation that Cheng and Holyoak (1985) attributed to this type of reasoning insofar as these goals are particularly useful when they refer to agents. In this context, the demonstration of this type of reasoning would support the importance of domain-specific deduction in human reasoning.

Three different factors have been considered as powerful determinants of the process of drawing a syllogistic conclusion. The first is the effect of the figure, which could be due to certain restrictions of working memory (Johnson-Laird and Byrne, 1991) and affects the direction of the conclusion to be drawn. The second is the atmosphere of the premises, considered by some authors to be another important (heuristic) influence affecting in this case the choice of conclusion quantifier (see Wheterick and Gilhooly, 1990). A third effect is the effect of content believability

where prior beliefs can affect the conclusion to be drawn (both in its quantifier and its direction). In this context our results provide evidence of a different influence on syllogistic reasoning, a pragmatic effect of the content, which was seen to be stronger than atmosphere and believability effects.

The causal-agency effect in the process of choosing the conclusion quantifier is closely related to the semantic of quantifiers. As aforementioned, several studies have demonstrated that the quantifiers "*all*" and "*some*" induce different interpretations of syllogistic statements (Glass and Holyoak, 1974; Holyoak and Glass, 1978). Likewise, several authors have also claimed that universal syllogistic premises are interpreted in a conditional way, and that this does not occur in existential premises (Ford, 1995; Stenning and Yule, 1997). In contrast, we have suggested that conduct→goal premises are interpreted in a conditional way and that this interpretation is compatible with both the quantifier "*some*" and "*all*". Various studies have pointed out that the context plays an important role in the interpretation of linguistic quantifiers. In this respect, it has been shown that the quantity signified can be affected by the extent to which the event or object is liked, the range of available quantifiers, the size of the set described, the expected frequency, the size of the object, and functionality (see Newstead and Coventry, 2000). We suggest that social world knowledge also acts as a context when the content of syllogisms refers to social actions. In this case, this knowledge provides the scenario to comprehend the size of the set indicated by the quantifier.

It could be considered that the experimental content in our syllogisms is more deontic than causal and agency, which would change the nature of reasoning required to solve the syllogisms. In fact, the goals contained in the syllogism first premise can be seen as related to social obligations: contributing to scientific progress, being loyal to the family and so on. However, we consider that the content of the syllogisms did not allude to a deontic context. This type of context usually contains a reference to an authority endorsing a social contract, or a social permission, or a social obligation, and points to the existence of persons motivated to break the social rule put to

the question. Moreover, we find that social obligations can be framed as goals, relevant to social agents in order to attain the more general goal of being (and feeling) socially competent.

Causal-Agency and content believability constitute syllogistic influences of different nature. The believability bias in syllogistic reasoning is related to the psychological requisite of giving realistic conclusions (conclusions that are true in the real world). Causal-agency bias is related to the requisite of giving practical syllogistic conclusions which are based on certain agency suppositions. As the act of making agency suppositions is relatively free, causal agency reasoning could lead to unbelievable conclusions such as the conclusion "All chemists go to hell" to this syllogism:

"All people that behave badly are people that go to hell"

"All chemists are people that behave badly".

However, the fact that this conclusion is unbelievable does not imply that the reasoner does not try to give plausible conclusions to it. The plausibility of the agent→goal conclusions is not related to adapting the conclusion to the truth in the real world, but depends on the appropriate evaluation of a hypothetical agency action; if we accept the possibility that a certain agent carries out a certain conduct, then it plausibly follows that this agent is affected by the consequence. However, we suggest that in real contexts, causal-agency reasoning is usually performed on believable premises in order to attain relevant practical agency conclusions. Agency consequences have to be in correspondence with what is true in the real world in order to be really practical.

The strength of the causal-agency bias shown in our results implies that the subjects preferred to focus on the content more than on the explicit form of the syllogisms. This strength would be representative of a tendency to reason in a meaningful way. In this context, we should, therefore, re-formulate the Wheterick and Gilhooly (1990) explanation of atmosphere effects to: Reasoners first look at the logic implied by the content, and if the content is arbitrary (the logic of the situation is not immediately apparent) then he/she generates a response that has at least the appearance of rationality.

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Table 1

Percentages of different type of conclusions for causal and control content syllogisms
in figure 1 and figure 2

	Causal content	Control 1	Control 2	Control 3
Figure 1				
All C-A*	50%	34%	20%	9%
Some C-A	13%	9%	20%	18%
All A-C	7%	10%	6%	6%
Some A-C**	30%	48%	54%	67%
Figure 2				
All C-A	70%	70%	50%	22%
Some C-A	23%	21%	34%	60%
All A-C	--	5%	6%	2%
Some A-C	7%	4%	10%	16%
N	23	29	32	22

* pragmatic-type conclusion

**form-driven driven conclusion