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ATMOSPHERE EFFECTS REVISITED:
THE EFFECT OF ATMOSPHERE ON JUDGMENTS OF VALIDITY
USING THEMATIC SYLLOGISMS

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Psychology

by

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May 1998

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DEDICATION

To my family and friends who, through encouragement and cajolery, were largely responsible for my completing this project. Thanks especially to my husband Jim. Without his inspiration, assistance, and patience, I would never have finished. Thanks to my children Vicki, Tracy, Jacki, and my dad Tom. And Mom, this is especially dedicated to you.
ACKNOWLEDGMENTS

I would like to thank Bob Mathews, Ed Henderson, Brian Bornstein, and Tim Buckley for the contributions they made to this project. Thanks also go to my colleagues, who assisted me in finding hundreds of volunteers to participate in this study. Most of all I want to thank my mentor, Husain Sarkar, and my touchstone of reason, John Baker, who kept me moderately sane. They and my other dear friends, Harriet Taylor, Ken Zacaki, Norma Paynter, and Elaine Mason, gave comfort and encouragement through a year of personal hardship and tragedy.
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ABSTRACT

Syllogisms having conclusions consistent with atmosphere are shown to be accepted at significantly higher rates than those having conclusions inconsistent with atmosphere. Furthermore, there is strong evidence that the dual influences of quality and quantity, independently affect acceptance rates.

The first experiment also indicates a main effect of gender on acceptance rates to certain invalid syllogisms (those with conclusions inconsistent with quality, or quantity, or both). The second experiment replicates the atmosphere effect found in the first experiment and extends it to valid syllogisms and indeterminate invalids consistent with both quality and quantity. It also proposes an alternative to the misinterpreted necessity explanation for the logic by belief interaction. Both explanations are tested, and results indicate both are incomplete or incorrect. Evidence of a three way interaction of logic, belief, and consistency with atmosphere is reported.

The third experiment tests the effect of instructions on response patterns. Instructions stressing correct logical procedures for judging validity fail to significantly improve performance or affect mean belief bias for either valid or invalid syllogisms. This
experiment also indicates a main effect of gender on belief bias.

The theoretical justification for an influence of consistency with atmosphere is proposed, as well as a model of syllogistic reasoning, which acknowledges the simultaneous influences of logic, believability, and consistency with atmosphere.
CHAPTER 1
INTRODUCTION

The study of deductive reasoning has engaged psychologists for decades. Some believe that the greatest insight into cognitive processing is provided by identifying the conditions under which erroneous reasoning is likely to occur; others believe more is learned by investigating the conditions that elicit pragmatically or logically "correct" inferences. But, to successfully formulate an accurate theory of deduction, both approaches are required.

A variety of logical tasks have been used in the laboratory to assess human reasoning abilities. This dissertation is concerned with investigating deductive reasoning on syllogisms, which are deductive arguments consisting of two premises and one conclusion. While on the surface, all syllogisms appear to be rather elementary arguments, certain ones are surprisingly difficult. From a logical perspective, the inferences that may be correctly drawn from any two premises are specific and should be independent of semantics. In reality, a large number of errors are associated with this task. Much of the research on syllogistic reasoning has been directed at identifying the various factors that influence participants' performance, and the conditions under which these factors are most likely to operate.

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Among researchers who study syllogistic reasoning, there is considerable agreement that performance is affected by both logical principles and by non-logical influences. (See Evans, 1989; Evans, Over, & Manktelow, 1993; Politzer, 1990.) These non-logical influences include certain features of the particular syllogisms used, linguistic factors, attentional factors, and experience or world knowledge. (For a review of the effect of these pragmatic influences on deductive reasoning see Girotto and Politzer, 1990.) On the other hand, there is considerable disagreement concerning the degree to which specific non-logical influences are attributable to methodological artifacts.

There appear to be two major perspectives driving current research. One assumes that participants are primarily good deductive reasoners (Erickson, 1974; Henle, 1962; Johnson-Laird & Bara, 1984; Wetherick, 1993). They first attempt to solve the syllogism using rules, Euler circles, mental models, or some other representation. If the conclusion they are presented with (in a judgment task) does not contradict the one generated by their particular reasoning method, they accept it. The non-logical influence of belief is secondary; it affects which rules are applied, how the Euler circles are combined, or whether alternate mental models are constructed. The non-logical influence of atmosphere, discussed in detail below, is minimized or ignored, because it has been characterized as
lacking theoretical underpinnings. Its effects are believed to be an artifact of methodology. Atmosphere refers to an overall "mood" created by the two premises of a syllogism, which is related to their combined attributes of quality and quantity. This mood affects which conclusions participants are likely to accept. It is discussed in detail in Chapters 2 and 3.

The second major perspective denies the priority of reasoning. It assumes that most participants, rather than reasoning immediately, are first influenced by the believability of the conclusion. They reason only when that conclusion is false or unbelievable (Evans, Barston, & Pollard, 1983; Evans, 1989). Those few participants who do reason prior to being influenced by belief, do not fully understand the notion of necessity. They reject conclusions that are falsified by the premises and reason about all others. If the conclusion is not contradicted by the premises, (i.e. it may be true, as opposed to must be true), participants tend to accept it when it is believable, and reject it when it is not (Evans, Barston, & Pollard, 1983). It is possible that the non-logical influence of atmosphere may be a disturbance variable that also affects responses (Evans, Newstead, & Byrne, 1993). It can be controlled for by selecting particular syllogisms for study.

The experiments reported in this dissertation are grounded in a third perspective. It is similar to the
second, except that the non-logical influence of atmosphere is believed to operate in conjunction with believability, and perhaps with reasoning as well. Its effect is not believed to be a methodological artifact. Subjects are not characterized as failing to fully understand the notion of necessity; they are simply failing to override a generally successful default bias or heuristic that favors conclusions consistent with atmosphere.

Regardless of perspective, current research on syllogistic reasoning has focused, almost exclusively, on the dual influences of validity (often called "logic") and believability, and their interaction. The influence of atmosphere, while sometimes acknowledged, has essentially been ignored. In fact, no studies since the mid-1970s, have manipulated this factor as an independent variable.

This dissertation presents the results of three experiments designed to demonstrate that syllogisms having conclusions consistent with the atmosphere of the premises are accepted at significantly higher rates than those having conclusions inconsistent with this attribute. The experiments also investigated whether the frequently described logic by belief interaction could more accurately be characterized as a logic by belief by atmosphere interaction. Lastly, they examined whether the influence of atmosphere could be mitigated by an instruction manipulation.
Typically, the total number of syllogistic forms used in reasoning studies with thematic problems is quite small (participants are given 2-8 problems), which brings into question the generalizability of results. The three experiments in this dissertation involve participants solving a minimum of 32 problems each.

With the exception of a recent study by Marilyn Ford (1994), few reasoning studies have examined gender differences in syllogistic reasoning, which the experiments in this dissertation will analyze. Ford indirectly addressed this issue using the method of protocol analysis. She identified two groups of participants: one which used spatial representations resembling Euler circles; and one which used verbal representations. Any reader taking note of the participants' first names, could reasonable infer that it is predominantly the male participants (e.g. Steve, Richard) who reasoned spatially and predominately the females (e.g. Lisa, Beth) who reasoned linguistically. While Ford's study used only valid syllogisms, the experiments in this dissertation will directly examine gender differences in performance using both valid and invalid syllogisms.

This paper is structured in the following way:

Chapter 2 provides a description of the task to be used in these experiments, including the formal definition of a syllogism and the logical attributes associated with it.
Chapter 3 includes an historical overview of the relevant literature, and a discussion of the major factors identified as influencing participants' responses to both abstract and thematic syllogisms. It is argued that the effects of atmosphere have been minimized or masked in recent studies, because of the method by which the syllogisms (to be studied) are constructed and categorized.

Chapter 4 presents the materials, methods, results and discussion for Experiments 1, and 2.

Chapter 5 presents the materials, methods, results and discussion for Experiment 3.

Chapter 6 summarizes overall results and general conclusions and provides recommendations for further research.
Logical Definition of Syllogism

A syllogism is a three statement argument consisting of two premises and a conclusion. A categorical syllogism is a special type of syllogism, where all three statements are standard form categorical propositions, which are statements that relate two classes or categories. All categorical syllogisms must contain a total of exactly three terms, where each term must be used exactly twice in distinct statements and only once in each statement.

A standard form categorical proposition relates the participant term to the predicate term by asserting that either all or part of the subject class is included in or is excluded from the predicate class. There are four types of standard form categorical propositions: All S are P - designated an "A"; No S are P - designated an "E", Some S are P - designated an "I", and Some S are not P - designated an "O".

Logical Attributes of Syllogisms

Quality and Quantity

Quality and quantity are two attributes of categorical propositions. Quality (affirmative or negative) refers to whether the proposition is asserting that members of subject class are included in or excluded from the predicate class. The A and I statements are affirmative; E
and O are negative. Quantity (universal or particular) refers to whether the proposition is asserting that all or some of the members of the subject class are included in the predicate class. A and E statements are universal; O and I are particular. Thus, each type of statement (A, E, I, and O) asserts a specific relationship holding between the subject and predicate classes: inclusion or exclusion of all or part of the former in, or from, the latter.

**Standard Form**

A syllogism is said to be in standard form when all three premises are standard form categorical propositions, when there is no equivocation of terms, and when the major premise is listed first, the minor premise second, and the conclusion last. The major premise is the one containing the major term (the predicate of the conclusion); the minor premise contains the minor term (the subject of the conclusion). Two examples of standard form syllogisms are:

a) All dogs are mammals. b) All D are M

Some dogs are snakes. Some D are S

No snakes are mammals No S are M

The first example, a), is referred to as a thematic syllogism; the second, b), is referred to as abstract.

**Mood**

After a syllogism has been put into standard form, the mood refers to the type of statements that make up the syllogism. The examples above have an A proposition as a major premise, an I proposition as a minor premise, and an
E as a conclusion. Therefore, the mood of both arguments is AIE. Given that there are four kinds of categorical propositions and three categorical propositions in a syllogism, there are \((4^3)\) sixty-four possible combinations of propositions, or moods.

**Figure**

The figure of a syllogism is determined by the placement of the middle term (the term shared by both premises). It is an attribute of a categorical syllogism which has been put into standard form. A figure 1 has the middle term as the subject of the first premise and the predicate of the second premise. In a figure 2 standard form categorical syllogism, the middle terms are the predicates of each premise; in a figure 3, the middle terms are the subjects of each premise; and in a figure 4, the middle term is the predicate of the first premise and subject of the second premise.

To simplify the above information, one can represent the 4 figures in the following way (ignoring the quantifiers and copulas):

<table>
<thead>
<tr>
<th>Figure 1</th>
<th>Figure 2</th>
<th>Figure 3</th>
<th>Figure 4</th>
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<tr>
<td>M-P</td>
<td>P-M</td>
<td>M-P</td>
<td>P-M</td>
</tr>
<tr>
<td>S-M</td>
<td>S-M</td>
<td>M-S</td>
<td>M-S</td>
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</table>

M stands for middle term; S stands for the subject term of the conclusion; P stands for the predicate term of the conclusion. The example syllogisms, a) and b) shown above, are both figure 3 syllogisms.
Number of Syllogisms

With four possible figures for each of the 64 moods, there are two hundred and fifty six distinct categorical syllogisms (4*64).

Logical Validity

Syllogisms can be classified into two categories based on a logical attribute defined in formal deductive systems. They can be either valid or invalid. A valid syllogism is an argument where if the premises are assumed true, it is impossible for the conclusion to be false. That is, the conclusion necessarily follows from the premises. An invalid deductive syllogism is one where if the premises are assumed true, it is possible for the conclusion to be false. That is, the conclusion does not necessarily follow from the premises. The AIE-3 example syllogisms above are both invalid. Of the 256 possible categorical syllogisms, 24 are valid and 232 are invalid.

Valid syllogisms can be further classified into two subcategories; unconditionally valid and conditionally valid. Unconditionally valid syllogisms are valid regardless of whether the terms in the premises or conclusion denote things that actually exist, like dogs or trees. Conditionally valid syllogisms are those which are valid only if certain terms (subject, predicate, or middle) denote actually existing things, rather than unicorns or goblins. If the relevant term does not fulfill this
condition, the syllogism is invalid. The 24 valid forms consist of 15 that are unconditionally valid, and 9 that are conditionally valid. All the valid syllogisms are shown in Table 1. It should be noted that the conditionally valid syllogism forms investigated in Experiments 1-3 all used terms denoting existing things, so they could never be invalid.

Table 1. List of Valid Syllogisms (Designated by Mood) for Each Figure

<table>
<thead>
<tr>
<th>Unconditionally valid</th>
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<td>EAE</td>
<td>EAE</td>
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<td>AII</td>
<td>AOO</td>
</tr>
<tr>
<td>EIO</td>
<td>EIO</td>
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</table>

*"If" refers to a requirement that the term shown must denote an actually existing thing, for the form to be valid. For example, an EAO-4 figure will be valid if M, the middle term, denotes a dog or cat; it will be invalid if it denotes a goblin or unicorn."
Factors Affecting Responses: From Research Using Abstract Syllogisms

Prior to the 1980s, most researchers used syllogisms comprised of statements having abstract content (e.g. All S are P). The emphasis has since shifted to using contextual syllogisms. The following factors were found to affect participants' responses to abstract syllogisms: (Refer to Chapter 2 for an explanation of underlined terms.)

1. Subjects may be influenced by a conclusion's consistency with atmosphere, which is related to the quality and quantity of the premises. According to the psychological literature, these attributes (quality and quantity) collectively produce an "atmosphere" that induces a participant to either accept or reject a certain conclusion consistent with it. For example, when participants are presented with a syllogism where both premises are "A" statements (e.g. All x are y), most will accept a conclusion of type "A", regardless of validity, and reject other conclusions. This "atmosphere effect" has been found in almost every experiment past and present and will be discussed in detail later in this document. (See Begg & Denny, 1969; Dickstein, 1978a; Johnson-Laird & Bara, 1984; Revlis, 1975; Sells, unpublished; Wilkins, 1928; Woodworth & Sells, 1935.)
2. Participants may be influenced by the **figure** of the syllogism. There is some evidence that difficulty in judging the validity of syllogisms increases from figures 1 to 4. Figure has also been found to affect the conclusion that participants will generate, by influencing the position of the subject and predicate terms. (See Dickstein, 1978a; Johnson-Laird & Bara, 1984; Johnson-Laird & Steedman, 1978; Pezzoli & Frase, 1968.)

3. Subjects may be **misinterpreting** the premises in a way which results in their switching the subject and predicate terms. That is, participants might (mis)understand "All A are B" to mean "All B are A". This "illicit conversion" results in participants solving a different syllogism that the one they were given. (See Begg & Denny, 1969; Ceraso & Provitera, 1971; Chapman & Chapman, 1939; Dickstein, 1975, 1978a & b; Revlis, 1975.)

4. Participants may be influenced by the actual logical status of the syllogism (**logical validity**). Subjects perform better when solving valid syllogisms as compared to solving invalid ones, the implication being that at least some participants are reasoning logically. (If perfect reasoning were universal, all valid conclusions would be accepted and all invalid ones would be rejected.) In the past, reasoning participants were thought to be applying formal rules, or drawing Euler circles. Recently, these means of representation have been rejected; participants
are now believed to be constructing mental models, as described by Johnson-Laird. (See Erickson, 1974; Johnson-Laird & Bara, 1984; Johnson-Laird & Byrne, 1991; Johnson-Laird & Steedman, 1978.)

5. Participants may be influenced by the number of mental models (single or multiple) that must be constructed to represent and integrate the information provided by the premises. This factor, comes directly out of Johnson-Laird's mental model theory, so it can influence only those participants who are, in fact, reasoning as the theory describes. In other words, this factor is associated with a particular explanation of the influence of logical validity (factor 4). (For a detailed discussion of model theory, see Johnson-Laird & Bara, 1984 and Johnson-Laird & Byrne, 1991). Proponents of model theory claim that the greater the number of different models that have to be constructed to draw a valid inference, the more difficult the syllogistic task will be.

Factors Affecting Responses: From Research Using Thematic Syllogisms

From the mid 1980s on, syllogistic reasoning studies began to focus predominantly on thematic, rather than abstract, syllogisms (comprised of statements e.g. "All dogs are mammals"). This added a new dimension; each of the possible 256 syllogistic forms could have a conclusion that was either in accordance with or contrary to a participant's belief. The term "belief" refers either to
one's attitude about an empirical statement or one's assessment of the truth (or falsity) of a statement of definition. An example of an empirical statement is "Some physicians collect stamps"; and an example of a definitional statement is "All dogs are mammals".

6. Perceived truth value, then, is the sixth factor found to influence participants' responses. More specifically, participants may be influenced by the believability of the conclusion. They are more likely to accept a conclusion (as a valid inference) when it is in accordance with their beliefs and reject it (as invalid) when the conclusion is discordant with their beliefs, regardless of the logical validity of such an inference. This tendency is termed the belief bias effect. Empirical findings (Evans et al., 1983; Evans & Pollard, 1990; Janis & Frick, 1943; Oakhill & Johnson-Laird, 1985; Oakhill et al., 1989; Wilkins, 1928) indicate a belief bias effect is evident both when participants generate a conclusion and when they evaluate one.

There is also robust evidence of an interaction between the influence of believability and logical validity. People seem to be more influenced by the truth value of the conclusion when they are reasoning about invalid syllogisms as opposed to valid ones. (Evans et al., 1983; Markovits & Bouffard-Bouchard, 1992; Newstead & Evans, 1993; Newstead, Pollard, Evans, & Allen, 1992; Oakhill & Garnham, 1993; Oakhill, Johnson-Laird, &
Garnham, 1989). Evans et al. (1993) have described this interaction from a slightly different perspective; the effects of validity appear to be stronger on syllogisms having unbelievable conclusions.

Recent research focuses primarily on the influences of validity and believability (factors 4 and 6). As a result, three of the remaining four factors known to affect responses have been relegated to a minor role (factors 1, 2 and 3). The effects of the latter two, conversion and figure, are routinely controlled by limiting the tasks used in a study (i.e. by selecting particular subsets of valid or invalid syllogisms). Factor 5, as already mentioned, moderates the influence of logic (factor 4) within mental model theory, and has been the focus of study for years. The influence of atmosphere (factor 1), however, has been unacknowledged or underestimated. It is the primary focus of this paper.

The experiments reported in this dissertation manipulated this factor as an independent variable, and provide evidence that it affects acceptance rates and belief bias for a large number of thematic syllogisms, both valid and invalid.

The focus on believability (factor 6) has resulted in researchers incorporating the belief bias effect into older processing models, or developing new models to explain it. There are currently four explanations for its source: illicit conversion; mental model representation; selective scrutiny; and misinterpreted necessity.
Illicit Conversion and Belief Bias

Prior to the early-1980s, the believability of the premises was thought to affect the way participants interpreted the premises and, therefore, the subsequent inferences they would draw. The belief bias effect was thought to arise as a result of this tendency to illicitly convert premises. (Revlin & Leirer, 1978; Revlin, Leirer, Yopp & Yopp, 1980). (See also Evans et al., 1983; Evans & Pollard, 1990; Oakhill & Johnson-Laird, 1985; Oakhill et al., 1989; Wilkins, 1928.) The body evidence from these experiments, however, shows there are belief bias effects even when conversion is blocked or when it makes no difference.

Mental Model Theory and Belief Bias

More recently, believability has been thought to affect the inferential reasoning process (Johnson-Laird & Byrne, 1991; Oakhill & Garnham, 1993; Oakhill, Garnham, & Johnson-Laird, 1990; Oakhill & Johnson-Laird, 1985; Oakhill, Johnson-Laird, & Garnham, 1989). This explanation has its underpinnings in mental model theory, which assumes that participants represent or model both premises of a syllogism using tokens for the subject and predicate terms. They then construct and integrate these models and draw a conclusion. There follows a search for an alternate model which will falsify the drawn conclusion, yet remain consistent with the premises. The theory's main prediction
is that the greater the number of alternative models that must be constructed to arrive at a valid conclusion, the more difficult the task.

Under this interpretation, believability is thought to affect alternative model construction. If the first model constructed results in a conclusion which is both consistent with the premises and believable, the participant will tend to accept it and refrain from further processing. This theory makes two predictions. First, with single model syllogisms, there should be no belief bias effect as there are no alternative falsifying models. Second, with multi-model problems there should not only be an effect of belief, there should be more errors where the conclusion is believable or neutral. Results of studies testing these predictions are inconsistent. (See Oakhill & Johnson-Laird, 1985; Oakhill et al., 1989; and Newstead et al., 1993.)

Selective Scrutiny and Belief Bias

Finally, believability has been thought to affect whether or not a participant will even engage in reasoning. Belief bias is understood simply as a response effect. That is, many participants are failing to reason at all; their responses are solely a function of the believability of the conclusion. (Evans, 1982; Evans, Barston, & Pollard, 1983; Evans & Pollard, 1990). Based on protocols, Evans et al. (1983) claimed that participants accept believable conclusions for both valid and invalid
syllogisms, and only attempt to reason if the conclusion is unbelievably. This explanation is referred to as the selective scrutiny model. It is acknowledged that other factors besides belief are present in solving syllogisms, since many participants do indicate they are reasoning.

When faced with an unbelievably conclusion, after logical analysis, participants will correctly accept more valid conclusions than invalid ones. Thus, while this model can explain the robust logic by belief interaction, it fails to explain why believable valid conclusions are more apt to be accepted than believable invalid conclusions. In other words, the account does not explain the effects of logic on believable conclusions.

Besides the protocol evidence, the model was supported by the finding by Evans & Pollard (1990) that increasing the complexity of multiple premise "syllogism-like" problems, did not increase the size of the belief bias effect. This is consistent with the model's prediction that believability exerts its influence prior to reasoning.

Misinterpreted Necessity and Belief Bias

Evans also explains the logic by belief interaction in terms of another response effect. It is based on the claim that participants fail to fully understand the notion of necessity. When a conclusion simply may be true when the premises are true (rather than must be true) the logically correct response is to state that nothing follows; the syllogism is invalid. Instead, participants
are likely to respond on the basis of their real world knowledge; they tend to accept a conclusion that is believable, rather than necessarily following from the premises. On the other hand, when a conclusion cannot possibly be true when the premises are true, it is clear that the syllogism is invalid, so there should be no effect of believability. As this likelihood of accepting conclusions which might be true occurs only for invalid syllogisms, this model can provide an alternate explanation for the logic by belief interaction.

The Influence of Atmosphere: Quantity and Quality of Premises

Syllogisms can be classified into two categories based on how closely their conclusions match the one that participants would select if they were influenced by the atmosphere or "global impression" created by the premises. A conclusion is either consistent or inconsistent with that influence. The idea is that premises of a certain kind, either with regard to quality (affirmative or negative), or with regard to quantity (universal or particular), create a certain atmosphere, which then induces the participant to accept a conclusion having a similar atmosphere.

The original hypothesis, stated below (excluding parentheses), was proposed by Woodworth & Sells in 1935 and restated by Begg & Denny (1969), as an explanation for the systematic errors that participants made on invalid, abstract syllogisms:
a) (Regarding quality:) whenever there is a negative premise, there is a negative atmosphere. Otherwise, the atmosphere favors an affirmative conclusion.

b) (Regarding quantity:) whenever there is a particular premise, i.e. containing the quantifier "some", there is a particular atmosphere. Otherwise, the atmosphere favors universal conclusions.

Evidence For the Effect:

Two of the earliest studies documenting this effect were discussed in a paper by Woodworth & Sells (1935). Wilkins (1928) gave participants 8 "invalid" premise pairs and 3 conclusions (one of which was usually valid) for each pair. Subjects judged the validity or invalidity of each conclusion. For every premise pair, the percentage of acceptance of the conclusion indicated by atmosphere was always higher than the percentage not indicated. Sells (unpublished) replicated Wilkins' findings; he gave participants 300 premise pairs, and they judged whether a single conclusion was valid or invalid. Since responses selected by atmosphere are correlated with the traditional logical rules for determining validity or invalidity, reasoning in accordance with the effect should result in valid conclusions being accepted more readily than invalid ones (i.e. valid conclusions should be "easier" than invalids.) Sells found direct evidence supporting this: there were 16% errors for the 71 examples of valid syllogisms versus 40% errors for the 229 invalid ones.
Most every study since has provided some evidence of this effect. For example, Begg & Denny (1969), using invalid premise pairs, found a pattern of errors consistent with the predictions of the atmosphere hypothesis. Dickstein (1978a) reported that 49% of participants' responses were consistent with those predicted by an atmosphere effect, where chance was 20%. Johnson-Laird & Bara's (1984) data, based on participants generating conclusions to 64 premise pairs, showed 43% responses consistent with atmosphere.

Evidence Against the Effect:

Some researchers claim that empirical evidence indicates the atmosphere effect may be weak. For example, Dickstein (1978a & b) found that participants frequently respond there is no valid conclusion, even though there is always some conclusion corresponding to the atmosphere of any two premises. Johnson-Laird & Steedman (1978), using a generation task, found a majority of participants responded there was no valid conclusion to a premise pair even though it did have a valid conclusion consistent with atmosphere predictions. (If atmosphere strongly determined participants responses, they would rarely respond "no valid conclusion".) Wason & Johnson-Laird (1972) reported the findings of a pilot study by Johnson-Laird which used only premise pairs that could lead to a valid conclusion in certain figures. There were more erroneous responses
incompatible with atmosphere, than there were compatible with atmosphere (3.9% vs. 1.8%). They did not report whether this difference was significant. It is also interesting to note that while there were more correct responses compatible with atmosphere, good performance was attributed to good reasoning rather than to the influence of this non-logical bias.

This same paper found that any tendency to be influenced by atmosphere varied with particular syllogisms. AII and AEO problems tended to elicit errors consistent with atmosphere, while IEO and A00 problems did not. (The syllogisms with O conclusions resulted in the most errors, overall.) Wason & Johnson-Laird (1972), while not acknowledging any influence of atmosphere, did concede that even if there were one, it could, at best, provide only a partial explanation of results. When participants are given the premises "All B are A" and "All C are B", atmosphere predicts an A conclusion, but does not predict a preference for either "All C are A" or "All A are C". They referred to Sell's (unpublished) results, which found that the former, which is the logically valid conclusion, was accepted by 94% of participants, while the latter was accepted by only 45%.

Summary

While it is clear that atmosphere is not the sole determinate of participants' responses, there is extensive evidence that its effects are present in most every study.
using abstract syllogisms, even those which failed to take them into account. Still, they are often dismissed by researchers as being an artifact of methodology, either of problem type or instructions.

This dissertation rests on the belief that there is ample evidence of atmosphere effects, which should not be discounted. Three experiments will investigate atmosphere effects in a judgment task using thematic syllogisms. These experiments will test the hypothesis that responses to thematic syllogisms are affected by the quality and quantity of the premises, as well as by the believability of the conclusion and its logical status (valid or invalid).

New Notation

Early experimenters who did investigate atmosphere effects identified whether or not participants' responses were consistent or inconsistent with the cumulative influence of quality and quantity. However, in order to fully understand the experiments and appreciate the problems arising from recently popularized nomenclature, it is necessary to use an additional notation designating whether responses are consistent or inconsistent with the individual influence of quality and quantity.

Syllogisms having a conclusion in accordance with both a) and b) of the original atmosphere "hypothesis" are classified as CBoth, consistent with both quality and quantity. This includes both valid and invalid problems.
Syllogisms having a conclusion that is in accordance with quality but not quantity, are denoted Cql. These include both valid and invalid forms.

Syllogisms having a conclusion that is in accordance with quantity but not quality are denoted Cqn. These include only invalid forms.

Finally, syllogisms not in accordance with either quality or quantity are classified as CNone. These include only invalid forms.

To summarize, there are four types of consistency classifications: CBoth; Cql; Cqn; and CNone. All valids are either CBoth or Cql syllogisms. Invalid syllogisms, have also been subdivided into 2 categories, indeterminate and determinately false (discussed below). Indeterminate invalids may have a conclusion which is CBoth, Cql, Cqn, or CNone; determinately false invalids may have a conclusion which is Cqn or CNone. It is unclear whether participants presented with different sub-categories of invalid problems will respond in the same way. This has not yet been determined experimentally. If syllogisms of varying consistency types differentially affect participants' conclusion acceptance rates, then results of studies using only one type of indeterminate or determinately false syllogism may not be generalizable.

Study by Newstead, Pollard, Evans, and Allen (1992)
Results reported in a recent study by Newstead et. al (1992) suggest that methodological considerations may
result in atmosphere effects being reduced. Newstead et al. ran 5 experiments to test the predictions of three models concerning the effect of belief and the logic by belief interaction: mental models, selective scrutiny, and misinterpreted necessity.

Before discussing their findings, it is necessary to discuss their nomenclature (also in Oakhill et al., 1989), which classifies syllogisms into 2 categories: "determinate", which designates valid and certain invalid syllogisms, and "indeterminate", which designates all other invalid syllogisms. "Determinately true" refers to valid syllogisms; "determinately false", refers to invalid syllogisms that have a conclusion that must be false (it is falsified by the premises). Logically, this occurs only when the conclusion is a statement which is contradictory to the valid conclusion that would follow from the given premises. Since there are 24 valid syllogisms, there are 24 determinately false syllogisms; 9 are type 3 (Cqn); 15 are type 4 (CNone). The remaining invalids are indeterminate.

Based on their terminology, all valid syllogisms are determinate, while invalid syllogisms are either determinately false or indeterminate. This dissertation will argue that an explanation of belief effects and the logic by belief interaction in these terms may be incomplete.
Summary of Findings: Experiments 1-5

The combined results of the 5 experiments appeared to be contrary to the selective scrutiny explanation of belief bias (which assumes the bias operates prior to reasoning). They provided some evidence in favor of, and some evidence contrary to, both the misinterpreted necessity account of belief bias and (a modified version of) the mental model explanation. More relevant to this dissertation, however, is the fact that the logic by belief interaction was found to disappear when participants were given determinately false invalid syllogisms and (single model) valid syllogisms. It reappeared when participants were given indeterminate invalid syllogisms and (multiple model) valid syllogisms. It is important, however, to point out that only 9 different syllogistic forms were used across the 5 experiments. These are shown on Table 2.

Relationship of Determinancy to Consistency with Atmosphere

A strong argument can be made that categorizing invalids as determinately false and indeterminate is problematic, as these two categories are not mutually exclusive with regard to the attribute of consistency with atmosphere. It is possible that the Newstead et al. findings were the result of differences in consistency, rather than determinancy.

In their series of 5 experiments, the conclusion acceptance rates of multiple model valid syllogisms were
always compared to those of indeterminate invalid syllogisms, and a logic by belief interaction was found. These particular invalid problems were formed by keeping the same premises as the valid syllogism, while switching the terms of the valid conclusion. As a result, the invalids were always consistent with quality and quantity and indeterminate, i.e. CBoth-IND.

Table 2. Syllogisms Used by Newstead et al. (1992)

<table>
<thead>
<tr>
<th>CBoth-V</th>
<th>CBoth-IND-I</th>
<th>Cql-V</th>
<th>Cqn-DF-I</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAE-1 SM</td>
<td>IEO-1</td>
<td>AAE-1</td>
<td></td>
</tr>
<tr>
<td>AAA-1 SM</td>
<td>AAA-4</td>
<td>EAA-1</td>
<td></td>
</tr>
<tr>
<td>EIO-1 MM</td>
<td>IEO-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EIO-2 MM</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Syllogisms are identified in this table by mood and figure, according to logical convention. The letters following the syllogism's figure refer to the number of mental models required to draw a valid conclusion, according to mental model theory. SM=single model syllogism; MM=multiple model syllogism. Syllogisms are listed in 4 categories: CBoth-V=valid conclusion is consistent with quality and quantity; CBoth-IND-I=indeterminate invalid conclusion is consistent with quality and quantity; Cql-V=valid conclusion is consistent with quality, but inconsistent with quantity; Cqn-DF-I=determinately false invalid conclusion is inconsistent with quality, but consistent with quantity. All forms had both true and false versions.

Only three distinct forms of indeterminates were investigated, IEO-1, IEO-2, and AAA-4. All multiple model valids were consistent with atmosphere (CBoth). [Responses to multiple model valids were not compared to determinately false invalids, in this study.]

When single model valids (also CBoth) were compared to determinately false invalids, the logic by belief
interaction disappeared. Again, all the invalid problems had the same premises as the valid forms, but had the contrary conclusion. For example, if the valid syllogism (AAA-1) had the conclusion "All sparrows are birds", the invalid version (AAE-1) had the conclusion "No sparrows are birds". Thus, invalids were always inconsistent with atmosphere quality, Cqn. Only two distinct forms of determinately false syllogisms were used in these five experiments, AAE-1 and EAA-1.

When single model valids were compared to indeterminate invalids, the invalids were formed by switching the terms of the valid conclusion, so again were all CBoth.

Therefore, these experiments involved only CBoth valid problems, both single and multiple model, CBoth indeterminate invalid problems, and determinately false invalid problems that were inconsistent with quality, but consistent with quantity. The logic by belief interaction was present when responses to indeterminate invalid problems were compared to valids, and it disappeared when determinately false invalids were compared to valids. (The methods used to generate the particular invalid forms in each experiment were probably the result of efforts to control for the effects of atmosphere and/or conversion.)

The problem is, from the prospective of logic, determinately false invalid problems do not have to be Cqn;
they can also be CNone. Likewise, indeterminate invalid problems do not have to be consistent, CBoth; they can be inconsistent with quantity, Cq1, inconsistent with quality, Cqn, or inconsistent with both, CNone. So, before results based on the categorization of syllogisms as indeterminate and determinately false can be generalized, it must be demonstrated that all indeterminate invalid syllogisms result in a logic by belief interaction and elicit similar conclusion acceptance rates. Likewise, it must be shown that CNone determinately false syllogisms elicit the same response patterns as Cqn. To summarize, it is hypothesized that it was the attribute of consistency, not determinancy, that influenced participants' responses in this Newstead et al study.

It is possible to sub-categorize valid syllogisms according to 4 features: mood and figure; determinancy; consistency; or the number of mental models required. Invalids can be sub-categorized by mood and figure, determinancy or consistency. Figure 1 shows the relationship between sub-categories of valid and invalid syllogisms categorized by these different features.

Although syllogisms described as determinately false invalids might elicit the same responses as syllogisms described as having conclusions inconsistent with atmosphere effects; and although certain indeterminate invalids might elicit the same responses as those characterized as having conclusions consistent with
atmosphere, it is important to emphasize that this is more than a mere verbal dispute. It is an epistemological dispute of some consequence. Subjects can only detect and be influenced by "determinancy" as a result of applying logical principles; the influence of atmosphere is conjectured to be an a-logical bias or heuristic.
### CATEGORIZATION OF VALID AND INVALID SYLLOGISMS

According to Logic
Valid & Invalid Categorized By Mood and Figure

Valid Sub-categorized as Unconditional or Conditional

<table>
<thead>
<tr>
<th>According to Determinancy</th>
<th>Valid</th>
<th>Indeterminate</th>
<th>Determinately False</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determinate(ly True)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple Model</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### According to Consistency with Atmosphere
(Used In This Dissertation)

<table>
<thead>
<tr>
<th>Valid</th>
<th>Indeterminate</th>
<th>Determinately False</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBoth</td>
<td>CNone</td>
<td>CNone</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Invalid</th>
<th>Indeterminate</th>
<th>Determinately False</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBoth</td>
<td>Cq₁</td>
<td>Cq₁</td>
</tr>
</tbody>
</table>

---

**Figure 1.** The relationship between sub-categories of valid and invalid syllogisms categorized by different features.
The first two experiments were designed to investigate the factors that influence participants' willingness to accept the conclusions to thematic syllogisms. The major hypothesis tested was whether a conclusion's consistency with atmosphere was predictive of participants' responses, in addition to its believability and/or logical validity. Experiments 1 & 2 tested this hypothesis by examining response rates to true and false versions of consistent (valid and invalid) and inconsistent (valid and invalid) syllogisms.

Experiment 1 used only invalid syllogisms inconsistent with quality, quantity, or both. It did not include CBoth invalids. It investigated whether atmosphere effects were evident for these IND and DF syllogisms, and whether certain forms elicited significantly different acceptance rates and/or belief bias. The main reason for looking at these particular invalid forms was to determine, which syllogisms, besides CBoth invalids, were to be included in the second experiment: IND Cql, IND Cqn, IND CNone, DF Cqn or DF CNone.

Experiment 2 extended the investigation of the influence of atmosphere to include CBoth and Cql valid, and CBoth IND invalid syllogisms. It also re-examined the frequently reported interaction between logic and belief.
As previously noted, Newstead et al. (1992) found that the interaction was present when IND invalids were compared to valids and disappeared only when DF invalids were used. This dissertation claims the results are problematic insofar as the experiments confounded consistency with atmosphere and determinancy. To reiterate, their 5 experiments used only CBoth indeterminate (IND) invalid problems and only Cqn determinately false (DF) invalid problems. Their explanation of the logic by belief interaction in terms of determinancy would require revision, if consistency with atmosphere affected this interaction.

Experiment 2 tested an alternative hypothesis to that of Newstead et al. (1992), that the logic by belief interaction occurs when invalid syllogisms have conclusions consistent with atmosphere, i.e. with CBoth IND forms; it disappears when the invalids have conclusions inconsistent with atmosphere, i.e. with other invalid forms. Results of Experiment 1 determined which particular types of inconsistent invalid forms were included in this second experiment. In addition to the main hypotheses, Experiments 1 and 2 examined the effect of gender on both acceptance rates and belief bias.

Findings from these two experiments were expected to be more generalizable than those of most others, as many more syllogisms were used and their particular forms were not constrained by other considerations. Because the
influence of atmosphere was treated as an independent variable, there were no limitations on which valid or invalid forms could be investigated. In other words, it was possible to determine conclusion acceptance rates for invalid forms that were unrelated to the valid forms to which they were compared.

**Notation**

Experiment 1 (and Experiments 2 & 3) used the notation presented in Chapter 3, which designated four ways in which a conclusion could accord with atmosphere predictions. To reiterate, the four consistency classifications were based on whether it was quality and/or quantity of the conclusion that was in accordance with the combined atmosphere of the premises. Both syllogisms were consistent with both quality and quantity; Cql were consistent with quality only; Cqn were consistent with quantity only; and CNone were consistent with neither.

In addition, valid syllogisms were denoted as "V" and invalids denoted as "I", with invalids also tagged either as "DF" or "IND" to indicate the differentiation recently drawn between determinately false and indeterminate invalid forms. Syllogisms having a true conclusion were denoted "T", and those having a false conclusion, "F". So, a syllogism designated as IND Cql-T referred to an indeterminate (invalid) problem, having a conclusion consistent with atmosphere's predictions regarding quality (but not quantity), which was true.
Experiment 1

Before Experiment 2 investigated the relationship of consistency, belief, and logic to participants' responses to valid and invalid syllogisms, Experiment 1 examined response rates to all invalid forms that were not CBoth; they were consistent with either quality, quantity, or neither. In particular, it was to determine two things: first, whether the categorization of invalid syllogisms by the feature of determinancy is warranted; and second, whether sub-categorizing these problems by consistency type is warranted (i.e. whether Cq1, Cqn and CNone problems elicit similar conclusion acceptance rates and/or belief bias effects). The result of these determinations dictated which invalid problems (besides CBoth IND) were included in Experiment 2.

With regard to the first determination: if acceptance rates and belief bias to DF vs. IND problems of the same type (e.g. Cqn or CNone) did not significantly differ, this indicated that determinancy was not the critical factor which predicted responses to invalid syllogisms; it was more likely consistency type. If, on the other hand, either acceptance rates or belief bias to these problems did significantly differ, this indicated the legitimacy of categorizing on the basis of determinancy. And, while this finding would not directly bear on the main hypothesis, that response patterns for syllogisms consistent with
atmosphere (both quantity and quality) differ significantly from those for syllogisms inconsistent with atmosphere (either quantity, quality, or both), it could complicate the issue. Experiment 2 would have to investigate both DF and IND syllogisms with inconsistent conclusions.

With regard to the second determination: if acceptance rates and belief bias among Cq1, Cq2 and CNone IND and between Cq2 and CNone DF invalids did not significantly differ, there was no need to sub-categorize on the basis of consistency type: the inconsistent (non-CBoth) invalid problems used in Experiment 2 could be of any type. On the other hand, if they did significantly differ, this could indicate atmosphere's influence had two component parts, consistency with quality and consistency with quality, which might differentially affect responses. Again, this result meant Experiment 2 had to investigate multiple types of inconsistent invalid problems.

Since these experiments were breaking new ground, it was unclear whether to expect significant differences in acceptance rates or belief bias among Cq1, Cq2 and CNone IND problems or between Cq2 and CNone DF problems. That said, it would not have been surprising if Cq1 IND problems were unique, as they were the only inconsistent type which had conclusions consistent with atmosphere predictions of quality (i.e. they were inconsistent only with regard to quantity).
Subjects. Seventy undergraduates from Louisiana State University, voluntarily participated in this experiment. All were enrolled in introductory level philosophy courses, and all were over 18 years of age. The population of these classes represented a wide range of college majors, and ethnic and racial backgrounds. There were approximately equal numbers of males and females, 32 and 38 respectively. None had any previous instruction in logic.

Prior to the experiment, participants were given a consent form, which they read and were required to sign. This explained the purpose of the study and procedure, as well as their rights as volunteers (including the right to confidentiality and right to withdraw).

Materials and Procedure. Thirty-eight syllogisms were used in this experiment, 8 valid syllogisms and 30 invalid. The valids were all Cq1; 2 forms were of figure 2 (EAO & AEO) and 2 were of figure 3 (AAI & EAO). Each form had a true and false version. These valid syllogisms were used as fillers, and were not included in the statistical analysis.

There were 5 inconsistent invalid problem types: IND Cq1; IND Cq2; IND CNone; DF Cq2; and DF CNone. Every problem type consisted of 3 syllogistic forms, one each of figures 2, 3, and 4. All forms had both true and false versions, which was a reference to the truth value of the conclusion. It was decided that content would be true or false by definition, so common classifications of the animal kingdom were used. Examples of true conclusions used in the experiment are "Some mammals are not dogs", "No
poodles are insects", and "All robins are birds". Examples
of false conclusions are "All mammals are insects", "Some
dogs are cats", and "No dogs are animals".

All syllogisms, regardless of the truth value of the
conclusion, had one true premise and one false one. This
was done because determinately false (DF) syllogisms, by
definition, cannot have a true conclusion when both
premises are true. It was decided to similarly constrain
both true and false versions of DF and IND problems, as
this would also balance belief effects arising in the
premises.

It was necessary to limit the total number of
syllogisms used in the experiment, so participants would be
more likely to complete the task. As a result, figure 1
forms, normally considered easier, were not included.

Within a given consistency type, the DF and IND forms
selected were similar with regard to the categorical
statements of which they were comprised (A, E, I, or O).
This was done so differences in DF versus IND response
rates could not reasonably be attributed to the use of
particular statements. Table 3 shows the syllogistic forms
used in Experiment 1.

Participants were given a booklet including a page of
instructions and the 38 problems in random order. Each
problem was presented on a single page, and participants
were verbally instructed to work the problems in order
without reviewing previous answers. They were given the
following instructions, which are similar to those used by Evans et al. (1983) and Newstead et al. (1992): "On each of the following pages, you will find a reasoning problem, consisting of two statements and a conclusion shown below the statements. Your task is to indicate if the conclusion necessarily follows from the two statements, assuming that these statements are, in fact, true. If you judge that the conclusion can logically be deduced from the statements, you should answer "yes", otherwise "no". Please circle the appropriate word (yes or no) given below the problem. Please take your time and be sure that you have the right answer before doing so." Participants were allowed as much time as they needed to finish all problems: everyone finished within 40 minutes.

Table 3. Experiment 1: Invalid Syllogisms Used

<table>
<thead>
<tr>
<th>Indeterminate</th>
<th>Determinately False</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cql</td>
<td>Cqn</td>
</tr>
<tr>
<td>AAI-2</td>
<td>AAE-2</td>
</tr>
<tr>
<td>AEO-3</td>
<td>AEA-3</td>
</tr>
<tr>
<td>IOE-4</td>
<td>EEA-4</td>
</tr>
</tbody>
</table>

Note. There was a true and false version of each form.

Results and Discussion Three participants did not complete every problem and were excluded from the analysis, leaving 31 male and 36 female participants.

Prior to the analysis, a correlation matrix was run to ensure that participants' responses were indeed correlated,
thus confirming the appropriateness of running a repeated measures analysis. A correlation was found and confirmed by the subsequent SAS analysis, which tests the assumption of equal variances and correlations in t-tests or ANOVA using the Greenhouse-Geisser-Epsilon and Huynh-Feldt-Epsilon statistics. As both were non-significant, the analysis proceeded as a repeated measures ANOVA. Table 4 shows the mean percentage of conclusions accepted for each problem type, both by gender and pooled over gender.

Table 4. Experiment 1: Mean Percentage Conclusions Accepted

<table>
<thead>
<tr>
<th>Problem Type</th>
<th>Truth Value</th>
<th>Female (n=36)</th>
<th>Male (n=31)</th>
<th>Female+Male (n=67)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IND</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cq1</td>
<td>True</td>
<td>57</td>
<td>54</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>False</td>
<td>54</td>
<td>32</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>56</td>
<td>43</td>
<td>50_A</td>
</tr>
<tr>
<td>Cqn</td>
<td>True</td>
<td>17</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>False</td>
<td>8</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>13</td>
<td>8</td>
<td>11_C</td>
</tr>
<tr>
<td>CNone</td>
<td>True</td>
<td>20</td>
<td>24</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>False</td>
<td>15</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>18</td>
<td>17</td>
<td>17_B</td>
</tr>
<tr>
<td>DF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cqn</td>
<td>True</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
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<td></td>
<td>False</td>
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<td>1</td>
<td>2</td>
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<tr>
<td></td>
<td>Total</td>
<td>3</td>
<td>2</td>
<td>2_D</td>
</tr>
<tr>
<td>CNone</td>
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<td>7</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>False</td>
<td>7</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>7</td>
<td>3</td>
<td>5_D</td>
</tr>
</tbody>
</table>

Note. The row labeled "Total" refers to acceptance rates for each invalid problem type, pooled over truth value. Means with different subscripts differ significantly at p<.005 in multiple t-tests using the Bonferroni correction.
Performance was first assessed using mean percentage conclusion acceptance rates as the measure. Only responses to the invalid syllogisms were of interest. Data were analyzed by a three factor mixed design ANOVA, with repeated measures on two factors. The within factors were problem type (five levels) and truth value or believability (two levels), and the between factor was gender (two levels). These data were also analyzed using logistic regression, a form of statistical modeling through odds ratios, appropriate for categorical outcome variables. The two methods of analysis yielded comparable results. ANOVA may not be ideal for use on categorical variables, but, as it is acceptable for making global analyses based on proportions, it was the statistical method of choice for subsequent analyses.

This experiment was primarily concerned with determining whether acceptance rates and/or belief bias differed among the different types of invalid problems, so responses were pooled over gender and analyzed. The analysis did reveal a significant main effect of problem type on acceptance rates, \( F(4,260)=122.52, p<.0001 \), shown in Figure 2. To test whether the distinction between IND and DF syllogisms was appropriate, post-hoc multiple t-tests using the Bonferroni correction were run. As this is a conservative correction for maintaining the experimentalwise level of significance at .05, a stepwise correction to the comparisonwise error rate was also used.
Figure 2. Experiment 1. Mean percentage acceptance rates for invalid syllogisms, collapsed over gender and truth value. n=67.
The mean acceptance rate of IND syllogisms was significantly higher than that of DF syllogisms, $t(66)=16.58, p<.001$, by both methods of correction.

In addition, the means of Cqn IND vs. Cqn DF and CNone IND vs. CNone DF syllogisms were compared. There was a significant difference in the acceptance rates of Cqn syllogisms; 11% vs. 2%, $t(66)=5.03, p<.001$, as well as in acceptance rates of CNone; 17% vs. 5%, $t(66)=6.76, p<.001$. The percentage of DF conclusions accepted ranged from 2-7%, while as many as 55% of IND conclusions were accepted. So, categorizing by the feature of determinancy did appear to be meaningful, with regard to acceptance rates. Further evidence of this came from comparing the IND problem type having the lowest mean acceptance rate (Cqn, 11%) to the DF problem type having the highest rate (CNone, 5%). Again, they were significantly different, $t(66)=3.47, p<.001$.

These differences in acceptance rates, between IND and DF syllogisms of the same consistency type, suggested that participants were being influenced by logic. Most participants were correctly rejecting conclusions to DF forms, yet continued to incorrectly accept conclusions to IND forms. Apparently, they were able to distinguish between conclusions that had no possibility of following from premises, from conclusions that might have some possibility of following. In other words, it did not appear that participants failed to understand the notion of
necessity. Some just failed to utilize it when responding to IND problems. The possibility that a conclusion might follow from the premises was sufficient to induce some participants to refrain from rejecting it.

When the 3 types of IND syllogisms were compared, results indicated that Cql acceptance rates (50%) were significantly higher than both Cqn (11%), \( t(66)=11.53, p<.001 \), and CNone (17%), \( t(66)=9.95, p<.001 \). CNone IND acceptance rates were significantly higher than Cqn, \( t(66)=-3.06, p<.005 \). Although it is unclear why more CNone IND problems were accepted than Cqn, what is clear is that the dual components of atmosphere, quality and quantity, independently affected acceptance rates to IND syllogisms. As a result, all 3 types of inconsistent IND syllogisms were to be included in Experiment 2.

The acceptance rates of the Cqn and CNone DF syllogisms did not significantly differ (2% vs. 5%, respectively). Therefore, it was not necessary to include both types of DF syllogisms in Experiment 2.

Results also showed a significant main effect of truth value \( F(1,65)=23.31, p<.0001 \). Acceptance rates of syllogisms having true conclusions were significantly higher than those having false conclusions. There was also an interaction of truth value with problem type, \( F(4,260)=3.78, p<.01 \), as well as a 3-way interaction of truth value, problem type, and gender, \( F(4,260)=2.84, p<.05 \). Both interactions will be discussed below.
Data analysis revealed a significant main effect of gender, $F(1,65)=4.51$, $p<.05$, with females accepting significantly more conclusions than males, 19% vs. 14% respectively. This was not really expected, as no studies in the literature have reported gender differences in solving invalid syllogisms. However, this finding was consistent with Ford's study (1994), which used only abstract valid syllogisms. She identified two modes of reasoning that appeared to be associated with gender. The group consisting of mostly females used a verbal representation, while the group including mostly males used a spatial one. Ford found that these different strategies resulted in a different pattern of correct responses. While an interaction of gender with problem type was not detected in this experiment, gender did enter into a 3-way interaction with problem type and truth value.

To clarify this and the interaction between problem type and truth value, the data were re-analyzed using belief bias as the dependent variable, where belief bias refers to the difference in mean acceptance rates between the true and false versions of a given problem type. An interaction of truth value with problem type can be detected by noting that lines connecting cell means of true vs. false problems are not parallel. Therefore, examining where there are significant differences in belief bias among problem types and between genders clarified the
nature of these interactions. Figure 3 and Table 5 show the mean percent belief bias for each problem type by gender. Table 5 also shows belief bias pooled over gender.

**Table 5.** Experiment 1: Mean Percentage Belief Bias by Gender, and Pooled Over Gender

<table>
<thead>
<tr>
<th>Problem Type</th>
<th>Female (n=36)</th>
<th>Male (n=31)</th>
<th>Female+Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>IND Cql</td>
<td>3.6</td>
<td>21.5</td>
<td>11.8</td>
</tr>
<tr>
<td>IND Cqn</td>
<td>8.3</td>
<td>4.3</td>
<td>6.5&lt;sup&gt;AB&lt;/sup&gt;</td>
</tr>
<tr>
<td>IND CNone</td>
<td>5.6</td>
<td>14.0</td>
<td>9.5&lt;sup&gt;AB&lt;/sup&gt;</td>
</tr>
<tr>
<td>DF Cqn</td>
<td>2.7</td>
<td>1.1</td>
<td>2.0&lt;sup&gt;AB&lt;/sup&gt;</td>
</tr>
<tr>
<td>DF CNone</td>
<td>0.9</td>
<td>-2.2</td>
<td>-0.4&lt;sup&gt;B&lt;/sup&gt;</td>
</tr>
<tr>
<td>ALL</td>
<td>4.3</td>
<td>7.7</td>
<td>5.9</td>
</tr>
</tbody>
</table>

Note. Means with different subscripts differ significantly at p<.005 in multiple t-tests using the Bonferroni correction.

The three way interaction between problem type, truth value and gender, $F(4,260)=2.84, p<.05$, was a result of there being a significant difference in average belief bias for IND vs. DF syllogisms for males, $t(30)=5.68, p<.001$, but not for females. This resulted from gender differences in belief bias when responding to Cql IND problems (see Tables 5 & 6). While both males and females accepted a majority of the conclusions to the true versions of these Cql IND problems, (54% vs. 57% respectively), they differed in their acceptance of false versions (32% vs. 54%). Only males had belief bias significantly different than zero for these problems (21.5%), ($t(30)=3.93, p<.001$), while females were unaffected by belief (3.6%). Outside of these
Figure 3. Experiment 1. Mean percentage belief bias for invalid syllogisms by gender. n=67.
problems, belief bias for males and females did not differ significantly, i.e. both genders were similarly affected by the believability of the conclusion.

The interaction between problem type and truth value (collapsed over gender) was analyzed using multiple t-tests with the Bonferroni correction and with a stepwise correction. These analyses indicated that the average belief bias elicited by IND syllogisms was significantly higher than that elicited by DF syllogisms, *t*(66)=4.12, *p*<.001. This was attributed to the fact that IND Cql problems elicited significantly more belief bias compared to DF CNone syllogism, *t*(66)=3.21, *p*<.05. Aside from this comparison, no other invalid problem types differed significantly with regard to belief bias. Belief bias for Cqn IND vs. Cqn DF and CNone IND vs. CNone DF syllogisms did not significantly differ, and there were no significant differences in belief bias among Cql, Cqn, and CNone IND syllogisms or between Cqn and CNone DF syllogisms.

It is tempting to conclude that the genders may be differentially affected by non-logical biases when faced with Cql IND syllogisms. If this were true, then a gender difference would also be evident when participants solved CBoth IND syllogisms. It remained to be seen whether Experiment 2, which included Cql IND and CBoth IND problems, would replicate this finding. Again, a claim of gender related biases would be consistent with Ford's (1994) finding of two different modes of generating conclusions to abstract valid syllogisms.
One more result is worthy of mention. There appeared to be two "odd" syllogisms among the 30 used in Experiment 1. All of the syllogisms within a given problem type elicited similar acceptance rates and belief bias, with two exceptions. One Cql IND problem, IOE-4, and one CNone DF problem, IAE-4, elicited negative belief bias. It is unclear what made these particular problems unique. It could have something to do either with their having an E statement as a conclusion, or their both being figure 4 syllogisms with an E conclusion. If these problems had been omitted from the analysis, the Cql IND problems would have elicited 20.7% belief bias vs. the 11% reported, which would have been significantly higher than any other IND invalid form. This would have more strongly suggested that problems consistent with quality are fundamentally different from other IND problems. Mean belief bias for the CNone DF problems would have been 2.5%, which would not have significantly differed from the -.4% reported.

An interesting picture emerged from these overall findings, keeping in mind that all of these syllogisms would be rejected, if participants actually reasoned in accordance with logic. One non-logical attribute of a syllogism (that of having a conclusion inconsistent with quality and/or quantity) appeared to differentially affect a participant's willingness to accept a conclusion. Yet, when participants solved these IND or DF problems, the influence of a second non-logical attribute, the
believability of the conclusion, was relatively uniform (with the exception of Cql IND problems, which may act more like CBoth-IND problems). In other words, regardless of the rate at which they were willing to accept a conclusion to an inconsistent invalid problem (Cqn or CNone, IND or DF), the effect of truth value appeared to be relatively constant, as shown in Table 5. This supported the hypothesis, tested in Experiment 2, that consistency with atmosphere, rather than determinancy, determines the presence or absence of the interaction between logic and belief.

Experiment 2

This experiment was designed to accomplish a number of goals. First and foremost, it was to determine whether a syllogism's consistency with atmosphere, independent of its logical validity and believability, affects the rate of acceptance of its conclusion. Experiment 1 found evidence of this influence of atmosphere, using inconsistent (non-CBoth) IND and DF invalid syllogisms. This experiment was to replicate this finding and determine if it extended to valid and CBoth IND invalid problems. Second, it was to confirm that atmosphere's dual influences, quality and quantity, independently affect acceptance rates. Third, it was to replicate the finding of a main effect of gender, as well as its 3 way interaction with truth value and problem type.
This experiment also tested the hypothesis that the logic by belief interaction occurs when valids are compared to invalids consistent with atmosphere, CBoth IND problems, and disappears when Cq1, Cqn, and CNone IND and DF forms are used. Recall that this hypothesis was the result of noting that determinancy was confounded with consistency in the Newstead et al. study (1992). The 5 experiments in that study used only IND CBoth and DF Cqn invalid problems. Given their method of constructing invalid problems, it was impossible to include IND or DF problems of any other type. Nevertheless, they concluded that the presence or absence of the logic by belief interaction is a function of a syllogisms determinancy. It is present with IND forms and absent with DF forms. Experiment 2 determined if their findings could be generalized to IND Cq1, Cqn, and CNone and/or DF CNone syllogisms, or if it was consistency with atmosphere, which was predictive of the interaction.

Results of Experiment 1 indicated that Cq1 IND problems elicited significantly higher acceptance rates and belief bias than other inconsistent (non-CBoth) IND problems. Experiment 2 determined whether these Cq1 problems elicited response patterns similar to CBoth IND syllogisms. A finding of significantly higher acceptance rates for CBoth vs. Cq1 would confirm the independent influence of quantity, whereas no significant difference would indicate that consistency with quality alone accounts for the higher acceptance rates.
In addition, a finding of no significant difference in belief bias for CBoth vs. Cql IND problems, would indicate that the hypothesis predicting the logic by belief interaction needed slight modification. It should state that valids compared to CBoth or Cql IND problems will result in an interaction, while valids compared to CNone or Cqn problems, IND or DF, will not. In other words, Experiment 2 not only tested the hypothesis that consistency, rather than determinancy, was predictive of the logic by belief interaction, it clarified whether this meant consistency with both quality and quantity, or consistency with quality alone.

Finally, Experiment 2 tested one particular prediction of mental model theory. The valid CBoth problems in this experiment included 2 multiple model and 2 single model syllogisms. The valid Cql forms also included 2 multiple model syllogisms and 2 single model forms (AAI), which were reclassified as multiple model according to Ford (1994). Model theory predicts no belief bias for the single models.

**Subjects** Ninety three undergraduates from Louisiana State University, voluntarily participated in this experiment. All were enrolled in either an introductory philosophy course or introductory course in speech communication. The population of these classes represented a range of majors, and ethnic and racial backgrounds. There were 51 females and 42 males. All were over 18 years of age and had no previous instruction in logic.
As was done for Experiment 1, before beginning the experiment, participants were advised of their rights as volunteers, and were required to read and sign an informed consent agreement.

**Materials and Procedure**  Forty different tasks were used in this experiment, 16 valid syllogisms and 24 invalid. Whereas Experiment 1 omitted figure 1 syllogisms, this study included all 4 figures. There were 4 valid forms of CBoth, one of each figure, and 4 valid forms of Cql, one of each figure. Each form had a true and false version. Ideally, this experiment would have included 4 types of IND and 2 types of DF syllogisms. However, to ensure that participants maintained their concentration and solved all the problems, it was necessary to minimize the number used.

As a result, there had to be a compromise between fulfilling the main goals of Experiment 2 and limiting the number of syllogisms. As already mentioned, one goal was to extend the investigation of the influence of atmosphere to include problems representing every figure, of both consistent (CBoth) and inconsistent (non-CBoth) valid and invalid syllogisms. This required the inclusion of 4 figures of (true and false) CBoth valid problems, 4 figures of (true and false) Cql valid problems, 4 figures of (true and false) CBoth IND problems and at least 4 figures of (true and false) inconsistent invalids. Experiment 1 indicated that Cql IND problems should be included in this
experiment, as they elicited significantly higher acceptance rates than either Cqn or CNone invalids. So, without counting the Cqn or CNone IND or DF problems to be included, the required syllogisms already numbered 32.

The other goal of Experiment 2 was to test the two hypotheses for the logic by belief interaction. This required including Cqn and/or CNone DF and IND forms. In Experiment 1, neither the acceptance rates nor belief bias of Cqn DF vs. CNone DF problems differed significantly. However, Cqn IND vs. CNone IND acceptance rates did differ significantly from each other and from the DF forms. Belief bias did not. The decision was made, therefore, to include 4 Cqn DF forms (which elicited greater belief bias than CNone DF), and 4 CNone IND forms (which elicited greater belief bias than Cqn IND), thus limiting the total number of syllogisms to 40. Selecting those particular IND and DF types maximized the likelihood that this experiment's hypothesis, (predicting a logic by belief interaction for Cql problems), would be falsified. Table 6 summarizes the syllogistic forms used in Experiment 2.

As in Experiment 1, this experiment used content that was true or false by definition. Each of the 4 syllogisms within a given problem type (one of each figure) used a set of terms referring to different classes of animals (e.g. reptiles, fish, birds, mammals), with the order balanced across categories. Also, as in Experiment 1, both the true
and false versions of each syllogism had one true premise and one false one.

To illustrate, two arguments are shown below:

1. Valid CBoth
   True
   All animals are salmon
   Some animals are fish
   Some fish are salmon

2. Invalid (IND) CNone
   False
   Some mammals are rabbits
   All lions are rabbits
   No lions are mammals

The first is an CBoth valid problem with a true conclusion (AII-3); the second is a CNone IND (invalid) problem with a false conclusion (IAE-2).

Table 6. Experiment 2: Valid and Invalid Syllogisms Used

<table>
<thead>
<tr>
<th>Valid</th>
<th>Indeterminate</th>
<th>DF</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBoth</td>
<td>Cq1</td>
<td>CBoth</td>
</tr>
<tr>
<td>EIO-1</td>
<td>AAI-1</td>
<td>IAI-1</td>
</tr>
<tr>
<td>AOO-2</td>
<td>AEO-2</td>
<td>OOO-2</td>
</tr>
<tr>
<td>AII-3</td>
<td>AAI-3</td>
<td>EAE-3</td>
</tr>
<tr>
<td>AEE-4</td>
<td>EAO-4</td>
<td>IEO-4</td>
</tr>
</tbody>
</table>

Note. There was a true and false version of each form.

Participants received the 40 problems in random order, with each problem on a single page. They were given the same instructions used in Experiment 1, and were verbally instructed to complete all problems in order, without reviewing previous answers. As in the first experiment, participants were given as much time as necessary to complete all the syllogisms. Everyone finished within 45 minutes.
**Results and Discussion** Performance was first assessed using mean percentage conclusion acceptance rate as the measure. Data were analyzed by a three factor mixed design ANOVA, with repeated measures on problem type (six levels) and truth value or believability (2 levels). The between factor was gender. The assumption of equal variances and correlations was confirmed by the SAS analysis (the Greenhouse-Geisser-Epsilon and Huynh-Feldt-Epsilon statistics were non-significant), so the analysis proceeded.

The analysis revealed no main effect of gender on either acceptance rates or belief bias. The significant difference in acceptance rates of males and females for invalid problems, detected in Experiment 1, was not replicated. This was not totally surprising, as a significant difference was found in only a single cell: false Cql IND problems.

Table 7 shows the mean percentage of conclusions accepted for true and false versions of all syllogisms, pooled over gender.

The analysis revealed a significant main effect of problem type $F(5,455)=167.38$, $p<.0001$. These results are also shown in Figure 4. Multiple t-tests using the Bonferroni correction were run to test differences in mean acceptance rates among problem types. Results were first checked to see if they replicated the robust finding of an effect of logical validity. The mean percentage of correct
responses for valids versus invalids was compared. Given that the average acceptance rate of valids vs. invalids was 70% vs. 37% (pooled over type of consistency and truth value), and that accepting the conclusion is logically correct for valids, but incorrect for invalids, there was a significant difference in correct responses to valid vs. invalid problems, 70% vs. 63%; $t(92)=3.10$, $p<.005$.

Table 7. Experiment 2: Mean Percentage Conclusions Accepted

<table>
<thead>
<tr>
<th>Problem Type</th>
<th>Truth value</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>True</td>
<td>False</td>
</tr>
<tr>
<td>Valid CBoth</td>
<td>83.9</td>
<td>75.3</td>
</tr>
<tr>
<td>Valid Cql</td>
<td>66.1</td>
<td>53.2</td>
</tr>
<tr>
<td>IND&lt;sup&gt;a&lt;/sup&gt; CBoth</td>
<td>70.2</td>
<td>48.4</td>
</tr>
<tr>
<td>IND&lt;sup&gt;b&lt;/sup&gt; Cql</td>
<td>49.7</td>
<td>28.2</td>
</tr>
<tr>
<td>IND CNOne</td>
<td>28.5</td>
<td>8.1</td>
</tr>
<tr>
<td>DF Cqn</td>
<td>14.5</td>
<td>4.3</td>
</tr>
<tr>
<td>Avg. Valids</td>
<td>75.0</td>
<td>64.2</td>
</tr>
<tr>
<td>Avg. Invalids</td>
<td>47.1</td>
<td>27.6</td>
</tr>
</tbody>
</table>

Note. Means with different subscripts differ significantly at $p<.001$ in multiple t-tests using the Bonferroni correction.

<sup>a</sup> One problem, EAE-3, elicited negative belief bias.
<sup>b</sup> One problem, AOE-4, elicited negative belief bias.

If participants were failing to reason at all, and were only influenced by consistency with atmosphere and believability, they would accept the same percentage of similar valid and invalid problems. It is obvious, by comparing the means of the true versions of CBoth valid vs. CBoth invalid syllogisms (84% vs. 70%), or the means of the false versions (75% vs. 48%), that logical validity did play a role in influencing acceptance rates. In fact,
Figure 4. Experiment 2. Mean percentage acceptance rates for valid and invalid syllogisms, collapsed over gender and truth value. n=93.
participants correctly solved approximately half as many of these invalid problems, true and false, as valid problems (80% vs. 41%).

A curious finding was that there were more correct answers to Cqn DF problems (91%) than to Cql valids (60%) or even CBoth valids (80%). If participants are able to ascertain that a conclusion cannot possibly follow from the premises, presumably because it contradicts what does indeed follow, why are they less able to ascertain what does indeed follow?

More interesting, however, was that CBoth valids had significantly higher acceptance rates than Cql valids; 80% vs. 60%; t(92) =7.25, p<.001. Proponents of mental model theory would probably attribute this to the number of mental models that had to be constructed. They would claim that valid Cql problems included more multiple model forms, which are more difficult, so their conclusions were accepted less frequently. In other words, failure to accept as many conclusions to Cql valids would ultimately be attributed to a problem with logical processing. But, assuming Ford's claim is correct, that AAI syllogisms are actually single model forms, then this explanation would fail, since both valid types included 2 multiple and 2 single model syllogisms.

This dissertation attributes the difference in acceptance rates of valid CBoth vs. valid Cql problems to the non-logical influence of atmosphere. Subjects seemed
more willing to accept conclusions whenever logical processing and the consistency bias agreed. When these two influences acted in opposite directions, (i.e. when logic recommended acceptance of the conclusion, but the conclusion was inconsistent with quantity), participants made more errors; there was a tendency to be more influenced by the non-logical bias and reject the valid conclusions.

Responses to invalid forms were analyzed by comparing the mean acceptance rates of DF Cqn and IND CBoth, Cql, and CNone problems. Results indicated that acceptance rates of each invalid problem type differed significantly from every other type. This replicated the first experiment's finding of an atmosphere effect on invalid problems, and extended it to include IND CBoth problems. Similar to the pattern found with valid problems, when the influences of logic and consistency agreed (CNone IND and Cqn DF problems) there were fewer errors. But when the influences conflicted, there was the tendency to be more influenced by the non-logical bias and incorrectly accept invalid conclusions.

A detailed look at responses indicated CBoth IND problems had a significantly higher mean acceptance rate than Cql IND forms; 59% vs. 39%; \( t(92)=7.77, p<.001 \). This IND CBoth mean acceptance rate was also significantly higher than CNone IND or Cqn DF problems, 18% and 9% respectively; \( t(92)=13.14, p<.001 \) and \( t(92)=17.41, p<.001 \). Cql IND problems had a significantly higher mean acceptance rate...
rate than CNone IND, $t(92)=7.79, p<.001$, and CNone IND was significantly higher than Cqn DF; $t(92)=4.34, p<.001$. Acceptance rates of Cql valid vs. CBoth IND syllogisms were not significantly different, 60% vs. 59%.

Results also indicated a main effect of truth value, or believability, $F(1,91)=59.46, p<.0001$. Within each problem type, true versions of the syllogism were accepted more often than false versions, but truth value also interacted with problem type, $F(5,455)=3.98, p<.005$. To clarify the interaction, as in Experiment 1, significant differences in mean percentage belief bias among problem types were examined. Results are shown in Figure 5.

If this interaction is accurately explained in terms of determinancy, per Newstead et al. (1992), then comparing any valid syllogism to any IND problem will result in a significant difference in their mean percentage belief bias (i.e. a logic by belief interaction). This difference should disappear when comparing a valid syllogism to any DF problem. The analysis of data from Experiment 2 casts doubt on the veracity of this claim. Information from Table 7 and Figure 5 were combined in Table 8 to elucidate the presence or absence of this interaction.

Before considering the logic by belief interaction, comparisons were made of mean belief bias for different problem types. No significant differences in belief bias were detected between Cql valid vs. CBoth valid problems, or among Cqn DF, CBoth IND, Cql IND, and CNone IND
Figure 5. Experiment 2. Mean percentage belief bias for valid and invalid syllogisms, collapsed over gender. n=93.
problems. The average mean % belief bias for three IND forms was significantly higher than for valid or DF forms, which is consistent with the Newstead et al. explanation of the logic by belief interaction. However, the finding of no significant difference in belief bias for CNone IND problems vs. Cqn DF forms is problematic for their explanation.

Table 8. Experiment 2: Mean Percentage Conclusions Accepted, Belief Bias, and the Logic by Belief Interaction.

<table>
<thead>
<tr>
<th></th>
<th>True</th>
<th>False</th>
<th>Belief Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid CBoth</td>
<td>83.9</td>
<td>75.3</td>
<td>8.6 &lt;sub&gt;A&lt;/sub&gt;</td>
</tr>
<tr>
<td>IND CBoth</td>
<td>70.2</td>
<td>48.4</td>
<td>21.8 &lt;sub&gt;B&lt;/sub&gt;</td>
</tr>
<tr>
<td>IND Cql</td>
<td>49.7</td>
<td>28.2</td>
<td>21.5 &lt;sub&gt;B&lt;/sub&gt;</td>
</tr>
<tr>
<td>IND CNone</td>
<td>28.5</td>
<td>8.1</td>
<td>20.4 &lt;sub&gt;AB&lt;/sub&gt;</td>
</tr>
<tr>
<td>DF Cqn</td>
<td>14.5</td>
<td>4.3</td>
<td>10.3 &lt;sub&gt;AB&lt;/sub&gt;</td>
</tr>
<tr>
<td>Valid Cql</td>
<td>66.1</td>
<td>53.2</td>
<td>12.9 &lt;sub&gt;A&lt;/sub&gt;</td>
</tr>
<tr>
<td>IND CBoth</td>
<td>70.2</td>
<td>48.4</td>
<td>21.8 &lt;sub&gt;A&lt;/sub&gt;</td>
</tr>
<tr>
<td>IND Cql</td>
<td>49.7</td>
<td>28.2</td>
<td>21.5 &lt;sub&gt;A&lt;/sub&gt;</td>
</tr>
<tr>
<td>IND CNone</td>
<td>28.5</td>
<td>8.1</td>
<td>20.4 &lt;sub&gt;A&lt;/sub&gt;</td>
</tr>
<tr>
<td>DF Cqn</td>
<td>14.5</td>
<td>4.3</td>
<td>10.3 &lt;sub&gt;A&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

Note. Mean belief bias for each valid problem type (CBoth and Cql) is compared to the mean belief bias for each invalid problem type. Any significant difference indicates a logic by belief interaction. Means with different subscripts differ significantly at p < .005 in multiple t-tests using the Bonferroni correction.

Table 8 shows significantly greater mean belief bias for CBoth IND forms (21.8%) vs. CBoth valid forms (8.6%), t(92) = 3.49, p < .001, which indicated a logic by belief interaction. This was consistent with Newstead et al. (1992). Cql IND forms also elicited significantly greater
belief bias (21.5%) than CBoth valids, $t(92)=3.43$, $p<.001$, also indicating a logic by belief interaction. However, neither CNone IND (20.4%) nor Cqn DF forms (10.3%) elicited significantly different belief bias than CBoth valids, indicating no logic by belief interaction with these problems. Since the Bonferroni correction is quite conservative (it increases the probability of accepting the null hypothesis), Bonferroni layering using a stepwise correction was used to establish comparisonwise error for these problem types. Still, no significant differences in belief bias were found. This analysis provided some evidence, admittedly not compelling, that while Newstead et al. are correct in claiming DF problems do not result in a logic by belief interaction, there may be certain IND problems which also fail to elicit an interaction.

Recall that Cqn IND problems were not included in this experiment, due to attempts to keep the number of tasks low. Instead, CNone IND forms were included, which elicited greater belief bias than Cqn IND forms in Experiment 1. IND problems with a higher mean percentage belief bias were more likely to confirm the Newstead et al. (1992) hypothesis and falsify the hypothesis tested in this experiment, which predicts the absence of a logic by belief interaction with invalid syllogisms inconsistent with quality (either Cqn or CNone). Had Cqn IND rather than CNone IND problems been used in this experiment, and had their belief bias been lower than the 20.4% elicited for
CNone, as in Experiment 1, more compelling evidence may have been found to support this dissertation's explanation for the interaction.

Despite the limited support found using CBoth valids, comparisons of belief bias for Cql valids vs. IND and DF invalids yielded more interesting results. There were no significant differences in belief bias, i.e. no evidence of a logic by belief interaction, when Cql valids were compared to any type of invalid problem, IND or DF. Again, when the less conservative stepwise correction was used to determine the comparisonwise error rate, the negative finding of no significant differences in belief bias was confirmed.

It appears that explaining the presence or absence of the logic by belief interaction in terms of either determinancy or consistency may be an oversimplification. When CBoth valids were compared to CBoth and Cql IND problems, there was evidence of an interaction. This interaction was absent when CNone IND syllogisms were compared to CBoth valids. It was also absent with DF problems. These findings contradicted Newstead et al. and supported this dissertation's hypothesis. It remained unclear, however, whether this would be true for Cqn IND problems, as they were not included in this experiment.

On the other hand, when Cql valids were compared to CBoth and Cql IND problems, there were no significant differences in belief bias, i.e. there was no evidence of
an interaction. Nor was there one with CNone IND or Cqn DF forms. This contradicted both Newstead et al. and this dissertations hypothesis. In other words, predictions of an interaction based solely on whether the invalid problems were IND or DF, or consistent or inconsistent with quality, were both inaccurate. What seems clear, however, is that an adequate explanation of the logic by belief interaction will have to address the effect of consistency with atmosphere. Apparently, there is a three way interaction of logic, belief, and consistency.

As already mentioned, there was an opportunity to test one prediction of mental model theory, that single model valid syllogisms should elicit no belief bias. Some studies have already reported evidence that contradicts this claim. Both Oakhill et al. (1989) and Newstead et al. (1992) have found belief bias effects on single-model syllogisms, as well as no effects on multiple model valids. Experiment 2 replicated their failure to confirm the prediction of mental model theory. Results indicated the mean belief bias for single model CBoth valid problems was non-significantly higher than for multiple model CBoth problems (10.7% vs. 3.6%). Of the Cql valids, the multiple models had non-significantly higher belief bias than the single models (10.7% vs. 9.5%).

It should be noted that there were 2 "odd" syllogisms in this experiment, which elicited negative belief bias. One was a CBoth IND problem, EAE-3, with -1% belief bias.
Excluding it from the analysis would have resulted in a mean belief bias for the remaining CBoth IND problems of 29.3%, compared to the 21.8% reported. The second odd problem was a CqI IND problem, AOE-4, which elicited belief bias of -.04%. Excluding this problem from the analysis would have raised the mean belief bias for CqI IND problems to 30.0%, from the 21.5% reported. Excluding both odd problems would have better differentiated the mean belief bias elicited by CBoth and CqI IND syllogisms (approximately 30%) vs. that elicited by CNone IND problems (approximately 20%). But even more interesting is the fact that had these odd problems been the only IND problems investigated in this experiment, no logic by belief interaction would have occurred for IND forms. Again, this finding would be contrary to both explanations of the logic by belief interaction.

Recall there was a similar odd problem in Experiment 1, a CqI IND, IOE-4, and omitting this problem from the analysis also raised the mean belief bias approximately 10%. There is no reference to anything like this finding in the literature, although Oakhill et al. (1989) and Newstead et al. (1992) reported negative belief bias for CBoth multiple-model valid syllogisms. All of the odd problems found in Experiments 1 and 2 of this dissertation were invalid IND syllogisms consistent with quality, and all had a universal negative conclusion. There is no explanation for this finding.
In summary, the results of Experiment 2 are clear. The often reported effects of logical validity and believability on acceptance rates were replicated. More importantly, this experiment replicated the effect of atmosphere found in Experiment 1, and extended it to 4 figures of IND invalid problems, and 4 figures of CBoth valid and Cq1 valid problems. It provided support for the hypothesis that the atmosphere effect is the result of dual influences: consistency with quality and consistency with quantity. It also confirmed that DF and IND problems do elicit significantly different acceptance rates, although it remains unclear whether every type of IND problem will elicit significantly higher belief bias than every type of DF problem.

Experiment 2 also provided evidence that the logic by belief interaction is better characterized as a three way interaction between consistency, logic, and belief. The logic by belief interaction was present when CBoth valids were compared to invalids consistent with quality (CBoth or Cq1), and it was absent otherwise (with Cqn DF or CNone IND). However, this pattern did not hold with Cq1 valids.

Regarding the other goals of Experiment 2, it did not replicate a main effect of gender, nor did it confirm mental model theory's negative prediction of no belief bias for single model syllogisms. It did confirm the finding that certain syllogisms elicit negative belief bias. If
the odd responses to these syllogisms are, indeed, attributable to their consistency with quality and their conclusion statement type, then a complete explanation of response patterns may be even more complicated than first thought.

Overall, the cumulative impact of these findings ought to be an increased awareness of the importance of non-logical influences on participants solving syllogistic reasoning problems, which could rattle the underpinnings of the currently embraced epistemology.

These results confirmed an influence of consistency with atmosphere on responses to both valid and invalid syllogisms. Experiment 3 investigated whether this influence could be reduced by an instruction manipulation.
CHAPTER 5
EXPERIMENT 3

Results of Experiments 1 and 2 indicated that a conclusion’s consistency with atmosphere, in addition to its believability and logical validity, influence participants' willingness to accept a conclusion in a syllogistic judgment task. Experiment 3 was designed to replicate the findings of these two experiments, but its primary goal was to investigate the effect an instruction manipulation would have on these influences of logic, belief, and consistency.

Current theories postulate that participants rely on non-logical biases or heuristics, like believability, when they fail to engage in logical reasoning. (Logical reasoning generally refers to reasoning according to the dictates of formal logic.) Therefore, instructions that explain how to solve syllogisms using logical principles should reduce reliance on these non-logical influences, and result in fewer errors. Acceptance rates for valids should increase, while acceptance rates for invalids should decrease. Unfortunately, only a handful of studies provide evidence to support this position.

If, in fact, increased reasoning does decrease belief bias, then it should decrease (or eliminate) the interaction between logic and belief, as well. And, since responding in accordance with atmosphere is also seen as
resulting from a non-logical bias or heuristic, augmented instructions should reduce its influence, with a correspondent reduction in errors. Experiment 2 indicated that most errors occurred where consistency and validity conflicted, i.e. for Cq1 valid, CBoth IND, and Cq1 IND problems. Therefore, any instructional effect was predicted to be most evident for those syllogisms.

To ensure that all types of IND and DF syllogisms were investigated in this experiment, it was necessary to limit the number of forms included for each problem type to two. (This experiment included the IND Cqn and DF CNone forms which had been excluded from Experiment 2.) This meant there were a total of 32 problems: 2 types of valid problems, and 6 types of invalid, 4 IND and 2 DF, with a true and false version of each form.

Experiment 3

Subjects. The participants in this study were also undergraduates from Louisiana State University. One hundred one students, representing a large number of college majors, and of varied ethnic and racial backgrounds, voluntarily participated. None had any previous instruction in logic. Prior to the experiment, participants were given a consent form to read and sign. The purpose of the study was explained, as well as their right to confidentiality and their right to withdraw.

Materials and Procedure. Thirty-two tasks were used in this experiment, 8 valid and 24 invalid. There were two types
of valids: CBoth and Cq1; and 6 types of invalids: IND CBoth, Cq1, Cqn, CNone and DF Cqn and CNone. Each problem type consisted of 2 forms, one figure 2 and one figure 3, and each form had a true and false version. As before, truth value referred to the truth value of the conclusion.

An attempt was made to avoid including "oddball" problems, like the IND syllogisms found in Experiments 1 and 2, which elicited negative belief bias. As a result, no CBoth IND or Cq1 IND type syllogisms having a universal negative conclusion were used in Experiment 3. Within every valid and IND problem type, each of the two forms had a particular statement as a conclusion. One form had an I conclusion and the other had an O.

This decision, to use figure 2 and 3 problems and avoid universal conclusions for valid and IND syllogisms in this experiment, complicated the selection of DF problems to be included. For one thing, such figure 3 CNone DF syllogisms do not exist. Second, only two figure 2 CNone DF forms have a particular conclusion, which is an I statement. As a result, the figure 3 form selected for this experiment had a universal negative (E) conclusion.

The selection of Cqn DF forms to be used in Experiment 3 was also constrained. It is logically impossible for a Cqn DF syllogism to have a particular conclusion. Therefore, both forms had a universal conclusion; one an A statement, the other an E. (The reason it is logically impossible is derived from the definition of "DF". Recall
that DF syllogisms are those having conclusions which are contradictory to the valid conclusion implied by the premises. A statement that is the contradictory of another must have the opposite quantity and quality of that statement. So, a Cqn DF problem, by definition, has a conclusion contradictory to a Cql conclusion of a valid syllogism. Valids with Cql conclusions are conditionally valid, and all have a particular conclusion. Therefore, all Cqn DF problems must have a universal conclusion.)

As in the previous two experiments, all versions of all syllogisms used content that included terms referring to common classifications of the animal kingdom. Table 9 summarizes the syllogistic forms used in Experiment 3.

Table 9. Experiment 3: Valid and Invalid Syllogisms Used

<table>
<thead>
<tr>
<th>Valid</th>
<th>DF</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBoth</td>
<td>Cql</td>
</tr>
<tr>
<td>AOO-2</td>
<td>AEO-2</td>
</tr>
<tr>
<td>AII-3</td>
<td>AAI-3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indeterminate</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBoth</td>
</tr>
<tr>
<td>AII-2</td>
</tr>
<tr>
<td>OOO-3</td>
</tr>
</tbody>
</table>

Note. There was a true and false version of each form.

Participants were given a booklet including a page of instructions and the 32 problems in random order. Each problem was presented on a single page, and participants
were verbally instructed to work the problems in order without reviewing previous answers. There were 2 groups of participants. One group was given the same instructions used Experiments 1 and 2. The second group was given an alternate set of instructions, shown below, which were designed to induce logical reasoning. These modified instructions clarified the meaning of the phrase "necessarily follows". They stressed the conditions under which a conclusion can be said to logically follow from information provided by other statements (the premises). The modifications to the original instructions are shown in bold print. Students were allowed as much time as necessary to finish all the tasks. All were finished within 45 minutes.

The following instructions were given:

On each of the following pages, you will find a reasoning problem, consisting of two statements and a conclusion shown below the statements. Your task is to indicate if the conclusion logically follows from the two statements, assuming that these statements are, in fact, true. Please circle the appropriate word ("YES" or "NO") given below the problem. Take your time and be sure that you have the right answer before doing so.

To correctly solve each problem, you should first look at the two premises and imagine that they are true. Then, you should look at the conclusion. If you determine that the conclusion would have to be true, given the assumed
truth of the premises, then that means it does necessarily follow, and you should answer "yes". In other words, if it is impossible to imagine exceptions to the conclusion, when the premises are imagined to be true, then you should circle "YES".

On the other hand, if you determine that the conclusion might be true, given the assumed truth of the premises, but it doesn't have to be true, then the conclusion does not necessarily follow. In other words, if you can imagine exceptions to the conclusion, when the premises are imagined to be true, then you should circle "NO".

To check your understanding of these instructions, circle the correct response to the following 2 problems:

1. A dog is a fish
   ZAZ is a dog
   YES

2. A dog is a mammal
   ZAZ is a fish
   ZAZ is a mammal
   ZAZ is a dog
   YES
   NO

Results and Discussion Three participants failed to complete the task, so were excluded from the analysis, leaving 43 females and 58 males. Performance was assessed using mean percentage conclusion acceptance rate as the measure. Where noted, the mean percentage correct was the measure. The mean percentage correct is the same as the acceptance rate for valids, and is equal to 100% minus the acceptance rate for invalids. Data were first analyzed by
a 4 factor mixed design ANOVA, with repeated measures on problem type (eight levels) and truth value (2 levels). The between factors were gender (2 levels) and instruction group (2 levels, standard and augmented). The assumption of equal variance and correlations was confirmed, as in the previous experiments, so the analysis proceeded as a repeated measures one. Results from both sets of instructions are shown in Table 10.

This analysis indicated there were no between subject effects, i.e. no main effect of gender and no main effect of instructions. The absence of a gender effect was not unexpected, as none was found in Experiment 2. But the absence of an instructional main effect, although not totally surprising, was unexpected, despite the fact that there is little evidence of it, in the literature. Newstead et al. (1992) reported that their augmented instructions did not significantly affect mean acceptance rates of valid syllogisms. In fact, false valids were accepted more often than true valids. Their augmented instructions did, however, lower the mean acceptance rate of true (believable) invalid syllogisms from 50% to 17%, thereby lessening the logic by belief interaction. The syllogisms used in their experiment were CBoth valids, EIO-2, and CBoth IND invalids, IEO-2.

Results from Experiment 3 replicated the findings of Newstead et al. (1992). No instructional effect on mean acceptance rates was found for valid syllogisms, while
there was a decrease in mean acceptance rates, with the augmented instructions, for certain true invalids. As in the Newstead et al. study, true CBoth IND invalid mean acceptance rates were lowered from 73.5% to 64%. In addition, the mean acceptance rates for the false versions dropped from 56.9% to 46%. However, this facilitating influence of augmented instructions did not generalize to other IND or DF invalid problems.

Table 10. Experiment 3: Mean Percentage Conclusions Accepted for Each Instruction Group, Pooled Over Gender

<table>
<thead>
<tr>
<th>STANDARD INSTRUCTIONS (n=51)</th>
<th>Problem Type</th>
<th>Truth value</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>True</td>
<td>False</td>
</tr>
<tr>
<td>Valid CBoth</td>
<td>86.3</td>
<td>90.2</td>
<td>88.5</td>
</tr>
<tr>
<td>Valid Cql</td>
<td>69.6</td>
<td>63.7</td>
<td>66.8</td>
</tr>
<tr>
<td>IND CBoth</td>
<td>73.5</td>
<td>56.9</td>
<td>65.4</td>
</tr>
<tr>
<td>IND Cql</td>
<td>60.8</td>
<td>33.3</td>
<td>47.6</td>
</tr>
<tr>
<td>IND Cqn</td>
<td>58.8</td>
<td>40.2</td>
<td>49.5</td>
</tr>
<tr>
<td>IND CNone</td>
<td>19.6</td>
<td>6.8</td>
<td>13.0</td>
</tr>
<tr>
<td>DF Cqn</td>
<td>7.8</td>
<td>5.9</td>
<td>6.7</td>
</tr>
<tr>
<td>DF CNone</td>
<td>7.8</td>
<td>4.9</td>
<td>6.2</td>
</tr>
</tbody>
</table>

| Avg. Valids                | 77.6 |
| Avg. Invalid               | 31.4 |

<table>
<thead>
<tr>
<th>AUGMENTED INSTRUCTIONS (n=50)</th>
<th>Problem Type</th>
<th>Truth value</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>True</td>
<td>False</td>
</tr>
<tr>
<td>Valid CBoth</td>
<td>91.0</td>
<td>85.0</td>
<td>87.7</td>
</tr>
<tr>
<td>Valid Cql</td>
<td>72.0</td>
<td>67.0</td>
<td>69.6</td>
</tr>
<tr>
<td>IND Both</td>
<td>64.0</td>
<td>46.0</td>
<td>54.9</td>
</tr>
<tr>
<td>IND Cql</td>
<td>61.0</td>
<td>41.0</td>
<td>51.5</td>
</tr>
<tr>
<td>IND Cqn</td>
<td>64.0</td>
<td>46.0</td>
<td>50.5</td>
</tr>
<tr>
<td>IND CNone</td>
<td>34.0</td>
<td>10.0</td>
<td>21.6</td>
</tr>
<tr>
<td>DF Cqn</td>
<td>8.0</td>
<td>0.0</td>
<td>3.9</td>
</tr>
<tr>
<td>DF CNone</td>
<td>9.0</td>
<td>2.0</td>
<td>5.5</td>
</tr>
</tbody>
</table>

| Avg. Valids                | 78.7 |
| Avg. Invalid               | 31.3 |

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In many instances, the instructional effect was in the opposite direction. For example, true versions of Cqn IND problems had a mean acceptance rate of 59% with standard instructions vs. 64% with augmented instructions. The same was true for false versions of Cqn IND problems, with a 40% mean acceptance rate with standard instructions vs. 46% with the augmented. (Other examples of non-significantly higher acceptance rates with the augmented instructions are evident in Table 10.)

There was even evidence of the augmented instructions resulting in significantly higher mean acceptance rates. Subjects solving true CNone IND problems had mean acceptance rates of 19.6% with standard instructions vs. 34% with the augmented. In fact, augmented instructions in Experiment 3 failed to significantly improve performance on any syllogisms save one. The mean acceptance rate for false Cqn DF problems was 5.9% with standard instructions vs. 0% with augmented instructions.

Data analysis also indicated that the significant main effect of problem type found in Experiments 1 and 2 was replicated in this experiment $F(7,693)=187.60$, $p<.0001$. Results were pooled over gender and instruction group and multiple t-tests using the Bonferroni correction were run to test differences in mean acceptance rates among the eight problem types. These results are shown in Table 11.

The effect of logical validity was evident, with valid syllogisms having significantly more correct responses than
invalid syllogisms, 78% vs. 69%, $t(100)=3.90$, $p<.001$. The effect of atmosphere on valid syllogisms was also replicated. CBoth valids had significantly higher acceptance rates than Cql valids, 88% vs. 67%, $t(100)=6.93$, $p<.001$. Furthermore, this difference of 20% between the two mean acceptance rates was approximately the same as that found in Experiment 2. As before, most errors were found where the influences of logic and consistency conflicted.

Table 11. Experiment 3: Mean Percentage Conclusions Accepted, Pooled Over Gender and Instruction Group

<table>
<thead>
<tr>
<th>Problem Type</th>
<th>Truth value</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>True</td>
<td>False</td>
</tr>
<tr>
<td>Valid CBoth</td>
<td>88.3</td>
<td>87.9</td>
</tr>
<tr>
<td>Valid Cql</td>
<td>70.9</td>
<td>65.5</td>
</tr>
<tr>
<td>IND CBoth</td>
<td>68.9</td>
<td>51.5</td>
</tr>
<tr>
<td>IND Cql</td>
<td>60.7</td>
<td>38.3</td>
</tr>
<tr>
<td>IND Cqn</td>
<td>61.8</td>
<td>38.4</td>
</tr>
<tr>
<td>IND CNone</td>
<td>26.2</td>
<td>8.3</td>
</tr>
<tr>
<td>DF Cqn</td>
<td>7.8</td>
<td>2.9</td>
</tr>
<tr>
<td>DF CNone</td>
<td>8.3</td>
<td>3.4</td>
</tr>
<tr>
<td>Avg. Valids</td>
<td>79.6</td>
<td>76.7</td>
</tr>
<tr>
<td>Avg. Invalids</td>
<td>38.9</td>
<td>23.8</td>
</tr>
</tbody>
</table>

Note. Means with different subscripts differ significantly at $p<.001$ in multiple t-tests using the Bonferroni correction.

This was also true for invalid problems. The CBoth IND problems elicited the greatest number of erroneous responses, with a 60% mean acceptance rate. Table 11 indicates, with subscripts, significant differences in mean acceptance rates among IND syllogisms. CBoth syllogisms
had a significantly higher mean acceptance rate than either Cql IND forms, 49.5%; $t(100)=3.27$, $p<.005$, or CNone IND forms; 17%, $t(100)=12.49$, $p<.001$. They also had significantly higher acceptance rates than both Cqn DF forms; 5%, $t(100)=17.42$, $p<.001$, and CNone DF problems; 6%, $t(100)=13.53$, $p<.001$. The CBoth IND vs. Cqn IND mean acceptance rates (60% vs. 50.1%) were just shy of significance; $t(100)=2.96$, $p<.006$. As in Experiment 2, acceptance rates of Cql valid vs. CBoth IND problems did not significantly differ, 68% vs. 60% respectively.

Both Cql IND and Cqn IND forms had significantly higher mean acceptance rates (49.5% and 50%) than CNone IND problems (17%); $t(100)=9.83$, $p<.001$; and $t(100)=10.29$, $p<.001$ respectively. The DF problems did not significantly differ.

One disturbing finding was the mean acceptance rates for Cql and Cqn IND problems did not differ significantly, contrary to Experiment 1. In fact, in that experiment Cqn forms elicited significantly lower acceptance rates than CNone IND problems, and for that reason were omitted from Experiment 2. It is unclear why response rates to this problem type differed between experiments. Again, it could be due to the fact that all Cqn syllogisms in Experiment 1 had universal conclusions, while in Experiment 3 all had particular conclusions. As already mentioned, if this is so, a fully articulated theory explaining response patterns

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to syllogisms may be quite complicated (although, only Cqn forms appear to be problematic).

The other interesting finding in Experiment 3, also found in Experiment 2, was that there were significantly more correct answers to Cqn DF problems (95%) than to Cql valid problems (68%); t(100) = 9.83, p < .001. Likewise, there were more correct answers to CNone DF problems (94%) than to CBoth valids (88%), although this difference was not significant. Again, it is generally held that correctly solving valid and DF problems requires an understanding of necessity. But if participants are able to determine that a conclusion necessarily cannot follow (presumably because it contradicts what must necessarily follow), it is curious that they appear less able to determine what necessarily must follow.

Results also indicated a main effect of truth value, F(1, 98) = 63.85, p < .0001. Within each problem type, true versions were accepted more often than false versions. Truth value was found to interact with problem type, F(7, 686) = 7.72, p < .0001, indicating a 3-way interaction of logic, consistency, and belief.

The data were next analyzed using mean percentage belief bias as the dependent measure. Again, no instructional effect was found, but there was a main effect of problem type and a main effect of gender, with no interaction. Females exhibited significantly higher belief bias than males, F(1, 98) = 5.67, p < .05. These results (pooled over instruction group) are shown in Figure 6a.
Belief bias, pooled over gender and instruction group, is shown in Figure 6b.

Differences in belief bias among problem types (pooled over gender) were analyzed using multiple t-tests with a Bonferroni correction. As before, CBoth and Cql valids were compared to all the invalid forms to test the Newstead et al. prediction that IND problems result in a logic by belief interaction, while DF problems do not. If true, only IND problems would have significantly different belief bias than valid. Also tested, was this dissertation's hypothesis that only IND problems consistent with quality (CBoth or Cql) will elicit significantly higher belief bias than valids. Results of these comparisons are shown in Table 12.

Recall that Experiment 2 indicated both explanations for the logic by belief interaction were incomplete, although it did provide evidence of a three way interaction between logic, belief, and consistency.

Experiment 3 revealed no significant difference in belief bias for Cql valids vs. CBoth valids (5.4% vs. 0.5%), and no significant differences among IND forms or between DF forms. Neither were there significant differences in belief bias for valids vs. DF forms. There was a logic by belief interaction when CBoth valids were compared to every type of IND problem, which disappeared when compared to DF forms. This finding was precisely what is predicted by Newstead et al. (1992). But, it was
Figure 6A. Experiment 3. Mean percentage belief bias for valid and invalid syllogisms, collapsed over instruction group. n=101.

Figure 6B. Experiment 3. Mean percentage belief bias for valid and invalid syllogisms, collapsed over gender and instruction group. n=101.
contrary to the predictions of this dissertation's hypothesis. Belief bias for CBoth IND was significantly higher than for CBoth valids, t(100)=3.27, p<.005; as was belief bias for Cql IND, t(100)=4.59, p<.001; for Cqn IND, t(100)=4.89, p<.001, and for CNone IND problems, t(100)=4.30, p<.001.

Table 12. Experiment 3: Mean Percentage Conclusions Accepted, Belief Bias, and the Logic by Belief Interaction, Pooled Over Gender and Instruction Group

<table>
<thead>
<tr>
<th></th>
<th>True</th>
<th>False</th>
<th>Belief Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid CBoth</td>
<td>88.3</td>
<td>87.9</td>
<td>0.5&lt;sub&gt;A&lt;/sub&gt;</td>
</tr>
<tr>
<td>IND CBoth</td>
<td>68.9</td>
<td>51.5</td>
<td>17.4&lt;sub&gt;B&lt;/sub&gt;</td>
</tr>
<tr>
<td>IND Cql</td>
<td>60.7</td>
<td>38.3</td>
<td>22.4&lt;sub&gt;B&lt;/sub&gt;</td>
</tr>
<tr>
<td>IND Cqn</td>
<td>61.8</td>
<td>38.4</td>
<td>23.4&lt;sub&gt;B&lt;/sub&gt;</td>
</tr>
<tr>
<td>IND CNone</td>
<td>26.2</td>
<td>8.3</td>
<td>17.9&lt;sub&gt;B&lt;/sub&gt;</td>
</tr>
<tr>
<td>DF Cqn</td>
<td>7.8</td>
<td>2.9</td>
<td>4.9&lt;sub&gt;A&lt;/sub&gt;</td>
</tr>
<tr>
<td>DF CNone</td>
<td>8.3</td>
<td>3.4</td>
<td>4.9&lt;sub&gt;A&lt;/sub&gt;</td>
</tr>
<tr>
<td>Valid Cql</td>
<td>70.9</td>
<td>65.5</td>
<td>5.4&lt;sub&gt;AB&lt;/sub&gt;</td>
</tr>
<tr>
<td>IND CBoth</td>
<td>68.9</td>
<td>51.5</td>
<td>17.4&lt;sub&gt;B&lt;/sub&gt;</td>
</tr>
<tr>
<td>IND Cql</td>
<td>60.7</td>
<td>38.3</td>
<td>22.4&lt;sub&gt;B&lt;/sub&gt;</td>
</tr>
<tr>
<td>IND Cqn</td>
<td>61.8</td>
<td>38.4</td>
<td>23.4&lt;sub&gt;B&lt;/sub&gt;</td>
</tr>
<tr>
<td>IND CNone</td>
<td>26.2</td>
<td>8.3</td>
<td>17.9&lt;sub&gt;B&lt;/sub&gt;</td>
</tr>
<tr>
<td>DF Cqn</td>
<td>7.8</td>
<td>2.9</td>
<td>4.9&lt;sub&gt;A&lt;/sub&gt;</td>
</tr>
<tr>
<td>DF CNone</td>
<td>8.3</td>
<td>3.4</td>
<td>4.9&lt;sub&gt;A&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

Note. Mean belief bias for each valid problem type (CBoth and Cql) is compared to the mean belief bias for each invalid problem type. Any significant difference indicates a logic by belief interaction. Means with different subscripts differ significantly at p<.005 in multiple t-tests using the Bonferroni correction.

The comparisons of belief bias for Cql valids vs. IND and DF invalids, again yielded more interesting results. There were no significant differences in belief bias (using
the Bonferroni layering correction), i.e. no logic by belief interaction, for these valids vs. any DF problems, as predicted by both Newstead et al. and this dissertation's hypothesis (since DF syllogisms are inconsistent with quality, nonCq1). However, neither was there an interaction for CBoth IND nor for CNone IND forms. While no interaction with CNone IND forms was consistent with this dissertation's hypothesis, the former finding was not. Neither finding was consistent with the Newstead et al. explanation.

In addition, results indicated there was a significant difference in belief bias for Cq1 valids vs. Cq1 IND problems, \( t(100)=3.04, p>.005 \), and vs. Cqn IND forms, \( t(100)=3.27, p>.005 \). Once again, only the former was predicted by this dissertation's hypothesis.

These findings conflicted, somewhat, with those of Experiment 2, where the logic by belief interaction was absent when Cq1 valids were compared to any IND or DF forms. However, Experiment 3 did provide evidence that the logic by belief interaction was affected by consistency with atmosphere, thus replicating the 3 way interaction of logic, belief, and consistency found in Experiment 2.

In summary, Experiment 3 replicated the effect of consistency with atmosphere for both valid and invalid syllogisms. Contrary to Experiment 1 results, however, Cqn IND problems had a mean acceptance rate not significantly different than the Cq1 forms. Apparently consistency with
quality was not the predictor of significantly higher acceptance rates, as hypothesized. Rather, consistency with neither quality or quantity appeared to result in significantly lower acceptance rates.

Experiment 3 also confirmed that DF and IND problems did elicit significantly different acceptance rates and belief bias (although CNone IND acceptance rates were closer to those of DF forms than to other IND forms). And it provided evidence that the logic by belief interaction was a function of consistency with atmosphere, i.e. there was a logic by belief by consistency (with atmosphere) interaction. There was also evidence, in this experiment, of gender differences in belief bias; females were more affected by believability than males. This is not a finding reported in the literature. See Figure 6a.

Finally, this experiment failed to show an instructional effect. Researchers who underscore the priority of reason have claimed that instructions stressing logical analysis will reduce the size of the logic by belief interaction. This was not confirmed by Experiment 3. Not only did it fail to reveal significant differences in belief bias between standard and augmented instructions for any problem type, it found evidence of non-significant differences in the opposite direction. Apparently it takes more than providing participants with instructions describing proper logical analysis to induce them to abandon certain non-logical biases or heuristics.
CHAPTER 6
SUMMARY AND CONCLUSIONS

The three experiments presented in this paper examined the effects of logical validity, believability, consistency with atmosphere, and gender on participants's responses to thematic syllogisms. The effects of validity and believability are robust in the literature, so these experiments were expected to replicate them. At the same time they tested whether the atmosphere provided by the premises of certain syllogisms affected the rate at which their conclusions were accepted. As atmosphere is comprised of dual components, quality and quantity, the experiments determined whether these two influences individually affected conclusion acceptance rates and/or belief bias. Furthermore, they examined gender effects on both acceptance rates and belief bias.

This study was originally conceived to support an explanation of response patterns that did not prioritize deductive reasoning. Rather, the aim was to offer an explanation grounded in an epistemology that gives equal weight to reasoning and non-logical influences. While the influence of believability on response patterns has been well established, it is generally portrayed as incidental to that of logical processing. It was hoped that these experiments would provide evidence of a second non-logical influence, consistency with quality and/or quantity, thereby underscoring the importance of such influences on
syllogistic reasoning. Results from each of the 3 experiments are summarized in Table 13. After a brief discussion, there will be an explanation of the major results, one which places logical reasoning and non-logical biases or heuristics on equal footing.

<table>
<thead>
<tr>
<th>Finding</th>
<th>Experiment Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Effect of Belief on mean % acceptance</td>
<td>Y</td>
</tr>
<tr>
<td>Effect of Consistency on mean % acceptance</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Effect of Determinancy on mean % belief bias&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Y/N</td>
</tr>
<tr>
<td>Effect of Logical Validity on mean % acceptance</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Effect of Gender on mean % acceptance</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Effect of Instructions</td>
<td>-</td>
</tr>
<tr>
<td>Interactions&lt;sup&gt;b&lt;/sup&gt; problem type*belief</td>
<td>Y</td>
</tr>
<tr>
<td>problem type*gender</td>
<td>N</td>
</tr>
<tr>
<td>belief*gender</td>
<td>N</td>
</tr>
<tr>
<td>problem type<em>belief</em>gender</td>
<td>Y</td>
</tr>
</tbody>
</table>

**Note.** "Y" and "N" refer to "Yes" the particular effect was found in a given experiment, or "No" it was not found.

<sup>a</sup> This refers to whether consistency with quality and/or quantity affected belief bias within, rather than among, IND, DF, or valid problem types.

<sup>b</sup> Recall that problem type is a reference to both logic and consistency, e.g. CBoth IND, Cql IND, or Cql Valid.

Experiment 1 used every type of invalid syllogism except for CBoth IND forms. That is, it used Cql IND, Cqn IND, Cqn DF, CNone IND, and CNone DF syllogisms. This
experiment replicated the main effects of logical validity and believability on mean percentage acceptance rates, but its most important finding was the main effect of consistency with atmosphere. Atmosphere's influence was found to be comprised of two separate influences, quality and quantity, and it was the influence of consistency with quality that elicited the highest acceptance rates. The mean percentage acceptance rates elicited by IND problems were all significantly different from each other and were significantly higher than for DF problems: Cql IND > CNone IND > Cqn IND > DF. Mean percentage acceptance rates for DF forms did not significantly differ.

The other noteworthy finding was that IND and DF invalid problems did elicit significantly different response patterns, so categorizing on the basis of determinancy is fruitful. Correct responses (lower acceptance rates) to DF problems are normally attributed to correct logical processing, as their conclusions contradict the logically valid inference that can be drawn from the premises. Results from Experiment 1 showed that participants apparently did understand the notion of necessity, as they correctly solved these DF forms. Still, they failed to consistently reject conclusions to IND problems based on this understanding. Furthermore, this failure appeared to be mediated by the conclusion's consistency with quality and/or quantity. So, while current theories can predict the significantly lower
acceptance rates of DF vs. IND conclusions, they cannot explain the effect of consistency on these acceptance rates.

Experiment 1 included one "odd" Cql IND syllogism, which elicited negative belief bias. Had it been omitted from the analysis, the mean percentage belief bias for Cql IND problems would have been significantly higher than for every other inconsistent IND and DF invalid problem type.

Experiment 1 also found a main effect of gender, with females accepting significantly more conclusions to these invalid syllogisms than males. While gender did not interact with problem type, it did enter into a 3 way interaction with believability. This was attributed to the fact that females accepted significantly more conclusions to false Cql IND problems than males. Outside of these problems, males and females were similarly affected by believability, i.e. there was no main effect of gender on belief bias in this experiment.

Experiment 2 replicated the main effects of logical validity and believability, as expected. More importantly, it confirmed the effect of consistency on mean percentage acceptance rates for IND forms, and extended this finding to both valid and invalid problems of all four figures. Mean acceptance rates for CBoth valids were significantly higher than for Cql valids, and all types of invalid problems had significantly different acceptance rates: CBoth IND > Cql IND > CNone IND > Cqn DF. Due to efforts
to minimize the number of syllogisms used, Cqn IND and CNone DF problems were omitted from this experiment.

Results of Experiment 2 suggested that consistency's influence was additive. That is, conclusions consistent with both quality and quantity, had significantly higher acceptance rates than conclusions consistent with only a single attribute. As Cqn IND problems were omitted from this experiment, this prediction had to be tested in the third experiment. Results also suggested that whenever the influences of logical validity, believability, and consistency acted in the same direction, the fewest errors occurred. True CBoth valid and false DF problems elicited the highest number of correct responses.

Experiment 2 also tested two explanations for the logic by belief interaction. The first, made by Newstead et al. (1992), was that the logic by belief interaction is present whenever valids are compared to IND invalid problems and absent whenever they are compared to DF invalid problems. The second explanation, examined in this dissertation, was that the interaction is present when valids are compared to syllogisms with conclusions consistent with quality (CBoth IND and Cql IND forms) and absent when compared to syllogisms with conclusions not consistent with quality (Cqn IND or DF, and CNone IND or DF forms). Results indicated that both explanations were incomplete or incorrect. Predictions of the logic by belief interaction based on determinancy or consistency
alone, were not uniformly confirmed. It was clear, however, that the logic by belief interaction was affected by consistency. In other words, there was evidence of a 3-way interaction of logic, belief, and consistency.

Several other noteworthy results came out of Experiment 2. First, it failed to reveal any main effect of gender on either acceptance rates or belief bias, a finding contrary to that of Experiment 1. Second, two additional odd problems were detected, which elicited negative belief bias. As in the first experiment, these were both problems consistent with quality, that had a universal negative conclusion (and E statement). One was a CBoth IND form; the other was a Cql IND form. There is no such finding reported in the literature. Last, Experiment 2 failed to confirm a prediction of mental model theory. It found belief bias effects for both single model and multiple model syllogisms.

Experiment 3 replicated all relevant findings of the first 2 experiments: effects of validity, believability, and consistency. However, it found that Cql IND and Cqn IND acceptance rates were not significantly different. This was one of the few findings that did not replicate across the 3 experiments, although it confirmed the assumption that consistency is additive (conclusions consistent with both attributes of atmosphere had higher acceptance rates than those consistent with a single attribute.) The reason why this particular finding varied
across experiments, is unclear, although it could be attributed to the fact that all Cqn syllogisms used in Experiment 1 had universal conclusions, while those of Experiment 3 had particular conclusions. If participants responses are affected by statement type as well as by consistency and believability, this could complicate any explanatory theory. Still, it would support this dissertation's claim that non-logical influences are underestimated. This influence of statement type should be investigated in the future.

Experiment 3 did not find a main effect of gender on acceptance rates, but did find females had significantly higher mean percentage belief bias than males. Experiment 1 found a main effect of gender on acceptance rates, but not for belief bias; Experiment 2 found no main effect of gender on either acceptance rates or belief bias. This was the second finding that failed to replicate across experiments, and, again, it is unclear why. Gender differences should be further investigated in the future.

The most interesting result from Experiment 3 was the failure to find any instructional effect on either acceptance rates or belief bias. In fact, the augmented instructions, which explained how to solve syllogisms using logical principles, failed to improve performance on any problem type except one. False Cqn DF problem acceptance rates decreased from 5.9% to 0%. The effect was expected to be most evident for IND syllogisms, as it is there that
most errors occur. Subjects demonstrated an understanding of necessity by successfully solving DF and valid problems, but apparently were unsure of how to respond when faced with a conclusion which was neither determinately true nor determinately false.

It was believed that giving participants instructions that focused their attention on the concept of necessity, explained it, and provided 2 illustrative examples, would be sufficient to improve their performance. It was not. Subjects did not easily abandon their beliefs or their adherence to the consistency cue. Either their responses are the result of automatic biases, or the result of deeply entrenched strategies highly resistant to change.

This experiment also tested the two explanations for the logic by belief interaction, as did Experiment 2. Again, both were falsified by the results. There was, however, a replication of a 3 way interaction of logic, belief, and consistency.

Collectively, these experiments demonstrate that participants who are judging the logical "acceptability" of conclusions to thematic syllogisms are influenced by the consistency and believability of the conclusions, as well as the problems' logical validity. And their judgments, to some extent, may reflect an effect of gender, although results were inconsistent. No current theories can account for the effects of consistency with atmosphere found in these experiments, and very few address the issue of gender differences.
In the past, whenever predictions of the so-called "atmosphere theory" were confirmed, they were dismissed as methodological artifacts. (In spite of the fact that results consistent with the theory have been found across paradigms.) As Evans et al. (1993) have pointed out, many researchers, who emphasized logical processing, were disturbed that such simple principles could successfully predict responses. Critics of atmosphere theory faulted it because it could not explain why people responded according to its principles.

It is generally held that the influence of believability is inversely proportional to that of logical validity. This influence, in these experiments, to be lowest for both DF syllogisms and valids, and highest for IND syllogisms. The influence was relatively constant for most IND problems, though lower for CNone IND forms. This does seem to support the idea that belief's influence is decreased when the influence of logical reasoning is increased. The question is then raised as to why the influence of logical reasoning is greater when participants are solving DF and valid problems.

The answer, already touched on, resembles one given in the misinterpreted necessity account to explain belief bias. DF problems are those where correct reasoning results in an impossible conclusion, one which is falsified by the premises (it is 0% probable). Valid syllogisms are
those where correct reasoning results in an irrefutable conclusion, one which is determined by the premises (it is 100% probable). These two results of reasoning are salient to participants, especially when they are asked to make a binary decision to accept or reject a conclusion.

Subjects solving thematic syllogisms are believed to be simultaneously influenced by logical reasoning, the conclusion's consistency with quality and/or quality (which is a linguistic cue), and their own beliefs. But in those instances where logic determines that a conclusion follows with 0% or 100% probability, this influence of logic is hypothesized to be more heavily weighted than that of the non-logical factors. Conversely, in instances where logical reasoning determines that the probability of a conclusion's being true is somewhere between these two extremes, participants are more likely to rely on and weight other influences more heavily.

For example, correct logical processing of IND syllogisms fails to result in a definitive answer as to whether a conclusion should be accepted or rejected. The conclusion is neither impossible nor irrefutable based on the premises, but it could possibly be true or even highly probable. If participants normally engage in inductive rather than deductive reasoning, they would not know from their logical processing alone, whether to accept or reject such an inference. This would depend on their assessments of the probability of the inference being true. In the
face of this uncertainty, participants would rely on the only two sources of information at hand: the linguistic cues provided by the premises (quality and quantity), and the believability of the conclusion.

The fact that invalid CBoth IND problems were accepted by more than half of all the participants in these experiments could be interpreted as supporting the hypothesis that participants tend to rely more on consistency cues than logic. (Even Cql IND problems were accepted by nearly half of all participants, except in Experiment 2, where there were odd problems in this group). As CNone IND problems, are not consistent with either quality or quantity, this linguistic cue indicates the conclusion should be rejected. In fact, these problems, did have lower acceptance rates than any other IND problems.

It is interesting that more DF problems were solved correctly than valid problems. As already mentioned, it would seem that in order to correctly infer that a conclusion is impossible (presumably because it contradicts the valid conclusion) one must first know what that valid conclusion is. The fact that there is evidence to the contrary implies that something besides logical reasoning accounts for this. We are more prone to reject that which is impossible (because contradictory evidence exists) than we are to accept that which appears to be irrefutable (because contradictory evidence is lacking). The reason
may be attributed to our having experienced numerous occasions where contrary evidence is ultimately found.

Despite the clear evidence of atmosphere effects provided by these experiments, one could still argue that they are an artifact of the methodology, that forcing participants to make a binary decision to accept or reject a conclusion accounts for this pattern of responses. But a convincing defense of this position would require more than conjecture. One would be obliged to show that the same syllogisms used in these experiments would elicit a different pattern of responses, with no atmosphere effects, when presented to participants within a different experimental paradigm. Subjects could, for example, be asked to select the correct response from a list of five responses, or asked to give a probability assessment of particular conclusions, or even asked to generate a conclusion.

On the other hand, one could argue that the paradigm of binary choice, used in this series of experiments, closely replicates reasoning in ordinary life situations. That is, the normal situation is where we are presented with a body of evidence, which we then assess as either supporting a particular conclusion or not. Whether the results reported here are artifacts of the methodology or representative of everyday reasoning, they should be of value to future research.
In summary, these experiments indicate that non-logical factors play an important role in syllogistic reasoning, when participants are judging whether to accept or reject a conclusion. There may be even more factors relevant to response patterns that should be investigated further. For example, Johnson-Laird & Byrne (1991) found evidence of a bias towards generating a conclusion of the same propositional type as one of the premises. The experiments in this dissertation revealed that certain Cql syllogisms elicited atypical responses. It is unclear whether gender may be a relevant factor; further study should give a clearer picture of how it is related to response patterns.

Perhaps the most important implication of these collective results is pedagogical: correct deductive logical reasoning, is not easy to attain or to induce. Nor should it necessarily be so. Instructions, that both explained the concept of logical necessity and included a procedure for correctly responding to syllogisms based on this concept, were not even marginally effective in reducing participants' biases. The reason for this non-effect may rest on the fact that the principles underlying deductive syllogistic reasoning and normal (informal) reasoning are quite different in kind.

Correct deductive inference is content independent. Introductory logic classes typically spend weeks, even months, examining different techniques and principles that ensure correct syllogistic reasoning. This requires an
understanding of the logical concepts of validity and necessity. Students are trained to focus on the structure of an argument, rather than its context, its content, or their own prior knowledge. They are taught methods to determine whether an argument's structure ensures the truth of its conclusion, when the premises are true.

Normal or everyday human reasoning, on the other hand, is semantic by its very nature, as Johnson-Laird and Byrne (1991) have pointed out. It is primarily inductive, rather than deductive, which means it has little to do with necessity, and everything to do with probability. The reasoner must assess the likelihood that a conclusion will follow from certain premises. Context, content, and prior knowledge directly bear on these assessments.

So, when we give participants deductive tasks, we may think we are measuring their logical capabilities, as reflected in their judgments of deductive validity. But, we may be measuring the influence of their biases, as participants appear to be accepting or rejecting conclusions based on their assessments of inductive strength, not logical validity. Perhaps it would be prudent to deemphasize the teaching of traditional deductive logic and determinations of validity, and reemphasize inductive logic like analogical reasoning, probability theory, fallacies, or fuzzy logic. This approach would be more compatible with how we seem to adapt to our environment.
Whether participants solving syllogistic reasoning problems are judging validity or assessing probability, the findings presented in this dissertation, of over 250 participants solving 110 syllogisms, should provoke interesting debate among proponents of the major theories of reasoning.
REFERENCES


Wilkins, M. C. (1928). The effect of changed material on the ability to do formal syllogistic reasoning. Archives of Psychology, New York, no. 16.


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# APPENDIX

## SYLLOGISMS USED IN EXPERIMENT 1

### Valid

**Cql (Cql-nonCqn)**

<table>
<thead>
<tr>
<th>Syllogism</th>
<th>True/False</th>
<th>S</th>
<th>P</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EAO-2</strong></td>
<td>1. True</td>
<td>S: dogs</td>
<td>P: poodles</td>
<td>M: animals</td>
</tr>
<tr>
<td></td>
<td>2. False</td>
<td>S: poodles</td>
<td>P: dogs</td>
<td>M: animals</td>
</tr>
<tr>
<td><strong>EAO-3</strong></td>
<td>3. True</td>
<td>S: mammals</td>
<td>P: dogs</td>
<td>M: poodles</td>
</tr>
<tr>
<td></td>
<td>4. False</td>
<td>S: dogs</td>
<td>P: mammals</td>
<td>M: animals</td>
</tr>
<tr>
<td><strong>AEO-2</strong></td>
<td>5. True</td>
<td>S: mammals</td>
<td>P: dogs</td>
<td>M: animals</td>
</tr>
<tr>
<td></td>
<td>6. False</td>
<td>S: dogs</td>
<td>P: mammals</td>
<td>M: animals</td>
</tr>
<tr>
<td><strong>AAI-3</strong></td>
<td>7. True</td>
<td>S: animals</td>
<td>P: dogs</td>
<td>M: cats</td>
</tr>
</tbody>
</table>

### Invalid

**Cql (Cql-nonCqn)**

<table>
<thead>
<tr>
<th>Syllogism</th>
<th>True/False</th>
<th>S</th>
<th>P</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AEO-3 IND</strong></td>
<td>11. True</td>
<td>S: mammals</td>
<td>P: dogs</td>
<td>M: poodles</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Some \( P \) are \( M \)
Some \( M \) are not \( S \)
No \( S \) are \( P \)

Invalid

**Cqn** (nonCql-Cqn)

**EAA-2** DF

No \( P \) are \( M \)
All \( S \) are \( M \)
All \( S \) are \( P \)

**AAE-3** DF

All \( M \) are \( P \)
All \( M \) are \( S \)
No \( S \) are \( P \)

**AEA-4** DF

All \( P \) are \( M \)
No \( M \) are \( S \)
All \( S \) are \( P \)

**AAE-2** IND

All \( P \) are \( M \)
All \( S \) are \( M \)
No \( S \) are \( P \)

**AEA-3** IND

All \( M \) are \( P \)
No \( M \) are \( S \)
All \( S \) are \( P \)

**EAA-4** IND

No \( P \) are \( M \)
No \( M \) are \( S \)
All \( S \) are \( P \)

Invalid

**CNone** (nonCql-nonCqn)

**AEI-2** DF

All \( P \) are \( M \)
No \( S \) are \( M \)
Some \( S \) are \( P \)

True:
- 13. \( S: \) poodles, \( P: \) insects, \( M: \) dogs
- 15. \( S: \) mammals, \( P: \) dogs, \( M: \) animals
- 17. \( S: \) insects, \( P: \) mammals, \( M: \) dogs
- 19. \( S: \) robins, \( P: \) mammals, \( M: \) animals
- 21. \( S: \) mammals, \( P: \) poodles, \( M: \) dogs
- 23. \( S: \) mammals, \( P: \) poodles, \( M: \) poodles
- 25. \( S: \) cats, \( P: \) poodles, \( M: \) dogs
- 27. \( S: \) poodles, \( P: \) poodles, \( M: \) dogs

False:
- 14. \( S: \) poodles, \( P: \) dogs, \( M: \) frogs
- 16. \( S: \) mammals, \( P: \) dogs, \( M: \) animals
- 18. \( S: \) mammals, \( P: \) dogs, \( M: \) cats
- 20. \( S: \) cats, \( P: \) dogs, \( M: \) mammals
- 22. \( S: \) poodles, \( P: \) dogs, \( M: \) poodles
- 24. \( S: \) mammals, \( P: \) poodles, \( M: \) poodles

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OAA-3 DF
Some M are not P
All M are S
All S are P

IAE-4 DF
Some P are M
All M are S
No S are P

IAE-2 IND
Some P are M
All S are M
No S are P

AAO-3 IND
All M are P
All M are S
Some S are not P

AAO-4 IND
All P are M
Some M are not S
All S are P

S: dogs
P: mammals
M: animals

S: insects
P: birds
M: robins

S: cats
P: dogs
M: poodles

S: dogs
P: mammals
M: animals

S: robins
P: birds
M: animals

S: mammals
P: insects
M: animals

30. False
31. True
32. False
33. True
34. False
35. True
36. False
37. True
38. False
SYLLOGISMS USED IN EXPERIMENT 2

Valid
CBoth  (Cql-Cqn)

EIO-1
1. True
No M are P  S: mammals
Some S are M  P: cats
Some S are not P  M: lions

ACO-2
3. True
All P are M  S: reptiles
Some S are not M  P: reptiles
Some S are not P  M: lizards

AII-3
5. True
All M are P  S: fish
Some M are S  P: salmon
Some S are P  M: trout

AEE-4
7. True
All P are M  S: sparrows
No M are S  P: pigeons
No S are P  M: birds

Valid
Cql  (Cql-nonCqn)

AAI-1
9. True
All M are P  S: fish
All S are M  P: trout
Some S are P  M: animals

AEO-2
11. True
All P are M  S: birds
No S are M  P: sparrows
Some S are not P  M: animals

AAI-3
13. True
All M are P  S: mammals
All M are S  P: rabbits
Some S are P  M: lions

1. True 2. False
S: mammals  P: cats  M: lions

3. True 4. False
S: reptiles  P: reptiles  M: animals

5. True 6. False
S: fish  P: salmon  M: trout

7. True 8. False
S: sparrows  P: pigeons  M: rabbits

9. True 10. False
S: fish  P: trout  M: rabbits

11. True 12. False
S: birds  P: sparrows  M: birds

13. True 14. False
S: mammals  P: rabbits  M: lions

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<table>
<thead>
<tr>
<th>EAO-4</th>
<th>15. True</th>
<th>16. False</th>
</tr>
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<tbody>
<tr>
<td>No ( P ) are ( M )</td>
<td>( S: ) animals</td>
<td>( S: ) reptiles</td>
</tr>
<tr>
<td>All ( M ) are ( S )</td>
<td>( P: ) reptiles</td>
<td>( P: ) animals</td>
</tr>
<tr>
<td>Some ( S ) are not ( P )</td>
<td>( M: ) snakes</td>
<td>( M: ) snakes</td>
</tr>
</tbody>
</table>

Invalid

CBoth (Cql-Cqn)

<table>
<thead>
<tr>
<th>IAI-1</th>
<th>17. True</th>
<th>18. False</th>
</tr>
</thead>
<tbody>
<tr>
<td>Some ( M ) are ( P )</td>
<td>( S: ) mammals</td>
<td>( S: ) cats</td>
</tr>
<tr>
<td>All ( S ) are ( M )</td>
<td>( P: ) lions</td>
<td>( P: ) lizards</td>
</tr>
<tr>
<td>Some ( S ) are ( P )</td>
<td>( M: ) cats</td>
<td>( M: ) mammals</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OOO-2</th>
<th>19. True</th>
<th>20. False</th>
</tr>
</thead>
<tbody>
<tr>
<td>Some ( P ) are not ( M )</td>
<td>( S: ) animals</td>
<td>( S: ) pigeons</td>
</tr>
<tr>
<td>Some ( S ) are not ( M )</td>
<td>( P: ) pigeons</td>
<td>( P: ) animals</td>
</tr>
<tr>
<td>Some ( S ) are not ( P )</td>
<td>( M: ) birds</td>
<td>( M: ) birds</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EAE-3</th>
<th>21. True</th>
<th>22. False</th>
</tr>
</thead>
<tbody>
<tr>
<td>No ( M ) are ( P )</td>
<td>( S: ) trout</td>
<td>( S: ) trout</td>
</tr>
<tr>
<td>All ( M ) are ( S )</td>
<td>( P: ) mammals</td>
<td>( P: ) fish</td>
</tr>
<tr>
<td>No ( S ) are ( P )</td>
<td>( M: ) salmon</td>
<td>( M: ) mammals</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IEO-4</th>
<th>23. True</th>
<th>24. False</th>
</tr>
</thead>
<tbody>
<tr>
<td>Some ( P ) are ( M )</td>
<td>( S: ) reptiles</td>
<td>( S: ) snakes</td>
</tr>
<tr>
<td>No ( M ) are ( S )</td>
<td>( P: ) snakes</td>
<td>( P: ) reptiles</td>
</tr>
<tr>
<td>Some ( S ) are not ( P )</td>
<td>( M: ) rabbits</td>
<td>( M: ) rabbits</td>
</tr>
</tbody>
</table>

Invalid

Cql (Cql-nonCqn)

<table>
<thead>
<tr>
<th>EEO-1</th>
<th>25. True</th>
<th>26. False</th>
</tr>
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<tbody>
<tr>
<td>No ( M ) are ( P )</td>
<td>( S: ) reptiles</td>
<td>( S: ) snakes</td>
</tr>
<tr>
<td>No ( S ) are ( M )</td>
<td>( P: ) snakes</td>
<td>( P: ) reptiles</td>
</tr>
<tr>
<td>Some ( S ) are not ( P )</td>
<td>( M: ) lizards</td>
<td>( M: ) lizards</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AAI-2</th>
<th>27. True</th>
<th>28. False</th>
</tr>
</thead>
<tbody>
<tr>
<td>All ( P ) are ( M )</td>
<td>( S: ) animals</td>
<td>( S: ) rabbits</td>
</tr>
<tr>
<td>All ( S ) are ( M )</td>
<td>( P: ) salmon</td>
<td>( P: ) salmon</td>
</tr>
<tr>
<td>Some ( S ) are ( P )</td>
<td>( M: ) fish</td>
<td>( M: ) fish</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AEO-3</th>
<th>29. True</th>
<th>30. False</th>
</tr>
</thead>
<tbody>
<tr>
<td>All ( M ) are ( P )</td>
<td>( S: ) animals</td>
<td>( S: ) birds</td>
</tr>
<tr>
<td>No ( M ) are ( S )</td>
<td>( P: ) birds</td>
<td>( P: ) animals</td>
</tr>
<tr>
<td>Some ( S ) are not ( P )</td>
<td>( M: ) sparrows</td>
<td>( M: ) sparrows</td>
</tr>
<tr>
<td>S</td>
<td>P</td>
<td>M</td>
</tr>
<tr>
<td>----</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>31. True</td>
<td>S: lions</td>
<td>M: cats</td>
</tr>
<tr>
<td>32. False</td>
<td>S: cats</td>
<td>M: rabbits</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S</th>
<th>P</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>33. True</td>
<td>S: sparrows</td>
<td>M: birds</td>
</tr>
<tr>
<td>34. False</td>
<td>S: pigeons</td>
<td>M: sparrows</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S</th>
<th>P</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>35. True</td>
<td>S: fish</td>
<td>M: lions</td>
</tr>
<tr>
<td>36. False</td>
<td>S: lions</td>
<td>M: rabbits</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S</th>
<th>P</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>37. True</td>
<td>S: reptiles</td>
<td>M: snakes</td>
</tr>
<tr>
<td>38. False</td>
<td>S: animals</td>
<td>M: reptiles</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S</th>
<th>P</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>39. True</td>
<td>S: trout</td>
<td>M: fish</td>
</tr>
<tr>
<td>40. False</td>
<td>S: trout</td>
<td>M: fish</td>
</tr>
</tbody>
</table>

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SYLLOGISMS USED IN EXPERIMENT 3

Valid
CBoth (Cql-Cqn)

AOO-2

1. True

All P are M
Some S are not M
Some S are not P

1. True

S: dogs
P: poodles
M: animals

2. False

S: dogs
P: mammals
M: poodles

AII-3

3. True

All M are P
Some M are S
Some S are P

3. True

S: snakes
P: cobras
M: reptiles

4. False

S: iguanas
P: snakes
M: pythons

Valid
Cql (Cql-nonCqn)

AEO-2

5. True

All P are M
No S are M
Some S are not P

5. True

S: aquatic animals
P: sharks
M: fish

6. False

S: sharks
P: fish
M: aquatic animals

AAI-3

7. True

All M are P
All M are S
Some S are P

7. True

S: birds
P: robins
M: blue jays

8. False

S: birds
P: frogs
M: robins

Invalid IND
CBoth (Cql-Cqn)

AII-2

9. True

All P are M
Some S are M
Some S are P

9. True

S: fish
P: sharks
M: trout

10. False

S: pigs
P: trout
M: fish

OOO-3

11. True

Some M are not P
Some M are not S
Some S are not P

11. True

S: snakes
P: cobras
M: pythons

12. False

S: pythons
P: snakes
M: cobras

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<table>
<thead>
<tr>
<th>Invalid IND</th>
<th>Cqn (nonCql-Cqn)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AAI-2</strong></td>
<td>13. True</td>
</tr>
<tr>
<td>All P are M</td>
<td>S: mammals</td>
</tr>
<tr>
<td>All S are M</td>
<td>P: collies</td>
</tr>
<tr>
<td>Some S are P</td>
<td>M: dogs</td>
</tr>
<tr>
<td><strong>EEO-3</strong></td>
<td>15. True</td>
</tr>
<tr>
<td>No M are P</td>
<td>S: frogs</td>
</tr>
<tr>
<td>No M are S</td>
<td>P: robins</td>
</tr>
<tr>
<td>Some S are not P</td>
<td>M: birds</td>
</tr>
<tr>
<td><strong>Invalid IND</strong></td>
<td>CNone (nonCql-nonCqn)</td>
</tr>
<tr>
<td><strong>AIO-2</strong></td>
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</tr>
<tr>
<td>All P are M</td>
<td>S: snakes</td>
</tr>
<tr>
<td>Some S are M</td>
<td>P: pythons</td>
</tr>
<tr>
<td>Some S are not P</td>
<td>M: cobras</td>
</tr>
<tr>
<td><strong>OIO-3</strong></td>
<td>19. True</td>
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<tr>
<td>Some M are not P</td>
<td>S: birds</td>
</tr>
<tr>
<td>Some M are not S</td>
<td>P: blue jays</td>
</tr>
<tr>
<td>Some S are P</td>
<td>M: robins</td>
</tr>
<tr>
<td><strong>Invalid IND</strong></td>
<td>CNone (nonCql-nonCqn)</td>
</tr>
<tr>
<td><strong>AAO-2</strong></td>
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<tr>
<td>All P are M</td>
<td>S: mammals</td>
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<tr>
<td>All S are M</td>
<td>P: trout</td>
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<tr>
<td>Some S are not P</td>
<td>M: fish</td>
</tr>
<tr>
<td><strong>AEI-3</strong></td>
<td>23. True</td>
</tr>
<tr>
<td>All M are P</td>
<td>S: dogs</td>
</tr>
<tr>
<td>No M are S</td>
<td>P: collies</td>
</tr>
<tr>
<td>Some S are P</td>
<td>M: spiders</td>
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<tr>
<td><strong>Invalid IND</strong></td>
<td>Cqn (nonCql-Cqn)</td>
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<tr>
<td><strong>EAA-2</strong></td>
<td>25. True</td>
</tr>
<tr>
<td>No P are M</td>
<td>S: robins</td>
</tr>
<tr>
<td>All S are M</td>
<td>P: animals</td>
</tr>
<tr>
<td>All S are P</td>
<td>M: birds</td>
</tr>
</tbody>
</table>

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AAE-3 27. True 28. False

All M are P  S: pigs  S: fish
All M are S  P: fish  P: trout
No S are P  M: sharks  M: sharks

Invalid DF
CNone (nonCql-nonCqn)

AEI-2 29. True 30. False

All P are M  S: reptiles  S: cobras
No S are M  P: cobras  P: pythons
Some S are P  M: snakes  M: snakes

AIE-3 31. True 32. False

All M are P  S: spiders  S: poodles
Some M are S  P: dogs  P: dogs
No S are P  M: collies  M: collies
VITA

Roberta (Bobbie) Love graduated in 1962 from Douglass College, Rutgers University, majoring in mathematics and philosophy. She accepted a position at ESSO (Exxon) Research and Engineering Company in Florham Park, New Jersey, where she designed equipment for chemical plants.

After marrying, she retired from Exxon and raised three daughters. She and her husband were transferred from New Jersey, to California, Rome (Italy), Normandy (France), and Louisiana (3 times).

In 1982, she entered the Pass program at Louisiana State University. Over a period of 4 years, she took courses in computer Science and philosophy. In 1986, she received a Master of Arts degree in philosophy. Since then, she has been teaching an introductory logic course in the Department of Philosophy.

In 1988, she entered the graduate program in the Department of Psychology. Her main interest was in deductive reasoning research, using tasks like the Wason Selection Task, conditional statements, and syllogisms. In 1990, she received a Master of Arts degree in Psychology. She presented the result of her research in a poster session at the annual meeting of the International Congress of Psychology at Brussels, in 1992. She also co-authored a paper on the Wason task, which was published in the British psychology journal, Thinking and Reasoning in 1995.
Bobbie hopes to resume teaching critical reasoning courses in the Department of Philosophy at Louisiana State University, while continuing to conduct research on deductive and inductive reasoning.
DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: Roberta E. Love

Major Field: Psychology

Title of Dissertation: Atmosphere Effects Revisited: The Effect of Atmosphere on Judgments of Validity Using Thematic Syllogisms

Approved:

[Signatures]

Major Professor and Chairman
Dean of the Graduate School

EXAMINING COMMITTEE:

[Signatures]

Date of Examination:

April 13, 1998