AMBIGUITY AS A PREDICTOR OF SYLLOGISTIC DIFFICULTY

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ABSTRACT

AMBIGUITY AS A PREDICTOR OF SYLLOGISTIC DIFFICULTY

By

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Bettinghaus, Miller, and Steinfatt (1970) investigated the relationship between the cognitive style variable of dogmatism and the ability to evaluate syllogistic validity. Their results suggest that different syllogistic forms may vary in difficulty and that the meaningfulness of the syllogistic terms, and the dogmatism of the persons judging the syllogisms, may affect this difficulty.

The present study sought to extend the Bettinghaus et al. findings by examining the relationship of syllogistic ambiguity and judgmental difficulty. A set of 21 logically unique syllogistic premise combinations was selected to represent all possible syllogistic forms. Each of these premise combinations was presented to 207 subjects with high meaningful and with low meaningful trigrams as the terms of the syllogisms. Two conclusions appeared with each premise combination, at least one of which could have produced an atmosphere effect.

It was hypothesized that the degree of difficulty of judgment of the validity-invalidity of a syllogistic conclusion would increase directly with the ambiguity of the premise combination associated with that syllogism. Ambiguity was defined by considering a source who encodes a message which is capable of being transformed into a syllogism. The receiver is assumed to be unaware of the original relationship between the terms of the syllogism which led the source to encode the message. In judging the validity of the syllogism, the receiver must attempt to reconstruct this source-observed relationship by analyzing the premises.

Given any two premises involving three terms, there are between two and eighty possible relationships which could obtain between the three terms, assuming the truth of the premises. The ambiguity of a premise combination is defined as this number: the number of possible relationships between the terms of a syllogism from which the premise combination of the syllogism could have originated. The receiver must sort through each of these relationships to determine if the conclusion is valid. As the number of relationships increases, so does the probability that the receiver will fail to consider, or will confuse, one or more possible relationships, and thus will judge the validity-invalidity of the syllogism incorrectly.

The results support the hypothesis. The main effect for syllogistic forms is significant at the .001 level, indicating that there are differences in difficulty among different syllogistic forms. A correlation of .695 was obtained between the observed rank order and the order predicted by the ambiguity hypothesis for the 21 syllogistic forms.

Term meaningfulness was found to interact with the syllogistic form variable such that for certain forms, low meaningful content was easier to judge, while for others, low meaningful content was more difficult. These differences were significant for only three of the 21 items at the .01 level.

An atmosphere-type effect was observed with five of the 21 items. Dogmatism did not enter into any significant effect.

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By

Thomas Martin Steinfatt

A THESIS

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DEDICATION

To Walter Louis Steinfatt, my father.
He was a great bridge player.

And to John Shawanibin, my friend.
He was a great hockey player.

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* * * *

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION AND RATIONALE

As McGuire points out, "the 'RATIONAL MAN' CONCEPT, long out of fashion in the behavioral sciences, is now undergoing a remarkable revival in the study of cognition" (1960, p. 65). This study extends that revival by attempting to establish a baseline on the difficulty of judging the validity-invalidity of different syllogistic forms over different levels of meaning for subjects of varying degrees of dogmatism.

Bettinghaus, Miller, and Steinfatt (1970) investigated the relationship between the cognitive style variable of dogmatism and the ability to evaluate syllogistic validity. They found support for the hypothesis that low dogmatic persons are better able to judge the validity of logical syllogisms than are high dogmatic persons when such syllogisms originate from positive and negative sources. A prediction of a second order interaction between dogmatism, validity, and source evaluation was also confirmed. These researchers used a pretest to determine which of nine valid and nine invalid syllogistic forms would be answered correctly by about half of all subjects. The terms used in these pretest syllogisms were abstract; specifically, they

were the capital letters A, B, and C. Two valid and two invalid forms were observed to have between 45 percent and 54 percent correct responses from all subjects with the abstract terms.

When more meaningful terms were employed in the main test (words and phrases concerning the war in Vietnam) the percentage of correct responses for each of the four forms changed radically from that obtained with abstract terms in the syllogisms. This was true despite rather elaborate counterbalancing of the experimental conditions intended to equalize the probability of correct judgments on valid and invalid syllogisms. Subjects who judged syllogisms containing meaningful terms gave significantly more correct answers for valid than for invalid items.

The four forms found to be of near median difficulty when using abstract terms were: (1) the Third figure (Ambrose and Lazerowitz, 1948, p. 265), containing EI premises and an O conclusion; (2) the Third figure, containing EI premises and an I conclusion; (3) the Second figure, containing EI premises and an O conclusion; and (4) the First figure, containing II premises and an I conclusion. Syllogisms (1) and (3) are valid and (2) and (4) are invalid. The percentage of correct responses to syllogisms with high meaningful terms using each of these forms was: (1) EIO3, 78 percent; (2) EII3, 77 percent; (3) EIO2, 60 percent; and (4) III1, 22 percent. Thus, the significant main effect for

valid over invalid items was not general, but was due almost exclusively to syllogisms of the III1 figure type. However, the Bettinghaus et al. study was not designed in such a way that the relationship between correct judgments of validity-invalidity and a syllogistic form factor could be analyzed, since their design purposely included only four syllogistic forms.

As mentioned above, Bettinghaus et al. also found that high dogmatic subjects were significantly less able to judge syllogistic validity-invalidity than low dogmatics when the syllogisms originated from positive and negative sources. By inspecting the percentages of correct responses given by high and low dogmatic subjects, they discovered that on certain syllogisms with high meaningful content, low dogmatics gave many more correct responses than high dogmatics but on most items the low dogmatics did only slightly better than the high dogmatic subjects. The syllogisms showing large differences in favor of the low dogmatics were of the III1 figure and the EII3 figure. This finding suggests the possibility of an interaction between dogmatism and a syllogistic form factor, but gives few clues as to the nature of such an interaction since only four syllogistic forms were involved and three of these employed the same premise combination (EI).

To summarize, the form of the syllogism employed in the Bettinghuas et al. study appears to have affected the

validity-invalidity factor to the extent that a significant validity main effect occurred when high meaningful terms were employed in the syllogisms, and high and low dogmatic subjects appear to have been affected differentially by differing syllogistic forms. Although the predicted significant second order interaction between dogmatism, source, and validity does not appear to have been enhanced or hampered by the form of the syllogisms employed, the discrepancies in percentage of correct judgments reported between syllogisms employing abstract terms and those employing more meaningful terms suggests that checking a given syllogistic form for ease of judgment of validity with abstract content is not an adequate control for difficulty of judging syllogistic validity when the terms of the syllogism are highly meaningful.

These findings suggest that three factors and their relationships need study before the Bettinghaus et al. results can be fully understood. These variables are dogmatism, syllogistic form, and term meaningfulness. An understanding of the relationships between these three variables is of interest in itself, and information concerning these relationships and the criterion variable of judgment of syllogistic validity-invalidity may be necessary to control for the differential effects, if any, of varying syllogistic forms and high and low term meaningfulness in future studies with high and low dogmatic persons.

Dogmatism Factor

As mentioned above, Bettinghaus et al. hypothesized and found a relationship between the degree of dogmatism of a subject and his ability to judge the validity-invalidity of non-abstract syllogisms. Since this personality trait appears to be related to judgmental ability, a study attempting to establish baselines for the ability to judge syllogisms should take it into account. In discussing the distinction between high and low dogmatic subjects, Rokeach states that the more closed the belief system of an individual, the more

> the relation among beliefs should depend on such irrelevant considerations [as outside authority] rather than on considerations of logical consistency. Isolation between parts [as in a closed system] reflects a tendency not to relate beliefs to the inner requirements of logical consistency, but to assimilate them wholesale, as fed by one's authority figure. On the other hand, the more open the system, the more should the person address himself to objective structural requirements--that is, logical relationships. . . (1960, p. 61).

This statement led Bettinghaus et al. to hypothesize the relationship stated above, but the hypothesis was limited to syllogisms originating from positive and negative sources.

Since positive and negative sources were not linked to the items used in this study, no dogmatism effect was predicted or expected. Still, the inclusion of dogmatism as a factor in this experiment seemed justified both by the Bettinghaus et al. findings, which suggest a possible

interaction of dogmatism and syllogistic form on particular syllogistic forms, and by way of establishing the necessity of positive and negative sources in producing a dogmatism effect.

Meaningfulness Factor

Bettinghaus et al. found striking differences in the judgmental behavior of the same subjects when confronted with the task of judging syllogisms with meaningful content as opposed to judging those same syllogisms with the capital letters A, B, and C used as terms. The use of these capital letters as terms was an attempt to determine the relative difficulty of the syllogistic forms themselves without the intrusion of meaningful content on the subjects' judgmental processes. While appropriate for their study, this test of the relative difficulty of syllogistic forms has two features which reduce its generalizability. First, the letters A, B, and C may be more meaningful than Bettinghaus et al. assumed them to be, since no norms were available on the meaningfulness of these letters. Second, the syllogistic forms chosen for use were only those valid forms which had a specifically invalid counterform and those counterforms. This latter problem is discussed below and in Appendix I in some detail in arriving at a more general syllogistic form factor. The former problem is one of term meaningfulness.

Many studies have shown that the nature of the terms of a proposition may have a direct bearing on the probabilities of a given subject judging it to be valid or invalid (Bettinghaus et al., 1970; Feather, 1964; Janis and Frick, 1943; Lefford, 1946; Morgan and Morton, 1944; Parrott, 1967; Thistlethwaite, 1950; Thouless, 1959). Much of this literature indicates that many subjects attempt to judge the truth of the conclusion in terms of its consequence for their own beliefs, rather than its logical validity. McGuire (1960) refers to this distinction as being between "wishful thinking" and "logical thinking."

Henle and Michael take issue with this distinction, going so far as to refer to the findings of Morgan and Morton (1944) as "artifacts," since Morgan and Morton assume that the influences of attitudes on the judgment of syllogistic forms are arbitrary in nature, "that attitudes operate blindly, indifferent to the nature of the material on which they act" (1956, p. 125).

There are at least two distinctions involved in these studies that merit clarification. Most of the researchers cited above have employed syllogisms with some form of symbolic content as a control condition, along with the same syllogisms used as vehicles for expressing statements which have attitudinal implications in an experimental condition. At least two separate variables are involved in moving from symbolic content to attitudinal content:

meaningfulness and attitude. Symbolic content is usually assumed to be of low meaningfulness and to be non-attitudinal in nature. Words and phrases involved in the terms of syllogisms in experimental conditions are usually of the high meaningful, attitude relevant type. Differences found between these two types of conditions are related to changes in two independent variables, meaningfulness and attitude arousal, which are confounded in the experimental conditions.

Morgan and Morton seek to draw this distinction implicitly when they differentiate between syllogisms which contain nothing in their terms to arouse a response based on personal convictions and syllogisms whose terms relate to the personal opinions and fears of an individual (1944, pp. 58-59). Wilkins also approaches this distinction when she comments that "ability to do formal syllogistic reasoning is much affected by a change in the material reasoned about. The easiest material is the familiar and concrete. The most difficult is the unfamiliar" (1928, p. 77). Morgan and Morton's distinction is attitudinal while Wilkins' is one of meaningfulness.

As Henle and Michael point out, the effect of the attitudinal variable is specific to the relationship between the attitude held by the subject and the attitude expressed in the syllogism. Thus, the present study will not attempt to investigate this attitudinal variable; rather, it will investigate the effect of the meaningfulness variable. To

what extent does a change in the meaningfulness of the terms of a syllogism, without an attempt to relate the meaningfulness to relevant attitudes of the subjects, affect the ability of those subjects to judge the validity-invalidity of a syllogistic form?

Morgan and Morton (1944) suggest that no differences based on meaningfulness alone will occur across syllogistic forms, but little further research bears on this point. No general meaningfulness effect is predicted or expected, but on the basis of the Bettinghaus et al. findings, a meaningfulness effect which is specific to certain syllogistic forms might be expected. Present data do not enable the researcher to predict the particular forms on which this effect should occur. If such an effect were strong enough, an interaction between meaningfulness and syllogistic form should occur. However, due to the incompleteness of available data, no formal hypothesis about this effect seemed justified at this time.

Syllogistic Form Factor

The derivation of the syllogistic form factor and the method of choosing its levels are contained in Appendix I. Numerous writers have commented in detail on the nature of logical thought and its place in human reasoning. Henle (1962) summarizes many of these sentiments in discussing the relationship between logic and thinking. Unfortunately, little attention is given in her work, or in the work which

she cites, to a logical form-based mechanism which might determine the difficulty of judgment of a given syllogistic form. What might such a mechanism be?

The difficulty of a given task is related to the length of the task and the complexity of the task; i.e., the number of errors associated with the performance of a given task is often a function of the number of separate parts of the task and the complexity involved in the performance of each part. There are, of course, many other factors, such as fatigue and ability, which affect number of errors but consider the number of parts to the task and the complexity of each. Logicians often use Venn or Euler diagrams to illustrate the relationships involved between the terms of a syllogism. The number of such relationships can be shown to be different for different syllogisms, or more specifically, for different premise combinations. One possible mechanism involved in judging the validity-invalidity of a given syllogism would be for the subject to consider the number of ways the three terms of a syllogism could combine and then to examine the conclusion for validity in terms of these combinations. Given such a mechanism, the number of such combinations might be used as an index of the number of parts of, as well as the complexity of, the task of judging syllogistic validity.

This idea may be approached from another direction. Consider the two premises of a syllogism and ask the question,

"How did these two premises originate?" Any possible premise combination could arise from more than one situation involving a relationship between the three terms of the premises. In this sense, all premise combinations are ambiguous. It is not possible to learn from an examination of the premises the exact situation of relationship between the terms which led to the formulation of the premises. Judgment of the validity-invalidity of a syllogism involves the listing and sorting of the possible relationships between the terms as indicated by the premises, and the comparison of the conclusion with each of the possible relationships to see if it must hold true. Thus, it is not unreasonable to expect that the difficulty of judging the validity-invalidity of a syllogistic conclusion is directly related to the number of possible relationships between the terms of a syllogism that the premises allow. These relationships may be conceptualized as all the possible situations from which the premises could have arisen. The larger the number of such relationships, the more complex is the task; therefore, difficulty of judgment should increase accordingly. The number of such relationships will be referred to as the <u>ambiguity</u> of the premise combination. Given differences in ambiguity, the major hypothesis of this study may be stated as follows:

> The degree of difficulty of judgment of the validity-invalidity of a syllogistic conclusion will increase directly with the ambiguity of the premise combination associated with that syllogism.

To illustrate the grounds for the hypothesis, consider the ambiguity of the AA1 and the AE2 conditions. How many different relationships are there between X, Y, and Z which allow the AA1 premises to be true? AA1 is "all Y is X; all Z is Y." There are four possible situations which a source with an intent to communicate could have examined and truthfully stated about each of the four that "all Y is X; all Z is Y." These four are: (1) X, Y, and Z are in identity with each other; (2) X and Y are in identity with each other and Z is contained within them; (3) Y and Z are in identity with each other and are contained in X; and (4) Z is contained in Y and Y is contained in X. There are no other possibilities which are different, as defined. Thus, the ambiguity of the AA1 condition is four. Continuing, the AE2 condition is "all X is Y; no Z is Y." How many situations could a source have examined and come up with these two statements, assuming that they are true? This is part of the question the receiver of the syllogism asks himself in order to determine its validity or invalidity. The answer here is two, and the receiver must check each of these with the conclusion to determine its validity (assuming a naïve receiver who is unfamiliar with a logician's

rules and shortcuts). The two are: (1) X and Y are in identity and Z is outside of them, and (2) X is contained within Y and Z is outside of Y. The ambiguity of AE2 is, thus, two. The major hypothesis of the study states that more errors should be expected in the AA1 condition than in the AE2 condition, since the AA1 is more ambiguous than the AE2.

In actual practice it may not be the case that differences in level of difficulty show up with small numerical changes in ambiguity, changes say, from two to four. The larger the increase in ambiguity, the more such differences should become apparent. A general method for determining the ambiguity of any premise combination is given in Appendix II, and a list of the ambiguity associated with each of the premise combinations used in this study is found in Chapter II, Table 1.

In summary, this study was generally concerned with variables affecting the ability of an individual to judge the validity or invalidity of a logical syllogism. Twenty-one logically unique syllogistic premise combination types were used in the study. A representative of each of these combinations was selected and these 21 premise combinations and conclusions became the 21 levels of a syllogistic form factor. A term meaningfulness factor was utilized to determine the effect of low and high meaningfulness of the terms of the syllogism on the ability to judge syllogistic

validity. Finally, subjects were grouped into three levels of a dogmatism factor: high, middle, and low. The major hypothesis of the study stated that the difficulty of judging the validity-invalidity of a given syllogistic form will vary directly with the ambiguity associated with the premise combination of that form. While an interaction between meaningfulness and syllogistic form might be suspected, insufficient information existed to justify a formal prediction. Due to the absence of positive and negative sources, dogmatism was not expected to produce a significant effect.

CHAPTER II

METHOD AND PROCEDURES

Subjects

A total of 229 Ss participated in the study. Ss were students enrolled in the basic speech course at The Cleveland State University. A total of 22 of the 229 Ss were discarded before the data were analyzed. Three of these were observed by proctors to be marking responses without looking at the test booklet; six were discarded for marking undefined responses on the answer sheet, and the remaining 13 were discarded for failure to respond to all items. This last number was minimized by checking each test booklet for completion as it was handed in. Thus, data from 207 of the original 229 subjects were analyzed.

The test booklet consisted of two parts. The first part contained 42 premise combinations, each premise combination having two conclusions stated below it for a total of 84 items. Part Two was the 20 item short form of the dogmatism scale (Rokeach, 1960; Troldahl and Powell, 1965). Part One and Part Two were separated by a single sheet of paper which instructed the subject to continue on. Each part contained a machine scored response sheet.

The 42 premise combinations consisted of two sets of 21 premise combinations, one set containing high meaningful terms and the second set containing low meaningful terms. These terms were all CVC trigrams obtained from Archer (1960) in the following manner. Nine low meaningful and nine high meaningful terms were chosen so they could be rotated in three groups of three, the trigrams in each group changing in each rotation. The criteria used for choosing the nine low meaningfulness trigrams were: (a) the first letter of each trigram must be different, (b) the middle letter of each trigram must not occur more than twice in the middle position (since there are only six vowels, three of them must repeat at least once in nine trigrams), (c) the third letter of each trigram must not occur more than twice in the third position for the nine terms, and (d) no letter may occur more than three times in the nine trigrams. The nine trigrams with the lowest collective average meaningfulness on criteria (a) through (d) were selected. These four criteria were intended to select nine low meaningful items which are easily recognizable as different from each other, so that no confusion between terms would occur. If the nine items lowest in meaning had been chosen, they would all have begun with X and would have appeared very similar. The nine low meaningful items chosen by the above method were XOM, RYW, TEJ, ZUF, YIV, VUQ, FAJ, PYB, and QIH. On Archer's

100 point scale, their meaningfulness ranges from 6 to 10, and averages 8.67.

The same four criteria were used to choose the high meaningful trigrams. In this case the nine trigrams with the highest collective average meaningfulness were selected. The criteria provided more leeway in the choosing of the nine high meaningful trigrams than in the nine low meaningful items, since there are many CVC trigrams with a meaningfulness score of 100. The nine high meaningfulness items chosen were those which met the above criteria and which were spaced relatively evenly throughout the alphabet in terms of their initial letter. These nine were BOY, FAR, HIM, JUG, NOD, PAL, TUB, WET, and ZIP, all of which have a meaningfulness score of 100. The 21 items in which the high meaningful trigrams were used formed the High Meaningful condition, and the 21 items employing the nine low meaningful trigrams formed the Low Meaningful condition.

Both the high and the low meaningful trigrams were alphabetized by first letter to form two lists. A correspondence was established such that for each usage of the trigram BOY in a premise combination or conclusion in a high meaningful item, the trigram FAJ appeared in exactly the same position in the corresponding low meaningfulness item, since BOY and FAJ are the respective first trigrams in terms of alphabetization. This correspondence was used for the

respective second, third, etc. pairs of low and high meaningfulness trigrams throughout the test booklet.

Twenty-one unique types of premise combinations were used in the study. Within each type, several forms are logically equivalent; i.e., they are reducible to each other and have the same set of term relationships from which they could have arisen. As indicated in Chapter I, one premise combination from each unique type was used to represent that type. The following method of selecting these particular premise combinations was employed. For those cases having only one premise combination of that type, that premise combination was used. This accounted for 8 of the 21 types. Of the remaining 13 types, all premise combinations which are the logical equivalent of each other contain the same two premise types; i.e., a given premise combination, such as an AE, can be logically equivalent only to another AE (or EA) premise combination. The distinctions between premise combinations within a given type are due to either difference of figure or difference of premise order. The premise orders in which the letter representing the first premise occurs first in the alphabet were arbitrarily chosen on that alphabetical basis. For example, AE was chosen over EA. Within the possible figures of a given premise combination type, it was desirable to employ one premise combination involving the same figure across all such premise combination types in which that figure is possible, in order

to control for a possible figure effect. That is, if figure one were used to represent one unique set of AA type premise combinations while figure three were used to represent a unique set of AI type premise combinations, where figure one could have been used with both types, any differences found between these two unique types would be confounded with premise figure. With the eight unique premise combination types for which there is only one case, such "confounding" is not really confounding, but rather an inherent difference between the premise combination types. Its introduction into the comparison between types in which such "confounding" is not an inherent condition of a given type does amount to true confounding of two distinct variables: figure, and premise combination type. For each unique premise combination type, the premise combination with the lowest figure number was arbitrarily chosen for this experiment.

It should be noted that the term "arbitrary" is used in a very restricted sense here, as it is with the choice of premise order. The possible alternatives in each case were reduced to a minimum level by the demands of the experiment and the constraints imposed by the control of extraneous variables in the experimental design. The arbitrariness of choice exists only within this minimum level. Thus, the only alternative to choosing the premise combination with the lowest figure number, given the above assumptions, would be to choose the premise combination with the highest or

second or third highest figure number in each case. These would work equally well.

The 21 premise combinations chosen by the above method to represent the syllogistic form factor of this experiment are contained in Table 1. In addition, the table lists the ambiguity score for each premise combination. The order of ambiguity is also the predicted order of difficulty for each of the combinations.

Table 1. Ambiguity of 21 syllogistic forms

Premise Combinations	Ambiguity Score
AE Second	2
AA First	4
EE First	5
AE First	6
AA Third	8
AA Second	10
EO Third	11
AO Second	12
EI First	12
AO Third	14
EO First	15
AI First	16
AO First	18
AO Fourth	18
AI Second	20
OO First	67
IO First	70
OO Second	73
OO Third	73
IO Third	76
II First	80

Note that in those cases where the ambiguity of two of the premise combinations is equal, the equality of ambiguity does not imply logical equality. The two premise combinations are logically unique in each case. The number of relationships is equal but they are different sets of relationships, as defined in Appendix II.

There are six possible conclusions in a syllogism, two A, two O, one E and one I. With 42 premise combinations, if each conclusion appeared with each premise combination, there would be a total of 252 items. Since it was desirable that each S judge each item for control purposes, and since fatigue effects increase rapidly with difficult judgmental tasks, it was decided to employ only two of the six possible conclusions for each premise combination. This resulted in a total of 84 items.

In a pretest with a group of 10 undergraduate students at the University of Michigan, it was determined that the average time required for 80 items of this type was between 20 and 40 minutes, but that this time increased to 40 to 70 minutes with 100 items. For 40 items the time ranged from 10 to 20 minutes. On this basis, it was determined that judging more than two conclusions for each premise combination might increase the fatigue effects to an unacceptably high level.

The use of two conclusions was considered more desirable than the use of one, in order to reduce error

variance due to such variables as guessing. For those premise combinations having two valid conclusions under the logical system explained in Appendix I, both conclusions were used. The valid conclusion of each premise combination having one valid conclusion was used along with an invalid conclusion. The six possible invalid conclusions were rotated through the items in which they appeared so that each appeared an equal number of times. One conclusion appearing with each syllogistic form was designed to check for a possible atmosphere effect (Woodworth and Sells, 1935).

In order to control for possible practice and fatigue effects associated with serial position, and in order to control for possible effects of the immediately preceding premise combination, six different orderings of the premise combinations were used. The two conclusions for each premise combination appeared in the same order for high and low meaningful items across all six forms of the test booklet. The 42 premise combinations were randomly ordered in the first form by means of a table of random numbers. The remaining five forms were ordered so that no premise combination was immediately preceded by the same premise combination more than once and so that the average rank order of each premise combination was between 19 and 23 out of the 42 positions.

Test Administration

The six forms were distributed such that every sixth person in the order of seating chosen by the subjects received a given form. The class instructor introduced the administrator as a person who would give instructions for filling out the test booklet. When six assistants finished passing out the booklets, Ss were asked by the administrator to look at the instructions, which were then read aloud by the administrator. The instructions contained a single example of a syllogism, one which did not appear in the test booklet.

Ss were instructed to judge whether each conclusion had to be true given that the premises were true. The instructions emphasized that the premises were always to be assumed true and that the judgmental task was to separate those conclusions which had to be true from those which might be true or might be false. Ss were told to assume the existence of all terms and were also told that the definition of "some" as used in the test items was "at least some" and not "only some." They were instructed not to go back and change answers on an item once they had begun the next item and not to look back to determine how they had responded to any previous items. The instructions stated that they should allow about 20 to 30 seconds per conclusion judged and that they could write on the test booklet if they wished.

Ss were told that the results of the test would have no bearing on their grades in the class. In order to provide motivation they were told by the administrator that the purpose of the test was to compare the performance of groups of undergraduates from different universities. They were also told that they need not put their name on the test booklet or on any answer sheet, but that they could put their name on the answer sheet for the syllogisms if they wanted to know how they had done.

The dogmatism items followed the syllogisms and had their own brief instructions. These items were represented as "statements which people have different opinions about" so that there were "no correct answers." No reason was given for including these 20 items in the test booklet.

Dogmatism Prediction

The apparent source of the test items was the test administrator. The administrator was introduced simply as a person who would tell the Ss what they would be doing during the class hour. No mention was made of his occupation or of any other personal data. According to interviews with 12 Ss immediately after the administration of the test, the administrator was seen as either an instructor or graduate student, but not as a person holding the rank of assistant professor or above. Two Ss stated that they believed the administrator was the employee of an educational testing service.

The Bettinghaus et al. study associated a positive or a negative source with each item used, by placing the name of the source and a brief description of his position above each item. In the present study, no sources were given for the syllogisms, so no direct linking of positive and negative sources with items occurred. As indicated earlier, Rokeach's theory would not predict a dogmatism effect without positive and negative sources being linked to the items. Thus, a dogmatism effect was not predicted for this experiment.

General Design and Analysis

The analysis of the data involves the factors of dogmatism, meaningfulness, and syllogistic form in a 3 x 2 x 21 design. Scores in the three dogmatism levels were treated as independent and scores in the two meaningfulness levels and 21 syllogistic form levels were treated as correlated, since each subject participated in each of the meaningfulness and syllogistic form conditions. In addition, all test booklets were examined for writing and figuring so that subjects who used paper-and-pencil-figuring in making their judgments could be analyzed separately from those who did not, in a second analysis.

CHAPTER III

RESULTS

Test of Major Hypothesis

The major hypothesis of this study is that the degree of difficulty of judgment of the validity-invalidity of a syllogistic conclusion will increase directly with the ambiguity of the premise combination associated with that syllogism. As an initial test of this hypothesis the data were subjected to a three factor analysis of variance with scores on the dogmatism levels assumed independent and scores on the meaningfulness levels and syllogistic form levels assumed correlated (Steinfatt, 1970, pp. 31, 33). The result of Hartley's test was not significant, indicating that the equality of variance assumption is satisfied.

The results of the analysis of variance are summarized in Table 2. The main effect for syllogistic form was significant ($p < .001$). This effect indicates that subjects gave significantly more correct responses to some syllogistic forms than to others. While the second-order interaction was not significant, the first-order interaction involving syllogistic form and meaningfulness was significant at the .001 level. The effect of this interaction on

Table 2. Three factor anova for scores of 207 subjects

Source	Sum of Squares	df	Mean Square	F
Between Subjects	361.3894	206		
A (Dogmatism)	6.5266	2	3.2633	1.8744
Subjects within groups	355.1628	204	1.7410	
Within Subjects	4358.3810	8487		
B (Meaningfulness)	0.1491	1	0.1491	< 1
AB	0.5638	2	0.2819	< 1
B x Subjects within groups	75.9538	204	0.3723	
C (Syllogistic Form)	523.4762	20	26.1738	50.2665*
AC	20.3430	40	0.5086	< 1
C x Subjects within groups	2124.5618	4080	0.5207	
BC	23.0441	20	1.1522	2.9757*
ABC	10.4024	40	0.2601	< 1
BC x Subjects within groups	1579.8868	4080	0.3872	

*$p < .001$.

the syllogistic form factor is described later in this chapter and discussed in Chapter IV.

The significant effect for syllogistic form justified a further test of the hypothesis by computing a Spearman rank order correlation between the predicted ranks and the obtained rankings for the combined meaningfulness levels. Ambiguity is not distributed normally in the population of syllogistic forms. Thus, the bivariate normal assumption of a Pearson product moment correlation could not be met and a rank order correlation was necessary. Either Spearman's rho or Kendall's tau could have been used and the Spearman method was chosen due to its greater familiarity to most researchers. The power-efficiency of each of these when compared with the Pearson r is 91 percent.

The Spearman rho between the predicted ranks and the obtained ranks is .695 with an N of 21 which is significant at the .01 level (Siegel, 1956, pp. 202-213, 284). This result offers further support for the hypothesis.

Spearman rhos were also calculated between the predicted ranks and the obtained ranks for high meaningfulness and low meaningfulness items separately to determine if the predictive power of the ambiguity measurement is enhanced by the use of either high or low meaningful terms in the syllogism. Rho for the high meaningfulness and ambiguity orders is .700 and .687 for the low meaningfulness and ambiguity orders, both of which are significant at .01.

This indicates that the hypothesis holds to approximately the same degree when either high meaningful or low meaningful terms are used in the syllogisms. These rankings are all listed in Table 3.

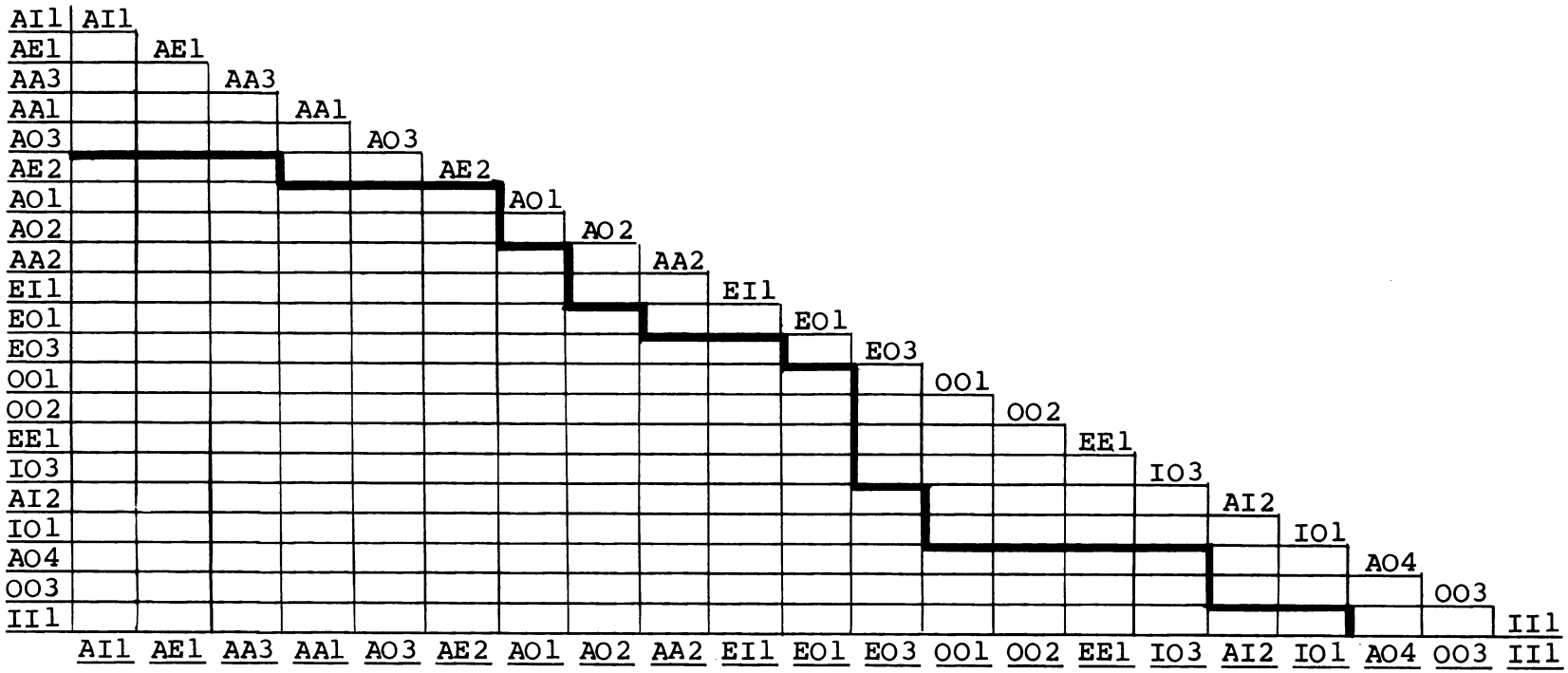
Individual Comparisons

The significant F for syllogistic form, along with the significant rho between predicted and obtained ranks, suggests a breakdown of significance between individual syllogistic forms. Table 4 contains a 21 x 21 triangular matrix of the significance of the difference between all pairs of means for each of the 21 syllogistic forms. All differences below the heavy line are significant at the .01 level by the Newman-Keuls method (Winer, 1962, pp. 77-89, 309-310). The large number of significant differences is due to the size of the significant F for syllogistic form. A significant difference between a pair of means indicates that that difference is reliable at the stated level of significance; i.e., that it is a non-chance difference occurring in groups of subjects drawn from the population of this study. For example, AI1 is reliably easier to judge than AE2 for groups drawn from this population, as indicated in Table 4.

Table 3. Percentage correct and rank order for 21 syllogistic forms

Percentage Correct					Obtained Rank		
Meaningfulness			Syllogistic Form	Predicted Rank	Meaningfulness		
Low	High	Low + High			Low	High	Low + High
71.26	75.36	73.31	AI1	12	3	1	1
74.40	69.81	72.10	AE1	4	1	4	2
71.98	72.22	72.10	AA3	5	2	2	3
70.29	70.53	70.41	AA1	2	5	3	4
70.77	66.67	68.72	AO3	10	4	6	5
62.08	69.08	65.58	AE2	1	6	5	6
57.00	61.35	59.18	AO1	13	7	7	7
55.80	59.90	57.85	AO2	8	8	8	8
50.24	57.49	53.86	AA2	6	10	9	9
55.80	41.79	53.50	EI1	9	9	11	10
47.34	56.76	52.05	EO1	11	14	10	11
47.10	48.79	47.95	EO3	7	15	12	12
47.10	46.14	46.62	OO1	16	16	13	13
48.07	45.17	46.50	OO2	18	13	14	14
49.28	41.79	45.53	EE1	3	11	15	15
48.31	40.10	44.20	IO3	20	12	16	16
44.44	39.61	42.03	AI2	15	18	17	17
46.38	36.96	41.67	IO1	17	17	20	18
40.10	37.68	38.89	AO4	14	19	19	19
36.71	39.13	37.92	OO3	19	20	18	20
34.78	34.54	34.66	II1	21	21	21	21

Table 4. Significant differences between pairs of 21 syllogistic forms[a]



[a]See discussion of this table in Chapter IV. All pairs below the heavy line are significantly different at the .01 level by the Newman-Keuls method.

Dogmatism and Meaningfulness Factors

The scores of the 207 subjects on the dogmatism test ranged from 20 to 94 with a median score of 60. Subjects were assigned to dogmatism levels by using the tertiary points of the data as cutoff levels. These points occurred at scores of 55 and 65, respectively, on the dogmatism scale. Ten subjects achieved a score of 55. These were randomly assigned to the low dogmatic and middle dogmatic levels, five in each level. Three subjects achieved a score of 65 on the dogmatism scale. These three were randomly assigned to the middle and high dogmatism levels, two to the middle group and one to the high group. Subjects with dogmatism scores below 55 were assigned to the low dogmatism level, while subjects with dogmatism scores of 56 to 64 were assigned to the middle dogmatism level and subjects with scores above 65 were assigned to the high dogmatism level. This manipulation resulted in three dogmatism levels with 69 subjects in each level.

The validity of these cutoff points, 55 and 65 on the dogmatism scale, is partially verified by their reliability, as in Bettinghaus et al. The similar cutoff points indicated by their data on the dogmatism levels of their subjects were 56 and 65, respectively. Numerically, the midpoint of the 20 item dogmatism test, with scores ranging from 20 to 120, is 70. The median on the scale is 60 for both Bettinghaus et al. data and the data of the present

study. Thus it seemed reasonable to assign subjects to dogmatism levels using 55 and 65 as the dividing points between low, middle, and high dogmatics.

As mentioned above, Table 2 indicates that the second-order interaction involving all three factors of this study is not significant. While the two first order interactions involving dogmatism are also non-significant, the remaining first-order interaction between meaningfulness and syllogistic form is significant at the .001 level. The main effects for meaningfulness and dogmatism are not significant. Thus, as expected, dogmatism does not enter into any of the significant main or interaction effects. The significant interaction between meaningfulness and syllogistic form indicates that the meaningfulness of the terms of the syllogisms was of differential importance across syllogistic forms. The mean number of correct responses to the high and low meaningfulness items for each syllogistic form is given in Table 3, above. The interaction of meaningfulness with syllogistic form is graphed in Figure 1.

To determine if any differences between high and low dogmatic subjects might be significant if the effect of the middle dogmatic subjects were removed, a second three factor analysis of variance was conducted using data from only high dogmatic and low dogmatic subjects. It produced no changes in significance level of any of the interaction or main effects, including dogmatism.

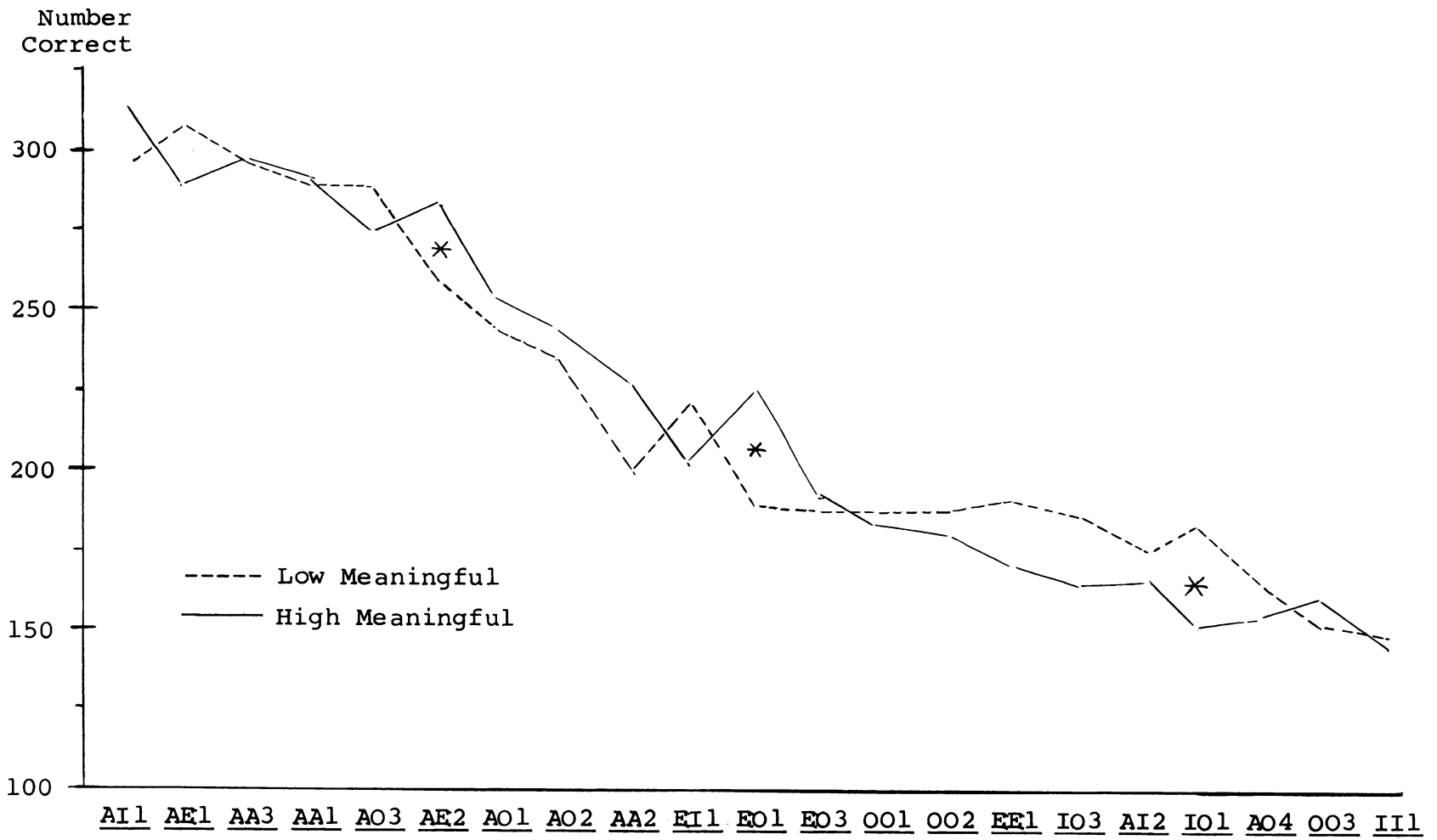


Figure 1. Meaningfulness x Syllogistic Form interaction for all 207 Ss (*significant at the .05 level by the Newman-Keuls method).

As a check on the effects of dogmatism and syllogistic form with only high meaningful terms in the syllogisms, a third analysis of variance was calculated using the scores of all 207 subjects on the high meaningfulness items, an analysis similar to a test for simple main effects. While the dogmatism x syllogistic form interaction was not significant, the dogmatism factor approached significance ($p < .10$). A t test between high and low dogmatic subjects using high meaningful items only still yields a probability level of alpha which is not significant. The syllogistic form main effect was significant at the .001 level ($F = 34.01$, $df = 20, 4080$). This indicates that the simple main effect for high meaningful items does not differ substantially from the overall meaningfulness main effect.

Individual comparisons were also conducted between the high and low meaningfulness means for each of the 21 syllogistic forms. Differences which are significant at the .05 level by the Newman-Keuls method are indicated by an asterisk in Figure 1. A significant difference indicates that the use of high meaningful terms in that syllogistic form resulted in a significant change in the difficulty of judgment of that form over that difficulty which occurred when low meaningful terms were used.

Diagrams in the Test Booklets

The test booklets of all of the 207 subjects were examined for marks of any kind. Thirty-five of the 207 booklets contained pencil marks which appeared to be either Venn diagrams or the letters "A," "B," and "C," with "equal to" or "not equal to" signs relating them. In some cases both Venn type diagrams and the letters occurred near different items in the same test booklet. The means for each of the 126 cells of the design were calculated for the data from these 35 subjects and visually compared with the means calculated for the remaining 172 subjects. The means were similar in all but two of the 126 cases, and these two differences were not large. Thus, no analysis of variance was calculated using marking as a factor.

CHAPTER IV

DISCUSSION

Ambiguity Hypothesis: Alternative Explanations for Non-Conforming Items

The significant main effect for the syllogistic form factor and the significant rhos between the obtained orders and the order predicted by the ambiguity hypothesis provide support for that hypothesis. Apparently, the ambiguity of the premise combination is directly related to the difficulty of judgment of syllogisms containing that premise combination. This is the major finding of this study. It may be useful to analyze those items for which the ambiguity predictions did not hold.

While most of the obtained ranks correspond quite closely to the predicted ranks, there are two forms which are distinctly out of line. These are the EEl form, which was predicted third but finished fifteenth, and the AIl form, which was predicted twelfth but finished first. Elimination of these two forms from the correlation would increase the overall rho from .695 to .851. Both forms finish near their overall position when only high and only low meaningfulness items are used to determine order. The EEl form finishes

eleventh, fifteenth, and fifteenth, with low, high, and low plus high meaningful items respectively, while the AI1 form finishes third, first, and first. An analysis of the distribution of responses to the items involving each of these forms indicates no particular response patterns such as an atmosphere effect (Woodworth and Sells, 1935) which might account for their departures from predicted positions. The conclusions for the AI1 form were A and I type conclusions. Just which of these two should benefit from any atmosphere effect is unclear with an AI premise combination. The A conclusion was marked correctly by 142 subjects in the low meaningful condition and by 139 subjects in the high meaningful condition. The I conclusion was marked correctly by 153 subjects in the low meaningful condition and by 173 subjects in the high meaningful condition. The A conclusion is invalid and the I conclusion is valid in AI1.

The conclusions for the EE1 form were E and O types, both invalid. The E conclusion was marked correctly by 101 subjects in the low meaningful condition and by 77 subjects in the high meaningful condition, while the I conclusion was marked correctly by 103 and 96 subjects, respectively, under those conditions. Thus, any atmosphere effect that might result in incorrectly marking the invalid E conclusion as valid occurs only with high meaningful terms, and even then the effect is not large. Since less than half of the 207 subjects responded correctly to any of the four conclusions

involving the EE1 form, its lower-than-predicted finish cannot be attributed to any one conclusion.

If the EE1 form were the only form that did not conform to prediction, a possible explanation might be that an excess of difficulty of judgment exists in conditions with multiple universal negatives, over the amount predicted by the ambiguity hypothesis. This may in fact be the case with the EE1 form, although it does not explain why such difficulty should occur with multiple universal negatives.

The AI2 form was included in this experiment because it is not the logical equivalent of the AI1 form. Nonetheless, both forms contain AI premise combinations and it is interesting to compare the predicted and actual rank order finish of each. AI1 was predicted twelfth and finished first. AI2 was predicted fifteenth and finished seventeenth. Thus, AI2 finished very close to the position predicted by the ambiguity hypothesis, while AI1 finished far from its predicted position. Yet only two changes can account for this difference: the change in the actual terms used (ZUF, YIV, FAJ, ZIP, WET, and BOY versus HIM, JUG, NOD, QIH, RYW, and TEJ), and the change of the position of the middle term in the first premise from first in the first figure to last in the second figure. Assuming the meaningfulness manipulation was properly controlled, attention focuses on the second change. This positional change for the middle term results in a logical difference between AI1 and AI2 and a

difference in ambiguity of 16 for AI1 and 20 for AI2. The logical difference results in a valid I conclusion for AI1 while AI2 has no valid conclusion.

Bettinghaus et al. found a strong main effect for validity indicating that valid syllogisms were less difficult to judge correctly than invalid syllogisms (1970, p. 242). Could it be that AI1 moved up in rank because it has a valid conclusion? If this were true, then in general: (a) syllogisms with valid conclusions should finish ahead of their predicted positions, (b) syllogisms with two or more valid conclusions should finish even further ahead of their prediction positions than syllogisms with only one valid conclusion since if two conclusions were valid for a form both were used, (c) syllogisms without a valid conclusion which were predicted to finish ahead of syllogisms with a valid conclusion should finish with a lower than predicted rank since they would be pushed down from their predicted positions by the rise of the syllogisms with valid conclusions, and (d) if the above changes occur, they must be concomitant with a larger number of subjects responding correctly to the valid conclusion than to the invalid conclusion in forms in which a single valid conclusion exists. Condition (d) simply demands that the changes actually occur because of valid conclusions, and not just to syllogisms which happen to have valid conclusions.

Eight forms used in this experiment have at least one valid conclusion. Four of these finish ahead of their predicted position, three finish below their predicted position, and one finishes in its predicted position. The sum of the predicted ranks for the eight forms with a valid conclusion is 51 for a mean predicted rank of 6.375, while the sum of the obtained ranks for these items is 39 for a mean obtained rank of 4.875. Thus, by this measure, items with valid conclusions tend to finish higher than predicted. Some of this effect is produced by the AIl form itself; however, since if this item were excluded, the mean of the predicted ranks would be 5.571, and the mean of the obtained ranks would be 4.429. At best, statement (a) appears to be partially correct for these data.

Almost the reverse of statement (b) appears to be true. The two syllogistic forms with more than one valid conclusion finished below their predicted rank, while four of the six forms with only one valid conclusion finished above their predicted rank. Thus, an effect as in statement (b) did not occur with the data of this experiment.

Four syllogistic forms with no valid conclusions were predicted to finish above one or more forms with a valid conclusion. Three of these four did finish lower in rank than predicted, and the fourth finished as predicted. Each of the shifts was due at least in part to forms with valid conclusions finishing higher than predicted. Thus statement (c) appears to be confirmed by the data.

Four of the six forms with a single valid conclusion finished above their predicted position. Two of these four, AE1 and AA3, had more subjects respond correctly to the invalid conclusion than to the valid conclusion. The remaining two, AI1 and AO3, had a larger proportion of subjects respond correctly to the valid than to the invalid conclusion. Thus, statement (d) is correct for only two of the four forms.

What conclusions are implied by the preceding discussion? The effect of having at least one valid conclusion on the difficulty of judging the validity-invalidity of a syllogistic form is certainly not a simple one. In four of six cases the effect appears to be one of decreased difficulty. Yet in two of these four cases this decreased difficulty is apparently due more to the invalid than to the valid conclusion. In the other two cases, the number of correct responses to the invalid conclusion was larger than expected, though smaller than the number correct for the valid conclusions. The effect is to decrease the difficulty of forms with a valid conclusion, but to do so as much because of a decreased difficulty of the invalid conclusion as of the valid conclusion. To further complicate the picture it appears that two valid conclusions are no better indicator of decreased difficulty than one valid conclusion. In general, these results imply that the quality of having at least one valid conclusion is directly associated with

an obtained ranking which is higher than that predicted on the basis of the ambiguity of the syllogistic form alone. The reasons why this is true are unclear.

Ambiguity and the Existence of a Valid Conclusion as Predictor Variables

Thus far this discussion has treated ambiguity and syllogistic forms with a valid conclusion as if they were independent predictors of the ease of judging syllogistic validity. The two variables are, of course, related. Ambiguity is the number of possible different relationships between the terms of a syllogism which are allowed by the premise combination of that form. As this number increases, it becomes increasingly more difficult to make a true statement concerning a way in which the two non-middle terms are consistently related over the entire set of these relationships. The greater the ambiguity, the less the possibility of a valid conclusion. In some cases, such as EE1, there is no valid conclusion even when there are only five possible relationships between the terms. This occurs when all six of the possible conclusions are ruled out by the relationship-between-the-relationships. The point is that the chances of all six being ruled out are generally greater with a larger number of relationships. A threshold apparently occurs with an ambiguity level of about 17, since no syllogism with an ambiguity greater than this has a valid conclusion. Thus, ambiguity is a non-perfect predictor of

the existence of a valid conclusion for a given syllogistic form, and the existence of such a conclusion for a form increases the probability of predicting the ambiguity of the form correctly. By combining ambiguity and validity in a predictive formula, the accuracy of the prediction could have been increased, at least in this experiment. For example, if the predicted position were obtained by ranking those items with a valid conclusion in a first group by their ambiguity order and those items without a valid conclusion by their ambiguity order in a second group below the first, the rho between predicted and obtained ranks would increase from .695 to .833. Of course, such a post hoc prediction has no status in terms of hypothesis testing, but a future study might profitably test such a hypothesis.

This discussion began as an analysis of why two items departed so far from their predicted ambiguity positions. Given the preceding predictive suggestion, attention should again be focused on these two items. Form EEI is the highest ranking form which has no valid conclusion when only ambiguity is used in the ordering. Form AIl is the lowest ranking form with a valid conclusion in this same ambiguity ordering. Combining these two facts with the suspicion that having a valid conclusion has the effect of making the syllogism easier to judge gives a partial explanation for the failure of the ambiguity prediction in these two cases.

The question now arises as to the usefulness of the ambiguity prediction. To what extent does it predict order within the two categories of syllogistic forms, with and without valid conclusions? For the 13 forms without valid conclusions, rho between the predicted ambiguity order and the obtained order is .654. For the eight forms with at least one valid conclusion the rho value is -.095. This difference means that ambiguity operated as a good predictor for the forms without a valid conclusion but had essentially no predictive power, either positive or negative, for the forms with valid conclusions, when these eight forms are considered alone.

The question of interest becomes one of whether ambiguity actually predicts only for items with no valid conclusions or whether there was some particular factor in this experiment which led to the observed outcome. The most obvious difference between the forms with a valid conclusion and those without is that the conclusions of those without were all invalid while the conclusions of those forms with at least one valid conclusion were sometimes valid. It would have been possible to make all of the conclusions to all of the forms invalid, but that would have led to a major response set control problem. An alternative would be to rank the 21 forms using only the responses on invalid conclusions to yield the obtained positions. The rho between these rankings and the predicted ranks would then be free of

the influence of the valid conclusions themselves, but would not suffer from control problems resulting from using no valid conclusions. If interest is in general application to all syllogistic forms with both valid and invalid conclusions, the data of Table 3, Table 4, and Figure 1 (Chapter III) should be used. The correlation between the predicted and obtained ranks is .695 on a straight ambiguity prediction basis, or .833 if the 21 items are ordered first by whether they have a valid conclusion and then by ambiguity order. If interest is only in invalid conclusions to syllogistic forms, then Table 5 and the correlations obtained from it are applicable.

Ambiguity as a Predictor with Only Invalid Conclusions

Table 5 contains the 21 forms in the order obtained by using the data from invalid conclusions only, except for forms AA1 and AE2 for which no data were available. The rho between the order obtained by the ambiguity prediction alone and the 21 items ordered by data from invalid conclusions only, with the two exceptions, is .687. If only the 19 items for which data from invalid conclusions are available are used, rho is .619. This indicates that ambiguity alone predicts level of difficulty about as well using data from invalid conclusions only as it does when data from both valid and invalid conclusions are used. The principal difference obtained by using invalid conclusions only in place of valid

Table 5. Twenty-one forms ordered by invalid items only

Predicted Order	Actual Order	Syllogistic Form	Table 3 Order	Percentage Correct
4	1	AE1	2	78.50
5	2	AA3	3	75.85
2	3	AA1*	4	70.41
12	4	AI1	1	67.87
1	5	AE2*	6	65.58
10	6	AO3	5	64.73
13	7	AO1	7	59.18
6	8	AA2	9	53.86
11	9	EO1	11	52.05
7	10	EO3	12	47.95
8	11	AO2	8	47.10
16	12	OO1	13	46.62
18	13	OO2	14	46.50
3	14	EE1	15	45.53
20	15	IO3	16	44.20
15	16	AI2	17	42.03
17	17	IO1	18	41.67
14	18	AO4	19	38.89
9	19	EI1	10	38.16
19	20	OO3	20	37.92
21	21	II1	21	34.66

*No data from invalid conclusions.

plus invalid is in the ordering of certain forms such as AI1 and AO2 which move down three ranks, and EI1, which moves down nine ranks. The rho between the two obtained orders, using invalid conclusions only as opposed to valid plus invalid, is .922.

Premise Combination Type, Figure and Items with Equal Ambiguity

The scores on the 21 items were visually inspected to determine if the variables of premise combination type and figure, when examined individually, might have had an effect on the difficulty of judgment of the items, and to determine if the results obtained with different items of the same ambiguity level are similar. There appear to be no particular differences between premise combinations within the First figure, the only figure in which all premise combination types appeared, which are not generally explained by considering ambiguity and the existence of a valid conclusion. Thus, inspecting all items of the same figure produced no new insights about possible variables affecting difficulty of judgment. Similarly, inspecting the scores on all items of the same premise combination type across figures adds little explanatory information. Neither the variable of figure nor the variable of premise combination type considered individually appears to account for any pattern of responses to the syllogisms.

Three pairs of premise combinations have equal ambiguity: AO2 and EI1, ambiguity of 12, AO1 and AO4, ambiguity of 18, and OO2 and OO3, ambiguity of 73. AO2 and EI1 are quite close to each other in eighth and tenth positions, as expected because of their equality of ambiguity. AO1 and AO4 finish far apart in seventh and nineteenth positions, while OO2 and OO3 finish fairly far apart in fourteenth and twentieth positions. The latter two results would not be expected on the basis of an ambiguity prediction. Apparently, the predictive power of ambiguity is not large for items with the same ambiguity, and it can be seen by inspection of Table 3 (Chapter III) that this is also true for items of similar ambiguity. The predictive efficacy of ambiguity is in terms of its overall predictions among all 21 forms. This is especially true when ambiguity is combined with knowledge of the existence of a valid conclusion for the particular forms.

Meaningfulness Main Effect and the Meaningfulness by Syllogistic Form Interaction

The main effect of the meaningfulness manipulation was not significant. With a possible range of zero to 42, the mean of the High Meaningfulness condition was 22.41 while the Low Meaningfulness mean was 22.58. This finding was not predicted, but it does not conflict with the results of previous studies. Morgan and Morton (1944) found no significant differences in the ability of subjects to select

the logical conclusion from a group of five conclusions when the terms of the syllogism were "X," "Y," and "Z," as opposed to when the terms were meaningful terms which were not related to the personal beliefs of the subject. Only "when an issue is injected which relates to the personal opinions, wishes, fears, or convictions of an individual [is the number of errors related] to the meaning involved in the terms of the syllogism" (1944, p. 59). Bettinghaus et al. used abstract terms in their pretest and meaningful terms involving the subjects' beliefs concerning the war in Vietnam in their main test. These researchers found marked differences in the ability of subjects to judge the validity of syllogisms under these two conditions. The present study used low meaningful terms in one condition and high meaningful terms in another, but in neither of these conditions were the "personal opinions, wishes, fears, or convictions" of the subjects brought into play. Thus, the Bettinghaus et al. results and the results of this study conform to the findings of Morgan and Morton (1944).

The differences obtained in the studies by Lefford (1946), Thistlethwaite (1950), Janis and Frick (1943), Feather (1964), and Parrott (1967) also follow this pattern. Across syllogistic forms, differences in the difficulty of judgment of syllogistic validity-invalidity vary with the meaningfulness of the terms of the syllogism only if this meaningfulness is related to relevant beliefs of the subjects.

Within the syllogistic form factor this pattern does not always emerge. In the present study, the interaction of meaningfulness and syllogistic form was significant. Thus, for particular syllogistic forms a change from low meaningful terms to high meaningful terms can have an effect on judgmental difficulty even when that change does not involve the emotions or relevant beliefs of the subjects. Some forms are apparently easier to judge with high meaningful content than with low, while the reverse is true for others. Figure 1 (Chapter III) indicates which differences in term meaningfulness were significant for the 21 syllogistic forms. The diagram reveals no general rule, unless many exceptions to it are allowed. Given many exceptions, there is a slight tendency for easier items to be still easier with high meaningful content, and for more difficult items to be even more difficult with high meaningful content. Three of the 21 differences are significant by the Newman-Keuls method (Winer, 1962, pp. 77-89, 309-312). The low meaningful AE2 and EO1 syllogistic forms were significantly more difficult than their high meaningful counterparts ($p < .05$, Newman-Keuls). The IO1 high meaningful syllogism was significantly more difficult than was the low meaningful IO1 syllogism ($p < .05$, Newman-Keuls). The remaining differences between high and low meaningful pairs are not significant.

When the scores of the high meaningful items are analyzed alone the syllogistic form factor remains significant at the .001 level, although the order of difficulty of the forms changes as can be seen from Table 3.

Syllogistic Form Main Effect and the Meaningfulness by Syllogistic Form Interaction

The main effect for syllogistic form is significant and the effect is obvious from Figure 1 (Chapter III). The statement of this significant effect must be tempered by the nature of the Meaningfulness by Syllogistic Form interaction described above. Table 4 (Chapter III) indicates which differences among all possible pairs of differences between the 21 syllogistic forms are significant by the Newman-Keuls method. Differences between forms more than five ranks apart in their order of difficulty are significant in all cases ($p < .01$, Newman-Keuls). This means that given a syllogistic form which finished in rank k, the chances are 99 out of 100 that a comparable group of subjects will make more errors on it than on the form that finished in rank $k-5$ and fewer errors on the form in rank k than on the form which finished in rank $k+5$. Much stronger statements may be made if the actual forms involved are specified. Consider form AO1, which finished in rank 7. Table 4 (Chapter III) indicates that it is significantly more difficult than all forms which ranked above it in number of correct responses

and significantly less difficult than all forms that ranked below it, with the exception of form AO2 which finished in the next lowest rank ($p < .01$, Newman-Keuls). Similar statements concerning each of the 21 forms may be derived from Table 4. Since any use of these forms would almost surely involve some type of content, statements of differences derived from Table 4 should be examined in light of Figure 1 (Chapter III) where content may be described as either low or high meaningful. It should be noted that in most cases of reversal of the meaningfulness effect between forms, for example, the case of the major reversal between forms AA2, EI1, and EO1, clearly illustrated by Figure 1, Table 4 indicates that the differences between these forms over high and low meaningful term content are not significant. When no reversals of the meaningfulness effect occur, as with forms AE2, AO1, AO2, and AA2 (see Figure 1), no problems of interpretation of the syllogistic form effects arise.

Three problem cases must be mentioned in which the significant difference listed in Table 4 is dependent on the meaningfulness of the terms of the syllogism. The AE2 form is listed as significantly different from forms AI1, AE1, AA3, and AA1, which rank above it. This is true only for low meaningful content or for combined low and high meaningful content. It is not true for high meaningful content alone. No problems occur with forms finishing below AE2. The second problem occurs with form EI1, which is listed as

significantly different from EO3, OO1, and OO2. This is true for low meaningful and combined low and high meaningful content, but not for high meaningful content alone. The final problem occurs with form EO1, which is listed in Table 4 as significantly different from OO1, OO2, EE1, IO3, AI2, and IO1. This is true only for high meaningful items and items with combined high and low meaningful content. It is not true for items with low meaningful terms only, as a glance at Figure 1 will reveal. All other differences listed as significant in Table 4 are significant for low, high, and combined low and high meaningfulness levels.

The significant Meaningfulness by Syllogistic Form interaction is the source of the three problem areas listed above, and is a good example of why significant main effects should not be reported unless significant interactions involving them are fully explicated. Once the nature of the interaction is understood, the main effect may be reported and understood in light of that interaction effect.

Dogmatism Main Effect

The dogmatism main effect was not significant. No dogmatism effect was predicted, since one would be expected only if the syllogisms were perceived by subjects as originating from positive or negative sources. Such perceptions were unlikely, given the experimental conditions of this study. It is interesting to compare the present result with the significant dogmatism effect obtained by Bettinghaus et

al. using positive and negative sources, and their finding of a non-significant dogmatism effect with neutral sources and neutral syllogisms (1970, pp. 241-242). These combined results follow the predictions of dogmatism theory; specifically, that only when the source is perceived as an authority, either positive or negative, will dogmatism figure as a relevant personality variable.

The mean number of correct out of 84 possible judgments for low, middle, and high dogmatics was 45.70, 45.90, and 43.36, respectively. The difference between only high and low dogmatics is not significant. To the extent that judgment of syllogistic validity may be seen as a test of intelligence, these data correspond to Rokeach's findings that dogmatism and intelligence are not correlated.

Diagrams in the Test Booklets and Ambiguity

As reported in Chapter III, the cell means obtained using only the 35 subjects who marked on their test booklets were similar to the means of the subjects who made few or no marks. Since the ambiguity measure is based on a diagrammatic conception of logical judgment, it seemed worthwhile to analyze the scores of these 35 subjects further to determine if ambiguity alone is a better predictor of final ranking of syllogistic form difficulty for subjects who use diagrams in responding to the validity-invalidity of a syllogism than it is for subjects in general. The rho

between the predicted ambiguity rankings and the rankings obtained for these 35 subjects is .683 as compared with .698 for the 173 non-marking subjects. Thus, the use of diagrams by subjects does not appear to result in a general increase in predictive power for ambiguity used alone. In terms of responding correctly to the items, the use of diagrams may have been slightly helpful. The average percentage correct for all 207 subjects is 53.55 percent. For the 35 marking subjects this figure increases to 54.72 percent. This difference is not significant, but the cases available are limited. An alternative interpretation might be that subjects who are better at logical judgmental tasks have a tendency to use diagrams in determining their responses to syllogistic conclusions, but again, this tendency is non-significant.

The Atmosphere Effect

The atmosphere effect was first identified by Woodworth and Sells (1935). They hold that the premises of a syllogism create an atmosphere which subjects perceive and carry into their judgments of syllogistic validity. This effect would occur in two ways. First, an A, E, I, or O premise should influence subjects to mark an A, E, I, or O, conclusion, respectively, as valid. Second, an E or O premise should create a negative atmosphere leading to increased acceptance of E or O conclusions, and an O or I

premise should lead to an increased acceptance of O or I conclusions through a someness atmosphere. The present study attempted to equalize any atmosphere effect across syllogistic forms. To determine whether an atmosphere effect did influence the scores on different syllogistic forms to a different extent, the scores were inspected for atmosphere influences. With many items as they appear in the test booklets, it is not clear which conclusions would be expected to benefit from an atmosphere effect. For example, consider the AE premise combination with A and O conclusions. By the atmosphere hypothesis, the A premise should increase the number of subjects responding "valid" to the A conclusion, and the E premise should do the same for the O conclusion by creating a negative atmosphere. Suppose one of these effects occurs but not the other. Was there an atmosphere effect? Morgan and Morton (1944, p. 40) use the definition given above of atmosphere effect yet they do not conform to this definition when they list which effects are expected to be atmospheric. For an AE premise combination they list only E as an atmosphere-type conclusion (1944, pp. 42-43). Thus, the exact predictions for the atmosphere effect appear to be equivocal. To avoid this problem perhaps only obvious cases of a predicted atmosphere effect, such as an AA premise combination with an A conclusion, should be considered. All items were examined for any atmosphere-type effect. This examination revealed that for

all but six of the 21 syllogistic form items there was no way to predict an atmosphere effect that was internally consistent. The data for these 15 items revealed, at best, very small effects of the type which on post hoc analysis might be termed atmospheric.

The six forms for which an atmosphere effect could be predicted were: AA1, AA2, EE1, II1, OO1, and OO2. A test of the significance of the difference between two proportions was conducted for each of these forms, comparing the proportion of responses marked valid on the suspect conclusion with the proportion of responses marked valid on the non-suspect conclusion for each form. The non-suspect conclusion for each form was used as a measure of the proportion of successes to be expected for that particular form. Five of the six differences were significant, with only the difference for EE1 failing to reach significance.

To what extent did these differences affect the rank order position of the five items? With item AA1 the direction of the atmosphere effect serves to increase the number of correct responses. With items AA2, II1, OO1, and OO2, the direction serves to increase the number of incorrect responses. The removal of the atmospheric conclusions has the effect of lowering AA1 in position and increasing AA2, II1, OO1, and OO2. Table 6 lists the 21 forms, using only data from non-atmosphere suspect conclusions. Rho between the ambiguity predicted order and this order is .603.

Table 6. Twenty-one forms ordered after removal of possible atmosphere effect

Predicted Order	Actual Order	Syllogistic Form	Table 3 Order	Percentage Correct
12	1	AI1	1	73.31
4	2	AE1	2	72.10
5	3	AA3	3	72.10
6	4	AA2	9	71.26
10	5	AO3	5	68.72
1	6	AE2	6	65.58
2	7	AA1	4	64.73
16	8	OO1	13	63.29
13	9	AO1	7	59.18
8	10	AO2	8	57.85
18	11	OO2	14	56.28
9	12	EI1	10	53.50
11	13	EO1	11	52.05
7	14	EO3	12	47.95
3	15	EE1	15	45.53
20	16	IO3	16	44.20
15	17	AI2	17	42.03
17	18	IO1	18	41.67
21	19	II1	21	40.34
14	20	AO4	19	38.89
19	21	OO3	20	37.92

That the differences between this order and the order of finish including the atmosphere suspect items are small is indicated by the rho between them of .939.

Note that the six items involved in the reordering on the basis of the existence of a valid conclusion are independent of the six items involved in the atmosphere reordering. Table 7 lists the 21 forms in the order obtained after removal of both the valid conclusion items and the atmosphere suspect items. Rho between the ambiguity order and the Table 7 order is .590, which is still significant at the .01 level. Between the Table 7 order and the initial order given in Table 3 (Chapter III) rho is .844.

The use of the Table 3 order as opposed to the Table 5 order was discussed above. Similar comments apply to the use of Tables 6 and 7. Table 6 was obtained by ordering the items without the influence of a naturally occurring atmosphere effect bearing upon five of the items used in the ordering or on the percentage correct statistics. In future use of these data, if the premise combinations are to be employed with conclusions that are free of an atmosphere effect, then the order of Table 6 is appropriate. If conclusions are used in which an atmosphere effect is possible, Table 3 order is the appropriate choice. If only invalid conclusions which do not involve an atmosphere effect are used, Table 7 should be employed.

Table 7. Twenty-one forms ordered by invalid items only after removal of possible atmosphere effect

Predicted Order	Actual Order	Syllogistic Form	Table 3 Order	Percentage Correct
4	1	AE1	2	78.50
5	2	AA3	3	75.85
6	3	AA2	9	71.26
12	4	AI1	1	67.87
1	5	AE2*	6	65.58
2	6	AA1*	4	64.73
10	7	AO3	5	64.73
16	8	OO1	13	63.29
13	9	AO1	7	59.18
18	10	OO2	14	56.28
11	11	EO1	11	52.05
7	12	EO3	12	47.95
8	13	AO2	8	47.10
3	14	EE1	15	45.53
20	15	IO3	16	44.20
15	16	AI2	17	42.03
17	17	IO1	18	41.67
21	18	II1	21	40.34
14	19	AO4	19	38.89
9	20	EI1	10	38.16
19	21	OO3	20	37.92

*No data from invalid conclusions.

Several additional comments on the atmosphere effect seem appropriate. While not appearing in an identifiable form on most items, the atmosphere effect did influence the rank order position and percentage correct of five syllogistic forms. One problem with the atmosphere effect is that while it is a name for an actual response tendency by certain subjects who are judging the logical validity of certain syllogistic conclusions, it may be regarded as a spurious source of variance which should be avoided. Such is not the case. Since atmosphere can affect the responses of subjects to syllogistic items, a ranking and listing of percentage correct achieved by using atmosphere prone conclusions with some premise combinations but not with others, would not be a proper ranking for use with either all possible conclusions, or with only non-atmospheric conclusions. Therefore, the effect must be controlled by giving it equal chance to occur in each form. For each premise represented in a premise combination of this study, a conclusion which could have produced an atmosphere effect appeared at least once with the premise combination. If the control used were one of eliminating all possible atmospheric conclusions, the results would apply, obviously, only to syllogistic judgments of non-atmospheric items, and not to syllogistic judgment in general. For this reason the rankings of Table 3 and the additional information supplied by Figure 1

and Table 4 (Chapter III) are the preferred rankings and percentage statistics for most uses involving syllogistic judgment.

A second problem of the atmosphere effect is that it confounds two distinct sources of variance in its conception. The first source is the atmosphere effect itself: for example, the effect of using a conclusion beginning with the word "all" following two premises which begin with the same word. The second source is the inherent difficulty of judging the validity-invalidity of an A conclusion, for example, in an AAA syllogism. The two must be kept conceptually distinct.

The effects of these two sources of variance could be investigated using operations similar to the following. The second variance could be estimated using the word "all" (or "none" or "some") to begin both premises, but substituting a word or phrase with similar meaning in place of "all" in the conclusion. For example, "all X is Y, all Y is Z, every single member of Z is a member of X." The variance of the first source would be difficult to estimate directly, since it should not involve the actual relationship of "X" and "Z," and "all X is Y, all Y is Z, all J is K" might involve a plausibility control problem, among others. The first variance could be estimated by subtracting the effect of the second source of variance from the overall effect of "all X is Y, all Y is Z, all Z is X."

Thus, the removal of the atmosphere effect as in Tables 6 and 7 removes not just the effect itself but also the effect of the conclusions which is confounded with it, another reason for using Table 3 (Chapter III) in most applications.

Summary

The principal points of this discussion are as follows:

1. The ambiguity hypothesis predicting the order of difficulty of the forms is supported. An analysis of the two forms which depart markedly from the predicted order leads to the conclusion that the ambiguity of a given form plus knowledge of the existence or non-existence of a valid conclusion for that form may result in greater predictive accuracy of the order of difficulty of the form than ambiguity alone, if difficulty is measured using both valid and invalid syllogisms. This latter hypothesis was not formally tested. The existence or non-existence of a valid conclusion is related to the ambiguity of a given syllogistic form. The choice of Table 3 (Chapter III) or Table 5 (Chapter IV) as a rank order list of syllogistic forms depends upon the way in which they will be used. Table 5 should be used only when all conclusions are invalid. Ambiguity predicts difficulty about as well with invalid conclusions only, as with valid and invalid conclusions.

2. An analysis across premise types and figures yields little new information. Analysis of the items of equal ambiguity reveals that ambiguity when used alone appears to be useful as a predictor of overall order of difficulty, rather than as an accurate predictor of order of finish between pairs of items.

3. A general meaningfulness effect did not occur in this experiment, while one did occur between the pretest and the main test of the Bettinghaus et al. study. These two results are in accord with the Morgan and Morton (1944) prediction that only when relevant beliefs of the subjects are involved does a change in term meaningfulness result in a change in apparent difficulty or syllogistic judgment across all syllogistic forms.

4. For particular syllogistic forms, a change in meaningfulness from low to high, as defined in Chapter II, can result in a change in apparent difficulty without invoking the relevant beliefs of subjects. The particular forms for which the invoking of relevant beliefs appears to be unnecessary in producing a change in apparent difficulty from a change in meaningfulness are AE2 and EO1, where low meaningful terms are more difficult than high meaningful terms, and IO1, where high meaningful terms are more difficult to judge than low.

5. There is a main effect for syllogistic form, and many individual comparisons between the levels of this

factor are significant by fairly conservative procedures. These effects must be interpreted in light of the significant Meaningfulness by Syllogistic Form interaction which restricts the between-form differences to particular meaningfulness conditions for certain forms listed in the text.

6. The non-significance of the dogmatism main effect is consistent with Rokeach's theory of dogmatism (1960) and with previous results such as those of Bettinghaus et al. Dogmatism as a personality variable appears to be relevant in judging syllogistic validity only when the syllogisms originate from a positive or negative source. To the extent that the ability to judge syllogistic validity is a measure of intelligence, this study offers support for Rokeach's findings that dogmatism and intelligence are uncorrelated variables.

7. Predictions based on ambiguity alone are no better for the responses of subjects who used diagrams in determining their responses than they are for all subjects. The use of diagrams by a subject was associated with a slight increase in the number of items marked correctly, but this difference is not significant.

8. An effect which could be called an atmosphere effect was found in five forms. Tables 6 and 7 (Chapter IV) give the order and percentage correct for the 21 forms corrected for atmosphere effect and for atmosphere plus the existence of a valid conclusion, respectively. Table 3

(Chapter III) remains the preferred table except when naturally occurring atmosphere effects and the effects of the existence of a valid conclusion are to be excluded from the relative and absolute difficulty ratings. The exact predictions concerning which items should produce an atmosphere effect are unclear. To the extent that an atmosphere effect exists it should be viewed as one of several legitimate sources of variance which influence subjects' scores on the various syllogistic forms. Moreover, the atmosphere effect involves two separate sources of variance: the effect relating specifically to the use of the same word in the conclusion as in the premises ("all," "none," "some") and the effect of the difficulty of the conclusion itself apart from the effect of the same word.

Concluding Remarks

Appendix I of this dissertation sets forth several assumptions which limit the generalization of the findings. First, it is possible to generalize from a given form to its logical equivalents logically, but it is not known if the behavioral effects will correspond. Thus, the results for the AE premise combinations may generalize to EA premise combinations, but no data are provided in the present study to verify this possibility. Similarly, no data are provided herein to indicate the soundness of regarding AE3, for example, according to the results for AE1, even though AE3 is

the logical equivalent of AE1. Tests of such behavioral generalizations must await future research.

This study sought to establish a baseline on the difficulty of judging the validity-invalidity of different syllogistic forms. It did so for two reasons. First, in studies which employ the judgment of syllogistic forms as a dependent variable, it is usually necessary to know the relative or absolute difficulty of different syllogistic forms. Second, the results are interesting in themselves in terms of a message variable of logical style. Little is known of the effects of different styles on message perception. Hopefully, this study has added to the knowledge of the effects of syllogistic styles in communication messages.

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APPENDIX I

DEFINITION OF THE SYLLOGISTIC FORM FACTOR

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The syllogistic form factor is the central focus of this study. A syllogism contains three statements: two premises and a conclusion. There are two terms in each statement and three distinct terms in each syllogism, each term being used in two statements. The term employed in both premises is called the middle term. The relationship between each of the two remaining terms and the middle term is stated in the premises, one relationship in each premise. The conclusion states a relationship between the two non-middle terms. The validity of the syllogism is determined by asking the question "must the relationship stated in the conclusion follow from the relationships stated in the premises?" If the answer is yes, the syllogism is valid. If the answer is no or not necessarily, the syllogism is invalid.

Four distinct types of relationships between the terms of a syllogism are possible. These are designated as A, E, I, and O. An A relationship is an all relationship. Letting X, Y, and Z represent the terms, "all X is Y" is an A relationship. Given two distinct terms, there are two

distinct A relationships: "all X is Y" and "all Y is X." An E relationship is a none relationship; for example, "no X is Y." There is only one such E relationship possible between any two terms X and Y: "no Y is X" is logically equivalent to "no X is Y." An I relationship is a some relationship; for example, "some X is Y." There is only one I relationship possible between two distinct terms since "some X is Y" is the logical equivalent of "some Y is X." An O relationship is a some are not relationship, such as "some X are not Y." Given two distinct terms there are two unique O relationships possible between them: "some X are not Y" and "some Y are not X."

The premises of a syllogism may be formed by using any two relationships of the A, E, I, and O type, one a relationship between the middle term and an X term and the other a relationship between the middle term and the Z term, where X is not in identity with Z. The conclusion of a syllogism is a relationship of the A, E, I, or O type between the X and the Z term. For convenience, this study will use X to refer to the non-middle term in the first occurring premise, Y to refer to the middle term, and Z to refer to the non-middle term in the second occurring premise. Note that no reference has been made to subject or predicate terms or, correspondingly, to minor or major premises. If the major-minor premise distinction is made, the non-middle term of the major premise becomes the predicate term and

occurs last in the conclusion, and the non-middle term of the minor premise becomes the subject term and occurs first in the conclusion. The major premise must be the first premise and the minor premise the second premise. This study does not consider these distinctions, as they add little to the discussion while making it more restrictive. Thus, there are no requirements placed on the premises other than those stated above, and they will be referred to as first premise and second premise depending only on their order of occurrence.

The figures of a syllogism are determined by the order in which the terms of the premises occur. If Y is the middle term, the order case in which Y occurs first in the first premise and second in the second premise is designated the First figure. For example, "all Y is X" and "all Z is Y" is a First figure premise combination. Adding any conclusion (A, E, I, or O, involving X and Z) would make them First figure syllogisms. The Second figure occurs when Y appears second in both premises. The Third figure occurs when Y appears first in both premises, and the Fourth figure when Y appears last in the first premise and first in the second premise. If X is always the non-middle term of the first premise and Z is always the non-middle term of the second premise, then these four figures are the only possible orders in which X, Y, and Z can combine. Note that these figures may be defined without reference to the form

or content of the conclusion, except to require that the conclusion involve an A, E, I, or O relationship between X and Z.

In summary, there are two premises involving three distinct terms in each syllogism with four figures or orders of presentation of these terms. Each first premise may be A, E, I, or O and each may be associated with an A, E, I, or O second premise, yielding 16 possible premise combinations. Since each of these 16 may occur in any of four figures there are a total of 64 possible distinct premise combinations. Note that the ordering of the terms in the four figures accounts for the two A relationships and the two O relationships so that there are in fact four and not six possible relationships in the premises of the form A, E, I, or O when using the figure system. The figures do not account for this distinction in the conclusion. Thus, for each of the 64 possible premise combinations there are six possible conclusions or 384 possible syllogisms. Since this is a rather large number, certain simplifying assumptions will be introduced so that these 384 syllogisms may be reduced to a more manageable total.

First, instead of referring to syllogisms proper, this paper will often discuss premise combinations with the understanding that there are six syllogisms for each of the 64 premise combinations, one syllogism corresponding to each

conclusion. This simply assumes a relationship between each premise combination and its set of conclusions.

The second assumption is that X, Y, and Z, the terms of the syllogism, are each non-empty: that there exists at least one element i which belongs to the set X, at least one element j which belongs to the set Y, and at least one element k which belongs to the set Z. This is an assumption which is not a part of many logical systems (for example, Ambrose and Lazerowitz, 1948, and most basic logic texts).

The reasoning behind it is as follows. Judging the validity of a syllogism assumes the truth of both premises for the purpose of making that judgment. If this were not so, no conclusion could be judged with respect to its validity or invalidity, since "all X is Y" might then mean "not all X is Y." This is a postulate of consistency. Within the frame of reference of a particular syllogism, a premise cannot be both true and untrue at the same time. If the assumption is that the premise is "true" in order to allow a judgment of the validity-invalidity of the conclusion with respect to the premises, then within the context of the judgment of the syllogism, that assumption must not be violated or there will be a logical contradiction.

The set Z cannot be empty in I and O premises. For, the contradiction of "some X is Y" is "no X is Y." Let Z equal the null set, and consider the statement "some Z is Y." "Some Z is Y" implies that there exists an element k

belonging to Z with the property that k belongs to Y. But "Z is the null set" implies that there exists no element k such that k belongs to Z. Thus, there exists no k with the property that k belongs to Z and that k belongs to Y. Therefore, "no Z is Y," which is a logical contradiction of "some Z is Y." It can be concluded that Z (and by the identical reasoning X and Y) may not equal the null set in I premises, nor in syllogisms involving I premises, when Z is the first term of the I premise.

Let Z equal the null set and consider "some Z are not Y." "Some Z are not Y" implies that there exists a k belonging to Z with the property that k belongs to not-Y. If Z equals the null set, then there exists no k belonging to Z. Therefore, there exists no k belonging to Z such that k belongs to not-Y, and this contradicts a direct implication of "some Z are not Y." Since the reasoning for X and Y is identical, it can be concluded that Z, X, and Y cannot equal the null set when any of them are used as the first term in an O premise.

The above two paragraphs demonstrate the necessity for the existence of the first term of an I or O premise. This existence in turn implies the existence of the second term in the I case, since for some Z to be Y there must be some Y. This implication does not hold for the second term of an O premise, nor can it be shown that A and E premises imply the existence of their terms. So in a given syllogism,

some terms are forced into existence by the premises and some are not. This introduces a problem in the definition of ambiguity of the premise combination. The existence or non-existence of the terms of a syllogism changes the number of relationships which are possible between the three terms. If the terms of the I premise and the first term of an O premise are assumed to exist while non-existence is an allowable state for the terms of A and E premises, the number of relationships, and thus the ambiguity, of premises of the A and E form is increased over the ambiguity of O and especially I premises. Thus, for purposes of prediction from ambiguity of the premises, consistency in existability is assumed, and since some terms must exist, all terms will be assumed to exist within the logical system used in this study.

The third assumption is that the order of occurrence of the premises is unimportant: that an AE premise combination, for example, may be treated as an EA premise combination, and vice versa. By the definitions used in this paper, such reversal is acceptable on strictly logical grounds. Since the major-minor premise distinction has not been adopted, the only difference between EA and AE in the logical context is the positioning of X and Z. Thus, this assumption reduces to the assumption that the symbols X and Z are interchangeable and have been used with the first premise and second premise only for convenience. Logically,

this is a justifiable assumption. Psychologically, this might not hold true. Logically, by the system used in this study, "all X is Y, no Y is Z" is equivalent to "no Y is Z, all X is Y." But a person receiving the former premise combination in a message might not react to it in the same way he would to the latter. This assumption means that in the logical context, results concerning AE will generalize to EA, to continue the example. In the psychological context we must caution that while such generalizations seem logical, they will have been tested only indirectly by this experiment and a direct empirical test may be warranted in the future to determine if such generalizations seem to hold.

The effect of the third assumption is to reduce the 64 possible premise combinations to 40 logically distinct combinations.

The fourth assumption is very similar to the third. It concerns the fact that the four figures involve logical duplication in certain premise combination conditions due to: (1) the reversibility of E and I premises, and (2) the duplication of premise order. Duplication of premise order is also discussed in the second assumption above. As an example of premise duplication, consider the four figures in the AA premise combination case. These are AA1, "all Y is X, all Z is Y"; AA2, "all X is Y, all Z is Y"; AA3, "all Y is X, all Y is Z": and AA4, "all X is Y, all Y is Z." Inspect the AA2 and AA3 cases. It can be seen by inspection

that these two cases are distinct from each other in the logical sense, since "all Y is X" is not logically equivalent to "all X is Y." The same may be said for their second premises. Now inspect the AA1 case and compare it with the AA2 and AA3 cases. The first premise of the AA case "all Y is X" distinguishes it from the AA2 case where the first premise is "all X is Y." Further, if the two premises are reversed in order for either case (but not both cases) and the convention of using X as the non-middle term of the first premise and Z as the non-middle term of the second premise is continued, it can still be seen that the AA1 and AA2 cases are logically distinct. The same operations may be performed on the AA1 and AA3 cases to demonstrate that they, too, are logically distinct. Now consider the AA1 and AA4 cases. First, reverse the order of the premises in the AA4 case, and then substitute X for Z and Z for X in accordance with the convention. The two premise combinations now both read "all Y is X, all Z is Y." Therefore, the AA4 case is logically equivalent to the AA1 case.

Continuing with the fourth assumption consider an example of E and I duplication. It will be recalled that "no X is Y" is the logical equivalent of "no Y is X," and that "some X is Y" is the logical equivalent of "some Y is X." This reversibility does not hold for A and O statements. Consider the four figures of the AE case. Using the same procedure as is outlined above under premise duplication,

it can be seen by inspection that the AE1 case is distinct from the AE2 case, since "all Y is X" is not equivalent to "all X is Y." But in cases AE1 and AE3, the first premise is "all Y is X" and the second premise is an E involving Y and Z. Since "no Y is Z" can be read (logically) "no Z is Y," both the AE1 and AE3 cases may be read "all Y is X, no Z is Y" and thus AE3 is the logical equivalent of AE1. By the same reasoning, AE4 can be shown to be the logical equivalent of AE2.

The assumption of duplication and equivalence has been justified on logical grounds, just as in the third assumption. The same reservation in generalization discussed for the third assumption holds for the fourth assumption. Logical equivalence may not result in psychological equivalence. Logically, what holds for the AE1 case must hold for the AE3 case, but the psychological ability to judge the validity of syllogisms involving these two premise combinations may or may not be equal. This is a type of psychological equivalence which will have to be confirmed or denied by future research.

The effect of the fourth assumption is to reduce the number of logically distinct premise combinations from 40 to 21. It will be demonstrated below that a given set of these 21 are not further reducible and, thus, that there are 21 logically unique premise combination types given the logical system and assumptions outlined above.

It should be noticed that the set of logically unique premise combinations is not a unique set since, for example, either AA4 or AA1 could be included in the set, but not both. The particular set of 21 logically unique premise combinations used in this study to represent the 21 unique cases is specified in Chapter II. These 21 premise combinations constitute the 21 levels of the syllogistic form factor.

APPENDIX II

GENERAL METHOD FOR DETERMINING AMBIGUITY

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GENERAL METHOD FOR DETERMINING AMBIGUITY

The ambiguity of a premise combination is the number of different relationships between the three terms of the combination which would allow the conditions implied by the premise combination to be true. For any two relationships of X, Y, and Z, one relationship is different from another if and only if there exists a specific subset of X-union-Y-union-Z which may be called W, with the property that W is empty in one relationship and non-empty in the other relationship. The condition that W must belong to the union of X, Y, and Z means that any changes in the relationships which occur outside of that union, such as a change from part-of-outside to all-of-outside, are not to be considered since they will have no bearing on the conclusions which may be drawn from premises concerning X, Y, and Z.

A general method for determining the number of situations from which a given premise combination could have arisen (ambiguity) is as follows. Consider the relationship of the middle term with either of the other terms, say X. Y and X have exactly five different ways of combining. These are (a) disjoint, (b) intersecting but neither

contained within the other, (c) identity, (d) X contained in but less than Y, and (e) Y contained in but less than X. No other different combinations of X and Y exist, given that neither X nor Y can be the null set, and using a definition of the difference between two sets which is a direct analogy to the definition of the difference between three sets, given above.

Now consider the ways in which the third term can combine with each of the five combinations of X and Y. The addition of the third term presents a problem that is best solved by dividing each of the five combinations of two terms into discrete, non-overlapping spaces. For case (a), Z may contain all, part, or none of X, all, part, or none of Y, and will either contain some area outside of X-union-Y or will not. Note that all-of-outside is not a separate option for Z since all-of-outside is not different from part-of-outside by the definition of different. The number of possible Euler diagrams or relationships for case (a) is given by multiplication since for each way in which Z may combine with X it may also combine in a given way with Y and also combine or not combine with the area outside of X-union-Y. Consequently, the number of different relationships between X, Y, and Z for case (a) is three (from X) times three (from Y) times two (from outside) minus one (since Z cannot be empty) or 17. The reasoning is similar for the remaining four cases.

For case (b), Z may combine with all, part, or none of X-minus-the-intersection-of-X-and-Y, all, part, or none of the-intersection-of-X-and-Y, all, part, or none of Y-minus-the-intersection-of-X-and-Y, and part or none of the area outside of X-union-Y. The number of different relationships for case (b) is given by multiplying three times three times three times two, minus one, or 53 possible different relationships for case (b).

Case (c) is the simplest case. Z may combine with all, part, or none of XY and with part or none of outside. Three times two, minus one, gives five possible different relationships for case (c).

Case (d) is similar to case (b) and case (e) where the problem must be phrased in terms of spaces that both cover the field and are disjoint. Z may combine with all, part, or none of X-minus-Y, all, part, or none of Y, and with part or none of outside. Multiplying, three times three times two, minus one, equals 17 different relationships for case (d). Since case (e) is identical to case (d) with X and Y reversing positions, the number of diagrams for case (e) will also be 17. Adding the totals for each case gives 109 total possible relationships between the three terms of a syllogism, given the assumptions of this study. This number is the upper limit of ambiguity, although the ambiguity of no single premise combination is that high in itself.

Using the above method with each of the 64 possible premise combinations discloses that the set of relationships implied by the premises of each premise combination which was eliminated by the simplifying assumptions of this paper (see Appendix I) are in identity with the set of relationships of the particular premise combination which represents the eliminated premise combinations. This is an independent verification that a set of 21 logically unique premise combinations are in fact the logical equivalents of the premise combinations which they represent. This method also demonstrates that a set of 21 logically unique premise combinations is truly logically unique, for, the set of relationships corresponding to each one of a given set of 21 logically unique premise combinations is different from each of the other 20 sets of relationships. The number of such relationships is occasionally the same for two of the 21, but the elements of each set are different. The application of the above method to each premise combination is slightly different, but the general method is to list those ways in which X and Y can combine which apply to the first premise, and then to inspect each of these for the proper multipliers with the second premise.

The AE2 case will serve as an example. The first premise, "all X is Y," is covered by the (c) and (e) cases. Cases (a), (b), and (d) do not apply. When inspected with the second premise of "no Z is Y," case (c) yields the

following results. Of the three possibilities with XY (all, part, or none) only none can apply to "no Z is Y." Of the two possibilities with the outside, either some or none may apply. By the existence assumption, the none-none case is ruled out. Thus, the number of relationships possible with case (c) is one times two, minus one, which equals one. Case (e) yields the following. Of the three possibilities with Y-minus-X, only none is allowable. Of the three with X only none is allowable. Of the two with outside, both are allowable. The none-none-none condition is again out. Multiplying, one times one times two, minus one, equals one. Adding across cases gives one plus one which equals two. Thus, the ambiguity of AE2 is two. While this is the simplest case, the principles involved remain constant across all premise combinations. The reason for setting up this counting method instead of simply enumerating the possible relationships with diagrams will become clear to the person who attempts to enumerate an II premise combination without it. The ambiguity associated with each of the 21 premise combinations is listed with each in Chapter II.