The Importance of Universal Quantifiers in a Hypothetical Reasoning Task

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Subjects were presented belief-contravening problems which required a forced choice between accepting either a general law (a universally quantified statement of the form *All A's are B's*) or a particular fact (*This Y is a Z*). The Ss consistently rejected the fact in favor of the generality. Laws with the affirmative quantifier (*All*) were accepted more often than those with the negative quantifier (*No*). Generalities expressing class-inclusion (*is a*) were accepted more often than those expressing property assignment (*has a*). Laws with familiar content were accepted more often than those with unfamiliar content. The contexts for the assertions (definitional, empirical, and unspecified) contributed to the acceptability of the generalities by providing Ss with an interpretation of the assertions.

In the philosophical literature, Goodman (1947) and Rescher (1964) have discussed the dilemma faced by a problem solver who must choose to reject one of two beliefs which he has previously accepted—one of them a general law (e.g., *All A's are B's*) and the other a particular fact (*This Y is a Z*). Such a problem is posed when a set of facts, accepted by the problem solver, is followed by a belief-contravening assumption. For example:

Beliefs: (1) This amoeba is not a vertebrate.
(2) This amoeba does not have a backbone.
(3) All vertebrates have a backbone.

Assumption: This amoeba is a vertebrate.

The problem solver's task is to accept the assumption as true and to delete any of the other three statements which lead to a logical contradiction when combined with the assumption. For example, statement (1) directly contradicts the assumption and therefore must be rejected. There are other contradictions in this example. For instance, when the assumption is combined with statement (2), the two contradict statement (3). That is, if this

amoeba is a vertebrate (the assumption) and it does not have a backbone [statement (2)], it must be false that all vertebrates have a backbone [statement (3)].

However, if the problem solver first chooses to join the assumption with statement (3) rather than (2), he then knows that the amoeba is a vertebrate and that all vertebrates have a backbone. It follows that statement (2) is false in saying that this amoeba does not have a backbone.

All problems of this form are logically ambiguous; there are always two possible solutions. Since the belief-contravening assumption fails to provide sufficient information to guide the problem solver's selection of statements to be retained, he must make the readjustment of beliefs through *nonlogical* means. The most that logical considerations can offer is that one of the two revisions is necessary. Logic alone cannot prescribe which modification ought to be made. Rescher (1964) has proposed a strong set of psychological hypotheses to describe the way in which problem solvers will resolve this dilemma. First, he posited that problem solvers will exhibit a preferential ordering in rejecting the initial beliefs. The ordering, in

increasing willingness to reject a belief, is:

(1) General laws operative in the case at issue.

(2) Facts needed for the applicability of the laws.

(3) Other facts.

Rescher treats the general law as *immune* to rejection. Second, he hypothesized that the high acceptability of the general law is independent of its syntactic form. Thus, positive and negative universals should be equally acceptable. Further, relations expressed by either copula (*to be* or *to have*) should be equally acceptable.

There are some results relevant to these hypotheses in the psychological literature. The importance of universal and particular quantifiers in syllogistic reasoning has been clearly shown in the attempts to specify and explain the Atmosphere Effect (Begg & Denny, 1969; Chapman & Chapman, 1959; Sells, 1936; Simpson & Johnson, 1966; Woodworth & Sells, 1935). Recently, efforts have been made to examine linguistic representations of quantificational terms (Johnson-Laird, 1969a) and the manner in which such representations may account for reasoning performances (Johnson-Laird, 1969b; Johnson-Laird & Wason, 1970; Meyer, 1969).

Meyer (1969) has shown that *verification* of statements with particular quantifiers (such as *Some A's are B's*) is easier than those with universal quantifiers (such as *All A's are B's*) because in the particular cases, one has only to confirm that there is a single instance that is true to verify the statement (i.e., if the statement is *Some men are tall*, one need only find one man who is tall to confirm that the statement is true). On the other hand, with universals, we must insure that there are no exceptions to the assertion (i.e., if the statement *All men are tall* is to be verified, the entire set of men must be explored to insure that the statement is true).

In contrast, universally quantified assertions are more readily *disconfirmed* than are

particulars: one negative instance can disconfirm a universal statement; whereas, for particulars, the entire set of men must be examined before the statement can be said to be false. Once the universal is verified, it can be used to deal with all future instances of the same Subject and Predicate. That is, if Ss do accept the assertion that *All men are tall*, they know that any instance of the class "man" will be a member of the class "tall people." Therefore, in contrast .with the apparent economy in the verification of particulars, acceptance of the lawlike universals precludes the existence of exceptions for which the subject has to account and remember. As a consequence, S should exhibit a stylistic preference for reasoning with universal or general statements than with particular ones. In addition, positive universals should be preferred to negative ones because the latter only tell in which of a range of classes an object is *not* contained and leaves uncertain the class in which it *is* contained.

In the literature on reasoning tasks, syntactic form of the stimuli has been clearly shown to make a major contribution both to decision time and to the kind of inferences which are made (e.g., Gough, 1965, Wason, 1961, 1965; Wason & Jones, 1963). To the extent that ease of verification influences acceptability, these studies would suggest that positive laws should be accorded greater preference than negative ones.

If Rescher's prescribed preference to retain universals were adopted by S, it would be informative to know whether such a preference was the result of the form of the general laws or Ss' familiarity with the contents of the laws. Wilkins (1928) controlled for the effects of familiarity with natural language material by substituting nonsense words for the subject and predicate of propositions. If there is indeed a preference for retaining general statements on grounds of form, it should be revealed both with familiar materials and with those made unfamiliar by Wilkins' technique.

The present study was designed to test Rescher's hypotheses by providing data on the solution of belief-contravening problems. The problem set was chosen to reveal the effects of Polarity and Familiarity (it included problems with negative general laws as well as positive ones—and problems with nonsense content as well as problems with familiar content). In addition, two other variables not directly suggested by the literature were included. The first of these, which we have called "relation," entails the comparison of problems involving the class-inclusion relation (expressed by the copula *to be*) with problems involving the property assignment relation (expressed by the copula *to have*). It was included as an additional test of Goodman & Rescher's hypothesis that the preferential ordering is independent of syntactic form.

A second variable, "context," was added to provide a control of Ss' interpretation of the deductive consequences of the laws. Three contexts were examined: *definitional, empirical,* and *unspecified.* In the definitional context, classes and properties are assigned by means of a linguistic convention, that is, either by fiat or by an agreed-upon ordering principle. The definitional universe of discourse is hierarchical and contains neither exceptions to, nor *lacunae* in, the rules; it is determined by the laws expressed as universal assertions. The empirical context is less completely determined than is the definitional one, since in the former, there may be objects whose properties are incompletely known, or there may be laws which have not been exhaustively tested. Because the empirical context is less determined than the definitional context, in the face of contradictory instances, Ss may show less reticence in rejecting laws which are empirical generalizations than those which are linguistic conventions. When the context is not specified, Ss may be unsure whether the general law's domain is the scientific-empirical universe of statements or the definitional universe of arbitrary categorizations. Consequently, the Ss' uncer-

tainty should result in a low acceptance of the universal assertion. In general, as the context is better specified, the implications of the laws become more definite, and Ss should exhibit a greater preference for retaining the general laws.

In sum, the present study is intended to examine whether Ss show a preference for reasoning with universal statements (when there is a choice between accepting a universal assertion and a particular fact), and whether this priority accorded the universal is affected by (*a*) Ss' familiarity with the content of the statements; (*b*) the relation expressed; (*c*) the polarity of the assertion; and (*d*) the context (the universe of discourse) in which the statements are set or for which they have consequences.

METHOD

Subjects

The Ss were 180 males and females fulfilling a course requirement for Introductory Psychology. They were tested in groups of approximately six, in sessions lasting about 30 minutes.

Design and Procedures

At the beginning of an experimental session, each S was given a booklet of 24 belief-contravening problems. Instructions were read aloud by E while Ss followed with their own copies of the instructions. A sample problem was presented and the two possible solutions were demonstrated. The Ss were then told to proceed through the problems at their own rates, crossing-out all statements which lead to a logical contradiction with the assumption (as explained above). Any questions regarding the logical ambiguity of the solution were answered by instructing S to choose the "best" alternative. The problems presented to any S were from a set of 48 problems constructed from definitions given for animal names (e.g., *All birds have wings*) and for common objects (e.g., *All bicycles have wheels*) in *Webster's New World Dictionary of the American Language* (1957).

A mixed design of two between-subjects variables and two within-subjects variables was employed. The between-Ss variables, context (unspecified, empirical, or definitional) and relation (class-inclusion or property assignment) were orthogonally crossed to form six groups of 30 randomly assigned Ss. To vary context, the laws in a problem booklet were preceded by

one of the following phrases: (*a*) *by definition*, which provides a definitional universe of discourse; (*b*) *it has been found that*, which provides an empirical context; and (*c*) no delimiting phrase preceding the covering law, leaving the context ambiguous. Relation was varied by using the copula *is a* in half of the problems and *has a* in the remaining half; this necessitated creation of problems with different subject and predicate terms to retain meaning in the laws. Since the three assertions which comprise a problem could appear in any of six orders on the page, any effect due to order was controlled by dividing each group into six subgroups of Ss. The particular order that a problem took was assigned randomly for each problem in each subgroup.

The within-Ss variables were crossed by having each S work on 24 problems differing in familiarity (factual and nonsense contents) and polarity (affirmative laws, *All A's are B's* or negative ones, *No A's are B's*). Within a group, all 30 Ss received the same sequence of problems. The sequence was formed by dividing the problems into six blocks, each of which was filled randomly with four problems (one problem from each of the Familiarty-Polarity combinations).

RESULTS

If Ss were making their selections randomly, they should reject the universal assertion on 50% of the problems. Table 1 presents an overall summary of the results for the within-Ss variables and indicates that when given a

TABLE 1

PERCENTAGE ACCEPTANCE OF
UNIVERSALLY QUANTIFIED ASSERTIONS

Content	Polarity of quantifiers		
	Positive	Negative	Average
Familiar	76.8	66.6	71.7
Unfamiliar	70.7	62.4	67.5
Average	73 8	64.5	69.2

choice between a universally quantified statement and a particular fact, Ss reject the fact in favor of the generality significantly more often than would be predicated by chance. All values in the table are found to be significantly greater than chance by chi-square tests for each cell, $p < .001$.

Table 1 also indicates that the results hold well for problems expressed in natural language about real objects and for problems devoid of content. The acceptance rates for familiar problems, however, are significantly greater than those for unfamiliar ones, $F(1, 174) = 13.9$, $p < .001$, showing that

TABLE 2

PERCENTAGE ACCEPTANCE OF
UNIVERSALLY QUANTIFIED RELATIONS

Relation	Polarity of quantifiers		
	Positive	Negative	Average
is a	75.0	73.6	74.3
has a	72.5	55.3	63.9

although quantification may be the critical factor in acceptability, Ss do attend to content.

Table 1 shows that the universal, negative statements, like the positive ones, are accepted more often than would be predicted by chance alone. However, the acceptance of positive universals is significantly greater than of negative ones, $F(1, 174) = 41.0$, $p < .001$. This effect due to polarity of the assertion does not interact with familiarity.

There is a significant difference in acceptability between the two relations, with laws expressing the inclusion relation (*is a*) accepted more often than those expressing property assignment (*has a*), $F(1, 174) = 35.8, p < .001$. However, Table 2 shows that despite this difference, the overall acceptability of both relations exceeds chance (*is a*: $\chi^2(20) = 259.5$, $p < .001$; *has a*: $\chi^2(20) = 120.9, p < .001$).

Table 2 also shows a significant interaction between relation and polarity, $F(1, 174) = 31.0$, $p < .001$, where the negative general laws, which assigned a property, were disproportionately depressed in acceptability.

That Context provides a profound effect on the acceptance of universal statements is shown in Table 3. There is a significant difference between the overall acceptance levels for each of the three contexts, $F(2, 174) =$

26.0, $p < .001$, where the two specified contexts show a greater acceptance of the laws than the unspecified context. Context did not interact with either of the within-subjects variables of familiarity or polarity.

TABLE 3

CONTEXT AND PERCENTAGE ACCEPTANCE
OF UNIVERSALS

Context	Polarity of quantifiers		
	Positive	Negative	Average
Unspecified	is a: 62.9	is a: 65.3	60.5
	has a. 72.3	has a: 41.4	
Empirical	is a: 78.2	is a: 75.0	71.0
	has a: 71.8	has a: 59.1	
Definitional	is a: 84.0	is a: 80.6	75.9
	has a: 73.4	has a. 65.5	

No significant effect due to blocks or to order of propositions was found.

DISCUSSION

The present results support the claim that when reasoning with belief-contravening problems, subjects exhibit a preference for accepting universally quantified propositions rather than particular facts. However, the priority accorded universal statements is shown more often when the universal quantifier is affirmative (*All*) rather than negative (*No*). This preference is also enhanced when the objects reasoned about are familiar ones and when the Relation expressed is class-inclusion rather than property assignment. The preference, then, is not completely independent either of syntactic form or semantic content. The most marked deviation from Goodman and Rescher's independence hypothesis is the strong and completely unexpected interaction between Relation and Polarity. From Table 2 it will be seen that the low acceptability of the *has a* covering laws comes largely from the negative form. At present, we have no clear explanation for this interaction.

The data show that the Polarity of the assertions has a pronounced effect on acceptability.

Although this result has an interpretation based on transformational complexity (Miller, 1962), the data from other verification tasks (Chase & Clark, in press; Gough, 1965) reveal an interaction between the truth status and polarity of assertions, indicating that the difference in acceptability between affirmative and negative statements cannot simply be the result of greater syntactic complexity for the negatives. That this differential preference may be a result of more general processes is suggested by the fact that scientific laws are rarely expressed as negative assertions; even definitions are constructed so as to affirm a relationship rather than disconfirm one—unless, of course, there is a common tendency to affirm an incorrect relationship such as *Whales are fish* (Wason, 1965). At present, it seems too early to try to suggest the nature of this "general process" more exactly.

There was a stronger preference for universals over particulars when the propositions were expressed with *to be* than with *to have*. The possibility that this nonequivalence in acceptability was related to grammatical complexity has been considered on the following grounds: many authors (Bach, 1967; Lyons, 1969; Twaddell, 1963) have made strong linguistic arguments for considering these auxiliaries as equivalently simple loci in surface structure (carrying overt markings for the syntactic distinctions of tense, mood, and aspect). However, Lyons (1969) has argued that *to have* is somewhat more complexly derived than *to be*, where the phrase *John has a book* is derived from an underlying structure in which *a book* is the Subject and *John* is in a predicative relation to it (somewhat akin to *The book is John's*). This explanation for the difference in acceptability must remain tentative until it is shown whether the behavior is the result of the relations predicated or the grammatical complexity of the terms used to express the relations.

The data show that the universe of discourse makes a critical contribution to the interpretation of the propositions. As the context moves

from unspecified to definitional, there is a general trend towards increased acceptance. Of particular relevance is the increased acceptability shown on the negative property assignment statements mentioned above. When the context is unspecified, subjects treat the negative, *has a* law as slightly less than equivalent in priority to the particular fact. However, when the universal assertion is placed within a context (empirical or definitional) it is accorded a law-like acceptability, Context × Relation × Polarity: $F(2, 174) = 10.1, p < .001$).

The relatively low acceptance level of the *is a* universals in the ambiguous context attests to Ss' uncertainty about how to categorize such assertions. In contrast, the higher acceptance of the affirmative *has a* universals may be a consequence of their empirical connotation, which may have provided some context even in this ambiguous setting.

CONCLUSION

It is clear that Rescher was substantially correct in claiming that problem solvers would show a preference for accepting general laws over particular facts, though the data require us to reject or seriously modify the hypothesis that this preference is independent of syntactic form. We found that the preference was altered by the Polarity of the general laws, by the Relation expressed, and by the interaction of these two variables as well as by the Familiarity of the content and by the Content in which it was presented. It is also clear that we have raised more questions than we have answered.

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