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"At least one" problem with "some" formal reasoning paradigms

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In formal reasoning, the quantifier "some" means "at least one and possibly all." In contrast, reasoners often pragmatically interpret "some" to mean "some, but not all" on both immediate-inference and Euler circle tasks. It is still unclear whether pragmatic interpretations can explain the high rates of errors normally observed on syllogistic reasoning tasks. To address this issue, we presented participants (reasoners) in the present experiments either standard quantifiers or clarified quantifiers designed to precisely articulate the quantifiers' logical interpretations. In Experiment 1, reasoners made significantly more logical responses and significantly fewer pragmatic responses on an immediate-inference task when presented with logically clarified as opposed to standard quantifiers. In Experiment 2, this finding was extended to a variant of the immediate-inference task in which reasoners were asked to deduce what followed from premises they were to assume to be false. In Experiment 3, we used a syllogistic reasoning task and observed that logically clarified premises reduced pragmatic and increased logical responses relative to standard ones, providing strong evidence that pragmatic responses can explain some aspects of the errors made in the syllogistic reasoning task. These findings suggest that standard quantifiers should be replaced with logically clarified quantifiers in teaching and in future research.

Syllogistic reasoning is a widely used measure of formal, deductive reasoning. In this task, reasoners are presented with two premise statements (e.g., "Some of the As are Bs" and "All of the Bs are Cs") and are then asked to decide whether a given conclusion statement logically follows from the premises (e.g., "Some of the As are Cs," which is a valid conclusion). Syllogistic reasoning is used as a vehicle to investigate such disparate phenomena as belief bias (Evans, Barston, & Pollard, 1983; Klauer, Musch, & Naumer, 2000; Newstead, Pollard, Evans, & Allen, 1992; Thompson, Striemer, Reikoff, Gunter, & Campbell, 2003), the role of working memory in reasoning (Capon, Handley, & Dennis, 2003; Copeland & Radvansky, 2004; Gilhooly, Logie, & Wynn, 1999; Quayle & Ball, 2000), strategies in reasoning (Bacon, Handley, & Newstead, 2003; Bucciarelli & Johnson-Laird, 1999; Chater & Oaksford, 1999), and disruptions to reasoning performance caused by age (Fisk & Sharp, 2002; Gilinsky & Judd, 1994) and other factors (Fisk, Montgomery, Wareing, & Murphy, 2005; Smeets & De Jong, 2005).

Although often taken as a measure of logical or analytic reasoning, it is almost certainly the case that performance on this task also encompasses a number of nonanalytic processes. For example, it is well known that the believability of both the premises and the conclusion have a large effect on the inferences that reasoners are willing to endorse (e.g., Evans et al., 1983; Klauer et al., 2000; Newstead et al., 1992; Thompson, 1996; Thompson et al., 2003). Even when the believability of the material is not an issue (i.e., premises and conclusions describe arbitrary or abstract relations), the reasoner must still interpret the task, the instructions, and the meaning of the quantifiers used in the problems. Poor performance, therefore, may not necessarily represent poor logical reasoning, but, instead, may reflect differences between the reasoner's and the experimenter's interpretation of the task requirements. For example, reasoners may conflate the concepts of logical possibility with logical necessity (e.g., Evans, Handley, & Harper, 2001; Evans, Handley, Harper, & Johnson-Laird, 1999; Newstead, Thompson, & Handley, 2002) and employ heuristic, rather than logical, strategies (Chater & Oaksford, 1999). Consequently, it is difficult to attribute contributions of analytic processes to performance in the absence of a well-articulated model of interpretation (Evans & Thompson, 2004; Thompson, 2000).

Thus, the goal of the present study is to investigate how the interpretation of the quantifiers used in syllogistic problems contributes to variability in reasoning performance. Surprisingly, relatively little is known about how interpretations along this dimension affect reasoning. There is also a well-developed literature documenting reasoners' interpretations of quantified premises in isola-

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tion (e.g., Begg & Harris, 1982; Déret, 1998; Evans et al., 1999; Newstead, 1989, 1995; Newstead & Griggs, 1983; Politzer, 1991; Rosenthal, 1980), but little that examines the relationship between these interpretations and reasoning on a complex task.

Of particular interest is the quantifier "some," which is used differently in formal logic than in everyday speech. In formal logic, "some" means "at least one and possibly all." Pragmatically, however, this interpretation of the word "some" is infelicitous, as "some" means "some but not all" in everyday speech. For instance, if James tells Sarah "Some of the employees are part of the union," then Sarah will infer that some employees are *not* part of the union (because only *some* of the employees are); Sarah would reasonably assume that if James had meant "all," then he would have said "all." This is termed the Gricean maxim of quantity (or informativeness; Grice, 1975/2002). Thus, when reasoners are presented with a premise such as "Some of the As are Bs," they will make the sensible conclusion that "Some *but not all* of the As are Bs." As a result, some syllogistic reasoning "errors" may not be errors at all. Rather, the error may reflect a Gricean, rather than a logical, interpretation of the premises.

Indeed, the evidence supports the conclusion that reasoners make pragmatic interpretations of quantified premises (e.g., Begg & Harris, 1982; Déret, 1998; Evans et al., 1999; Newstead, 1989, 1995; Newstead & Griggs, 1983; Politzer, 1991; Rosenthal, 1980). Much of the data is derived from the immediate inference task, where reasoners are presented with a single premise statement (e.g., "All of the As are Bs") and are then asked to judge whether a given conclusion statement follows (e.g., "None of the As are Bs," which would be false). Pragmatic interpretations are common. For instance, reasoners are 22% more likely to conclude that "Some of the As are Bs" follows from "Some of the As are not Bs" than from "All of the As are Bs," even though the former is invalid and the latter is valid (Evans et al., 1999). Furthermore, although instructing reasoners on the logical interpretation of the word "some" increases logical responses (Newstead, 1995), it does not prevent pragmatic responses (Begg & Harris, 1982; Newstead, 1989; Newstead & Griggs, 1983). Similar findings have been obtained using a different paradigm, the Euler circle task, in which the conclusions are circle diagrams instead of statements (Begg & Harris, 1982; Newstead, 1989).

Although there has been a long-standing assumption that these types of Gricean interpretations contribute to the large number of errors typically observed in syllogistic reasoning tasks, the existing data do not corroborate this hypothesis. For example, Newstead and his colleagues (Newstead, 1989, 1995; Newstead & Griggs, 1999) have demonstrated that, although Gricean interpretations are common on immediate inference tasks, they appear to account for little, if any, variance on the more complex syllogistic reasoning task. That is, when one looks at the errors reasoners make, there is little evidence to show that they are produced by a Gricean interpretation of the premises (Newstead, 1995); indeed, such errors tend to be produced less often than expected by chance. However, Newstead (1995) found a small correlation between the tendency to endorse Gricean interpretations on an Euler circle task and the probability of endorsing a conclusion consistent with a Gricean interpretation in the syllogistic reasoning task. He also observed a small but statistically reliable reduction (28% to 19%) in responses consistent with a Gricean interpretation when reasoners were given instructions about the logical meaning of "some." Additionally, Roberts, Newstead, and Griggs (2001) have shown that a portion of syllogistic errors are consistent with a pragmatic interpretation of the premises, assuming that they also make reversible interpretations of the premises (e.g., such that "Some of the As are not Bs" entails "Some of the Bs are not As").

One interpretation of these data is that the expression of Gricean interpretations is but one of many factors that affect performance on these tasks (Roberts et al., 2001). This would make the calculation of chance rates of observations difficult. How many pragmatically consistent errors does one need to observe in order to conclude that they occur in significant proportions in contexts where responses are multiply determined? Moreover, given that overriding the inclination to interpret "some" as "some but not all" is a working-memory-demanding task (Feeney, Scrafton, Duckworth, & Handley, 2004), instructions to do so might have limited utility in the context of a highly working-memory-demanding task, such as syllogistic reasoning.

In the present article, we have adopted an alternative approach, namely to replace the ambiguous quantifiers with new quantifiers that precisely articulate their logical interpretations. This manipulation should not pose extra demands on working memory; thus, to the extent that "errors" on syllogistic tasks reflect pragmatic interpretations of the quantifiers, performance should improve on tasks that employ the logically clarified versions of the quantifiers.

We know of only two studies that have attempted to reduce the ambiguity of the premises by substituting alternative phrases for them (Ceraso & Provitera, 1971; Newstead & Griggs, 1999). In those studies, the quantifiers were replaced with extended sentences (e.g., the sentence "Whenever I have a square block it is blue, but I also have some blue blocks that are not square" indicates that some *but not all* blue blocks are square). It is important to note, however, that the elaborated premises did not specify the *logical* meaning of quantifiers, but instead reduced ambiguity by eliminating some possible interpretations of the quantifiers. Indeed, in some cases, the meaning of the quantifiers was altered to such an extent that the elaborated and traditional versions entailed different valid conclusions.

Nonetheless, the elaborated premises had a significant impact on the conclusions that reasoners endorsed, suggesting that some variability in syllogistic reasoning can be attributed to ambiguity in the interpretation of the premises. The goal of our study is to take this one step further, clarifying the logical meaning of the particular quantifiers by replacing them with statements that precisely articulate their logical meaning, namely "at least one" (similar to Geurts, 2003). The use of "at least one" quantifiers should decrease reasoners' inclination to make pragmatic responses for two reasons. First, "at least one" stresses the focus on *particular* (i.e., individual) cases instead of on sets of cases. Second, "at least one" pragmatically allows for the possibility "all." Both of these characteristics are important, because a statement such as "Some of the As are Bs" logically allows for the possibility that *only one* A is a B, that *all* As are Bs, or anything in between. The only possibility ruled out is that none of the As are Bs; "at least one" is consistent with this logical meaning. That is, "at least one" clearly asserts that there is one A that is a B and allows for any or all of the remaining As to be Bs.

The present experiments have two goals. The first is to demonstrate that reasoners interpret our new logically clarified "at least one" quantifiers as we intended them to. In Experiments 1 and 2, we tested the hypothesis that logically clarified premises will reduce pragmatic responses and increase logical responses on two versions of the immediate inference task. The second goal was to extend this analysis to syllogistic reasoning. In Experiment 3, we predicted that logically clarified premises would likewise facilitate logical responses on a syllogistic task. Finally, we discuss the implications of our findings for theories of syllogistic reasoning.

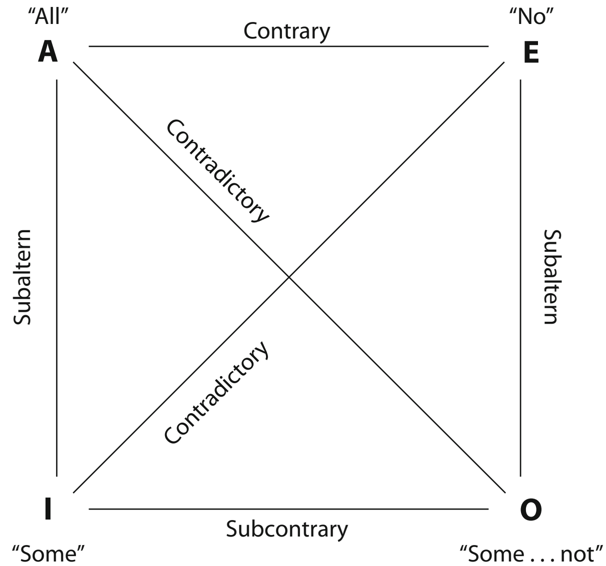

Figure 1. There are four moods in the square of opposition. (A) The universal affirmative: "All of the As are Bs." (E) The universal negative: "None of the As are Bs." (I) The particular affirmative: "Some of the As are Bs." (O) The universal negative: "Some of the As are not Bs."

EXPERIMENT 1

Participants (*reasoners*) in this study completed an immediate inference task with one of three types of quantifiers. The first was the standard particular premises ("some" and "some . . . not"). The second was the logically clarified quantifiers ("at least one" and "at least one . . . not"). Finally, as a control condition, we also included pragmatically clarified quantifiers ("some but not all" and "some but not all . . . not"), which should provide an estimate of reasoners' inclinations to make pragmatic responses when it is unambiguously appropriate to do so.

We were interested in two types of responses: pragmatic and logical. Logical responses should be based on the *square of opposition*, as illustrated in Figure 1. In contrast, pragmatic interpretations should resemble the pattern depicted by the *triangle of opposition* in Figure 2. Figure 1 depicts the relationship among the four standard quantifiers: "all," "no," "some," and "some . . . not." Traditionally, each quantifier represents one of four moods that make up an orthogonal combination of universality (universal, particular) and polarity (affirmative, negative). "All" is the universal affirmative (e.g., "All of the chemists are beekeepers"), "no" is the universal negative (e.g., "None of the chemists are beekeepers"), "some" is the particular affirmative (e.g., "Some of the chemists are beekeepers"), and "some . . . not" is the particular negative (e.g., "Some of the chemists are not beekeepers").

However, given that reasoners often interpret "some" pragmatically rather than logically, Begg and Harris (1982) argued that reasoners divide logical reality into just three categories: "all," "no," and "some but not all." In this view, there are truly only three logical moods, which could be modeled as a triangle of opposition as depicted in Figure 2. The "all" and "no" moods are the same as in the square of opposition, but the "some" and "some . . . not" moods are replaced by a single "some but not all" *partition* mood, where "some" and "some . . . not" are merely exemplars of the partition mood. Under this interpretation, each of the three types of moods—universal affirmative, universal negative, and partition—should be

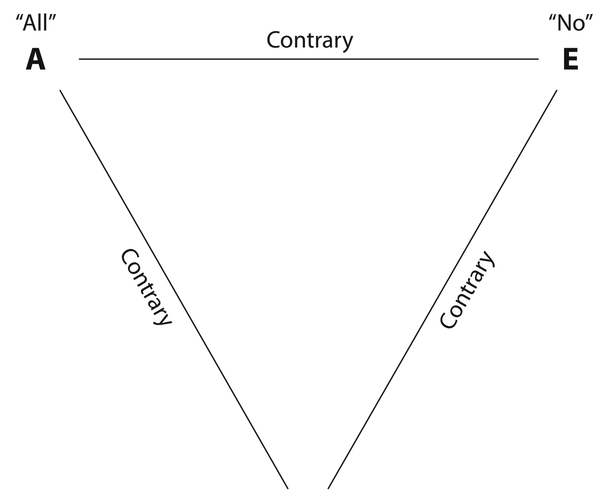

Figure 2. There are three moods in the triangle of opposition. (A) The universal affirmative: "All of the As are Bs." (E) The universal negative: "None of the As are Bs." (U) The partition: "Some but not all of the As are Bs," which is assumed to be equivalent pragmatically to "Some of the As are Bs" and "Some of the As are not Bs."

mutually exclusive. That is to say, no two of these moods (e.g., "all" and "no") can be true at the same time; the truth of one mood (e.g., "all") implies the falsity of the remaining two (i.e., "no" and "some but not all").

If the quantifier manipulation is successful in changing the frequency of pragmatic responses, then differences among the three types of quantifiers should be observed. The rate of logical responses should be highest with the logically clarified premises, and the rate of pragmatic responses should be highest with the pragmatically clarified premises. That is, reasoners given logically clarified premises should produce responses consistent with the square of opposition depicted in Figure 1, whereas pragmatically clarified premises should elicit responses consistent with the triangle depicted in Figure 2. Under the assumption that traditional quantifiers are ambiguous in their interpretation, we expect a mixed pattern for these.

However, as illustrated in Figures 1 and 2, the differences among the quantifiers should be selective, applying only to problems in which a pragmatic interpretation of the quantifier would lead to a conclusion different from that of the logical interpretation. The two types of problems for which these differences should be observed are called *subcontrary* and *subaltern* problems.

For subcontrary problems, reasoners are presented a particular premise followed by the reverse-polarity conclusion (i.e., "Some of the As are Bs" followed by "Some of the As are not Bs," or vice versa). Under a pragmatic interpretation, these conclusions follow validly. Under a logical interpretation, however, neither conclusion is necessary, because "some" allows the possibility of "all," and "some . . . not" allows the possibility of "none." Consequently, we expected the rates of endorsement for these conclusions to be highest for the pragmatically clarified premises, lower for the standard, and lower still for the logically clarified premises; conversely, the pattern of logically valid responses (i.e., indications that these conclusions are possible) should be the reverse.

For subaltern problems, reasoners are presented a particular premise followed by the same-polarity universal conclusion (i.e., "Some of the As are Bs" followed by "All of the As are Bs," or "Some of the As are not Bs" followed by "None of the As are Bs"). These conclusions are logically, but not pragmatically, possible. Thus, reasoners should be more inclined to reject these inferences in the pragmatically clarified condition than in the standard condition, followed by the logically clarified condition. Again, logical responses (i.e., indications that these conclusions are possible) should be the mirror image of this pattern.

For the two remaining problem types, there should be no effect of the quantifier manipulation, because the logical and pragmatic interpretations of the premises lead to the same conclusion. For *identity* problems, reasoners are presented a premise followed by the same statement as a conclusion (i.e., "Some of the As are Bs" followed by "Some of the As are Bs," or "Some of the As are not Bs" followed by "Some of the As are not Bs"). Both logically and pragmatically, these conclusions necessarily follow. For *contradictory* problems, reasoners are presented a premise followed by a conclusion with the opposite universality and polarity (i.e., "Some of the As are Bs" followed by "None of the As are Bs," or "Some of the As are not Bs" followed by "All of the As are Bs"). Both logically and pragmatically, these conclusions are necessarily false.

In summary, for two critical problem types (subaltern and subcontrary), logical responses should be increased and pragmatic responses should be decreased in the logically clarified condition, and the reverse should be true in the pragmatically clarified condition. For the remaining two problem types (contradictory and identity), responses should be consistent for all three quantifier types (standard, logically clarified, and pragmatically clarified).

Method

Participants (Reasoners). Twenty-four reasoners with no background in logic completed Experiment 1. Six reasoners were volunteers, and the remaining 18 were University of Saskatchewan undergraduates who received course credit or C$5 for participating.

Materials and Design. Each problem was presented on the page in the following form:

IF IT IS TRUE THAT:
At least one of the chemists is a beekeeper
THEN IS IT THE CASE THAT:

All of the chemists are beekeepers	Y__ N__ M__
None of the chemists are beekeepers	Y__ N__ M__
Some of the chemists are beekeepers	Y__ N__ M__
Some of the chemists are not beekeepers	Y__ N__ M__

All problems related one category of individuals to another category of individuals. Each of the 48 unique categories used was either a profession or a hobby. The particular affirmative and particular negative premises were presented using standard ("some," "some . . . not"), logically clarified ("at least one," "at least one . . . not"), or pragmatically clarified ("some but not all," "some but not all . . . not") quantifiers. This resulted in six premise types (2 polarities $\times$ 3 quantifiers). Four versions of each premise type were created using unique combinations of hobbies and professions. The conclusion statements were always the four standard moods ("all," "no," "some," and "some . . . not") and were followed by three response options: "Y" (for "yes"), "N" (for "no"), and "M" (for "maybe").

Procedure. The 24 problems were presented in four blocks, each with one instance of each premise type. The order of the items within blocks was randomized for each group of 4 reasoners. Orthogonal to this, the four conclusion statements were presented in four counterbalanced orders. Each reasoner was given a booklet that began with the following instruction page:

Immediate Inference Task

IF IT IS TRUE THAT:
Either a magpie or a magpie and a crow are in the yard
THEN IS IT THE CASE THAT:

A magpie is in the yard	Y__ N__ M__
A magpie is not in the yard	Y__ N__ M__
A crow is in the yard	Y__ N__ M__
A crow is not in the yard	Y__ N__ M__

Assume that the first "premise" statement (i.e., "Either a magpie or a magpie and a crow are in the yard") is true. You must then decide whether each of the four following ("conclusion") statements is NECESSARILY true, NECESSARILY false, or POSSIBLY true given that the premise statement is true.

For instance, because the premise is true, with or without a crow, there must be a magpie in the yard. As such, the first conclusion statement ("A magpie is in the yard") is necessarily true. Thus, you would check the space next to the "Y" (for "yes").

> Conversely, the second conclusion statement ("A magpie is not in the yard") is necessarily false. Thus, you would check the space next to the "N" (for "no").
>
> The remaining two conclusion statements are both possible but not necessary because a crow could or could not be in the yard (e.g., the magpie could be alone in the yard). For both of these statements you should therefore check the space next to the "M" (for "maybe").
>
> In the problems presented below assume that all the statements refer to a gathering of people in a room. After you have finished a problem, please do not return to it (even if you realize that you have made a mistake). If you are unclear about any of these instructions, please ask the experimenter to clarify them before you continue. When you are ready to begin, flip the page.

Reasoners were tested alone or in small groups. No time limit was set for completing the problems. Most reasoners took about 15 min.

Results

The dependent measures for Experiment 1 were proportion logical and pragmatic responses; since the overall results for these dependent measures were always complementary, the analysis will focus only on the logical responses. The data are plotted in Figure 3.

A 3 (quantifier: logically clarified, standard, pragmatically clarified) × 4 (problem type: contradictory, subaltern, subcontrary, identity) within-groups ANOVA for logical responses revealed a significant main effect for quantifier [$F(2,46) = 20.178$, $MS_e = 1.115$, $p < .001$], a main effect for problem type [$F(3,69) = 103.565$, $MS_e = 8.774$, $p < .001$], and an interaction [$F(6,138) = 17.160$, $MS_e = 0.746$, $p < .001$]. Planned comparisons were then conducted.

We predicted that subaltern problems (i.e., problems for which "some" or "some . . . not" was the premise and "all" or "no," respectively, was the conclusion) would elicit different responses in the three quantifier conditions. A logical interpretation acknowledges that, for instance, "all" is not impossible given "some"; thus, clarifying the meaning of "some" should facilitate this interpretation. As predicted, reasoners made more logical responses with "at least one" (.65) quantifiers relative to "some" (.36) quantifiers [$t(23) = 3.446$, $p = .002$, $SE_{\text{diff}} = .085$], and fewer logical responses with "some but not all" (.05) quantifiers relative to "some" [$t(23) = 4.541$, $p < .001$, $SE_{\text{diff}} = .068$]. As expected, these findings were mirrored by a reduction in pragmatic responses for "at least one" (.34) relative to "some" (.64) quantifiers [$t(23) = 3.562$, $p = .002$, $SE_{\text{diff}} = .083$], and an increase in pragmatic responses for "some but not all" (.94) quantifiers relative to "some" [$t(23) = 4.460$, $p < .001$, $SE_{\text{diff}} = .068$].

We predicted that subcontrary problems (i.e., problems for which "some" was the premise and "some . . . not" the conclusion, or vice versa) would elicit different responses in the three quantifier conditions. A logical interpretation acknowledges that "some" does not imply "some not," and vice versa; thus, clarifying that "some" means "at least one" should block this interpretation. Consistent with this prediction, reasoners made more logical responses with "at least one" (.51) quantifiers relative to "some" (.31) quantifiers [$t(23) = 2.483$, $p = .021$, $SE_{\text{diff}} = .081$], and less with "some but not all" (.12) quantifiers relative to "some" [$t(23) = 3.016$, $p = .006$, $SE_{\text{diff}} = .063$]. As expected, these findings were mirrored by a reduction in pragmatic responses for "at least one" (.44) relative to "some" (.64) quantifiers [$t(23) = 2.369$, $p = .027$, $SE_{\text{diff}} = .084$], and an increase in pragmatic responses for "some but not all" (.83) quantifiers relative to "some" [$t(23) = 3.194$, $p = .004$, $SE_{\text{diff}} = .060$].

For contradictory problems, we expected no differences between premise conditions, given that the conclusion is impossible regardless of whether a pragmatic or logical interpretation is made (e.g., "none" cannot follow from either "some" or "at least one"). Consistent with this prediction, no differences were found between "some" (.94) and "at least one" (.97) quantifiers [$t(23) = .917$, $p = .369$, $SE_{\text{diff}} = .035$], or between "some" (.94) and "some but not all" (.93) quantifiers [$t(23) = .432$, $p = .670$, $SE_{\text{diff}} = .022$].

Similarly, no differences were expected for identity problems. Consistent with this prediction, there was no difference in logical responses for "some" (.99) and "some

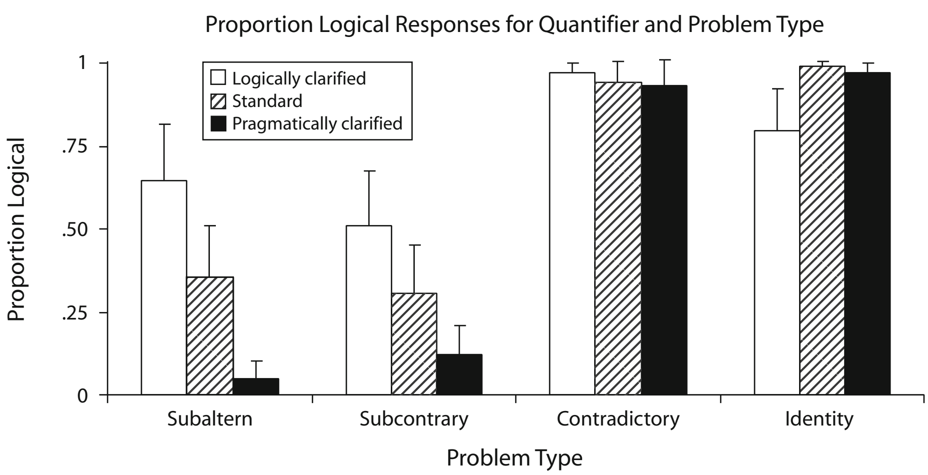

Figure 3. Proportion of logical responses and 95% confidence intervals as a function of problem and premise type in Experiment 1.

but not all" (.97) quantifiers [$t(23) = 1.381$, $p = .181$, $SE_{\text{diff}} = .011$]. However, contrary to predictions, logical responses for "at least one" (.80) quantifiers were significantly reduced relative to "some" quantifiers [$t(23) = 3.182$, $p = .004$, $SE_{\text{diff}} = .060$]. This was mirrored by a rise in "maybe" responses for "at least one" (.20) relative to "some" (.01) quantifiers [$t(23) = 3.171$, $p = .004$, $SE_{\text{diff}} = .061$]. This apparent anomaly is likely due to the fact that, although logically clarified versions of the premises were used, the conclusions were presented in the standard form. Whereas logically clarified statements allow for the possibility of universal (i.e., "all") or singular (i.e., "one") interpretations, standard statements imply more than one but not all; as such, given "at least one," "some" does not *pragmatically* follow (i.e., if "all" or "one" is true). Thus, these data serve as additional evidence that reasoners do not interpret standard and logically clarified statements to mean the same thing.

Discussion

Our manipulation successfully reduced the number of pragmatic responses given to particular quantifiers. Specifically, for subaltern and subcontrary problems, the rate of pragmatic responses was reduced by 30% and 20%, respectively, with logically clarified "at least one" quantifiers; this decrease was accompanied by concomitant increases in logical responses. Thus, reasoners interpret "at least one" to mean something more similar to the logical meaning of particular connectives than the traditional "some." It is worth noting, however, that performance for the logically clarified premises was not at ceiling, indicating that we were not 100% successful in promoting a logical interpretation.

In addition, it is clear that some reasoners made a logical interpretation of the standard quantifiers, given that pragmatic responses were more prevalent in the pragmatically clarified condition. These data suggest that the standard quantifiers are ambiguous and produce highly variable interpretations. In order to avoid the variance in performance that can be attributed to differences in interpretations, researchers might be advised to specify the intended meanings of the premises using either the pragmatically clarified or logically clarified premises.

EXPERIMENT 2

The goal of Experiment 2 was to replicate and extend the findings of Experiment 1 in the following ways. First, Experiment 1 used a within-groups design, opening up the possibility of carry-over effects. That is, given that the various quantifiers were presented in close proximity, reasoners may have made a conscious effort to discriminate their meanings. Thus, we wished to rule out the possibility that the high rate of logical responses and low rate of pragmatic responses on the logically clarified problems were artificially elevated and decremented, respectively, due to exposure to the standard problems. To accomplish this goal, we used a between-groups design in Experiment 2. Pragmatically clarified quantifiers were not presented in Experiment 2.

A second goal of Experiment 2 was to address the concern raised in the results of Experiment 1 by providing logically clarified conclusions as well as logically clarified premises. That is, those reasoners who received "at least one" premises also received "at least one" conclusions. By so doing, we were able to provide a more appropriate identity condition for logically clarified quantifiers. In addition, this manipulation allowed us to increase the number of conclusions that were predicted to differ for standard and logically clarified premise types, in particular, for subaltern problems with universal premises. For these problems, reasoners were presented a universal premise followed by the particular premise with the same polarity (i.e., "All of the As are Bs" followed by "Some of the As are Bs," or "None of the As are Bs" followed by "Some of the As are not Bs"). These conclusions are logically necessary, but pragmatically impossible. Thus, logical "yes" responses should be increased, and pragmatic "no" responses should be decreased in the logically clarified condition than in the standard condition.

For the remaining new problem types, no effect of quantifier is expected, because both logical and pragmatic interpretations lead to the same response. Specifically, contradictory and identity problems with universal premises follow the same logic as do contradictory and identity problems with particular premises. In contrary problems, reasoners are presented a universal premise followed by the reverse-polarity universal premise (i.e., "All of the As are Bs" followed by "None of the As are Bs," or vice versa). The type of particular quantifier cannot affect performance in this condition because particular quantifiers do not appear in these problems.

The final goal of Experiment 2 was to extend our analysis to situations in which the premises are assumed to be false. For instance, if it is false that "Some of the As are Bs," then is it the case that "None of the As are Bs"? Thus, for half of the problems, reasoners were asked to judge what was implied by a true premise, and for the remaining half, they were asked to judge what should follow from a false premise.

As we pointed out earlier, the pragmatic interpretation outlined in Figure 2 suggests that the three moods (universal affirmative, universal negative, and partition) will be mutually exclusive. That is to say, no two of these moods (e.g., "all" and "no") can be true at the same time, so the truth of one mood (e.g., "all") implies the falsity of the remaining two (i.e., "no" and "some but not all"). Conversely, a false premise (e.g., "all") implies that each of the remaining two moods (i.e., "no" and "some but not all") are still possibly true. Consequently, in the false premise task, the majority of a pragmatic reasoner's responses should conform to a simple pattern in which all conclusions are to be regarded as being possibly true, except for the false identity conclusions (including the subcontrary conclusions, because "some" and "some . . . not" are regarded as being the same). Reasoners should be more likely to adopt this pragmatic strategy as their primary strategy in the standard condition than in the logically clarified condition.

The pattern of responses under a logical interpretation will be different. To derive a logical interpretation, one needs to determine what follows logically from the contradiction of the premise. For example, if the premise "Some of the As are Bs" is false, this can be construed to mean that the premise "None of the As are Bs" is true. The reasoner can then use this "no" premise to evaluate the conclusions (i.e., "all" and "some" are false, and "no" and "some . . . not" are true). Reasoners should be more likely to adopt this strategy in the logically clarified than the standard condition.

We also anticipated that reasoners would have difficulty making inferences from false premises. For example, reasoners often have difficulty determining which situations contradict or are inconsistent with a set of premises and must first eliminate the set of true possibilities before they can derive the false possibilities (Barres & Johnson-Laird, 2003). Since this may overtax working memory, reasoners are prone to error. In the present task, we hypothesized that reasoners might take a mental shortcut—in particular, by accepting the "opposite" of the premise (i.e., the reverse polarity), where "all" and "no" are opposites and "some" and "some . . . not" are opposites (e.g., a false "all" may seem to imply a true "no"). In principle, the polarity rule could be used just as easily by pragmatic and logical reasoners.

Method

Reasoners. Thirty-two University of Saskatchewan undergraduates with no background in logic completed Experiment 2. Reasoners received course credit or C$5 for participating. None of the reasoners in Experiment 2 had participated in Experiment 1.

Materials and Design. The same 48 categories of professions and hobbies used in Experiment 1 were used in Experiment 2. Half of the reasoners were presented standard quantifiers ("some," "some . . . not"), and half were presented logically clarified quantifiers ("at least one," "at least one . . . not") for both premises *and* conclusions. In addition to particular premises, all reasoners were presented with universal affirmative ("all") and universal negative ("no") premise statements. Each problem used one of the four premises with all four conclusions. Each reasoner was presented with six blocks of four randomly ordered problems (one for each premise type) for a total of 24 unique problems. The conclusion statements were presented in the same four counterbalanced orders as in Experiment 1. Half of the reasoners were to assume the premise was true for the first half of the problems and false for the second half of the problems. The other half of the reasoners received the false premises first and the true premises second. This order manipulation was orthogonal to the counterbalancing order of conclusion statements and to the quantifier manipulation. The premise headings were changed so that the word "True" or "False" was in all capital letters, bold, italicized, and underlined (e.g., "If it is ***True*** That:") for the true and false premise problems, respectively. As in Experiment 1, reasoners were to put a check next to the "Y," "N," or "M" for each conclusion statement.

Procedure. The procedure for Experiment 2 was identical to that for Experiment 1 except that there were two instruction pages. The instruction page for the true premise problems was identical to that used in Experiment 1. The instruction page for the false premise problems was only slightly modified because different conclusions follow from true and false versions of the same premise, but was otherwise identical.

Results

The dependent measures for Experiment 2 were proportion logical and pragmatic responses; as before, we will base our analysis primarily on the logical pattern. Results will be presented in three subsections: (1) overall logical responses, (2) true premise problems with particular premises (i.e., the conditions used in Experiment 1), and (3) true premise problems with universal premises, which will provide an additional test of the quantifier hypothesis. Note that 5 reasoners (4 in the standard condition and 1 in the logically clarified condition) were removed from Experiment 2 for having three or more errors on any of the identity, contradictory, or contrary problems. Failure to respond logically to these self-evident problems suggests that these reasoners did not comprehend the task. We did not use a similar exclusion criterion for Experiment 1 because this would have concealed the reduction in acceptance of identity problems in the logically clarified condition. Removing the 5 reasoners from the present experiment did not alter the findings reported below.

Overall logical responses. To characterize the data broadly, a 2 (quantifier: standard, logically clarified) × 2 (premise truth: true, false) mixed ANOVA for proportion logical responses was conducted. These data are reported in Figure 4, in which it is clear that more logical responses were given for true (.81) than false (.57) premise problems [$F(1,28) = 64.691$, $MS_e = .014$, $p < .001$]. As expected, the ANOVA also revealed that logical responding was higher for logically clarified (.75) problems than for standard (.63) problems [$F(1,30) = 5.906$, $MS_e = .037$, $p = .021$]. The interaction was nonsignificant [$F(1,28) = 0.067$, $MS_e = .014$, $p = .797$], indicating that the advantage for logically clarified quantifiers is about the same with both true and false premise problems.

However, our suspicion that reasoners would have difficulty with the false premise problems was confirmed. This data was quite noisy, both within and between reasoners, making more fine-grained analyses low in power and difficult to interpret. In particular, many reasoners appeared to have simply reversed the polarity of the premise, as we hypothesized. Several reasoners specifically edited the problems in this way in their testing books (e.g., the "not" in "some . . . not" problems would be crossed out, or "none" would be crossed out and replaced with "all"). Interpretation of responses therefore becomes difficult;

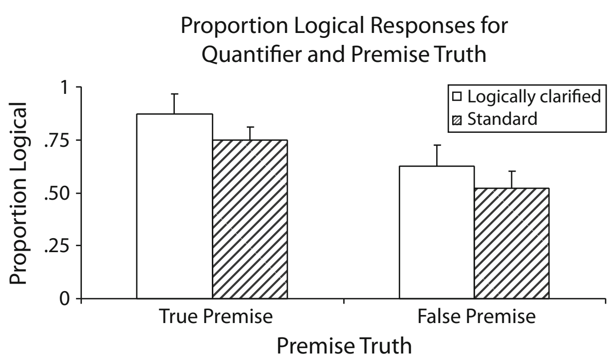

Figure 4. Proportion of logical responses and 95% confidence intervals as a function of premise truth and premise type in Experiment 2.

for example, if a reasoner thinks that a false “at least one” premise is equivalent to a true “at least one . . . not” premise, but otherwise reasons logically, he or she will think that the logically necessary “no” conclusion is merely possible, which is exactly the expected response when a reasoner solves the problem pragmatically. For the rest of this section, we will focus on the true premise data.

True particular premise problems (some and some . . . not). The proportion-logical response data for problems with a true particular premise are presented in Figure 5. A 2 (quantifier: logically clarified, standard) × 4 (problem type: contradictory, subaltern, subcontrary, identity) ANOVA for logical responses revealed a significant main effect for quantifier [$F(1,25) = 7.672$, $MS_e = 0.752$, $p = .010$], a main effect for problem type [$F(3,75) = 28.008$, $MS_e = 1.499$, $p < .001$], and an interaction [$F(3,75) = 5.641$, $MS_e = 0.302$, $p = .002$]. Planned comparisons were then conducted.

As in Experiment 1, a quantifier effect was predicted for both the subaltern (some/some . . . not followed by all/none) and subcontrary problems (some followed by some . . . not, and vice versa). The data were consistent with both predictions. For the subaltern problems, reasoners made more logical responses with “at least one” (.82) quantifiers relative to “some” (.43) quantifiers [$t(25) = 3.142$, $p = .004$, $SE_{diff} = .125$]. This was mirrored by a reduction in pragmatic responses for “at least one” (.17) quantifiers relative to “some” (.56) quantifiers [$t(25) = 3.287$, $p = .003$, $SE_{diff} = .119$]. Similarly, for the subcontrary problems, there were more logical responses with “at least one” (.66) quantifiers than with “some” (.36) quantifiers [$t(25) = 2.075$, $p = .048$, $SE_{diff} = .147$], a trend that was again mirrored by a reduction in pragmatic responses for “at least one” (.23) quantifiers relative to “some” (.60) quantifiers [$t(25) = 2.580$, $p = .016$, $SE_{diff} = .141$].

Responses to the contradictory and identity problems were not expected to differ for standard and logically clarified quantifiers. For the contradictory problems, the rates of logical responses was almost identical for “some” (.96) and “at least one” (.97) quantifiers [$t(25) = .229$, $p = .821$, $SE_{diff} = .033$]; the same was true for identity problems for “some” (1.00) and “at least one” (.97) quantifiers [$t(25) = 1.667$, $p = .108$, $SE_{diff} = .020$].

True universal premise problems (all and none). The proportion logical response data for problems with a true universal premise are presented in Figure 6. A 2 (quantifier: logically clarified, standard) × 4 (problem type: contradictory, subaltern, contrary, identity) ANOVA for logical responses revealed a significant main effect for quantifier [$F(1,25) = 6.203$, $MS_e = .193$, $p = .020$], a main effect for problem type [$F(3,75) = 14.449$, $MS_e = .474$, $p < .001$], and an interaction [$F(3,75) = 3.643$, $MS_e = .120$, $p = .016$]. Planned comparisons were then conducted.

Logically clarified quantifiers were expected to increase logical responses for universal subaltern problems (all/none followed by some/some . . . not). Consistent with this prediction, reasoners made significantly more logical responses with “at least one” (.87) quantifiers relative to “some” (.58) quantifiers [$t(25) = 2.086$, $p = .047$, $SE_{diff} = .136$]. As expected, this was mirrored by a reduction in pragmatic responses for “at least one” (.03) quantifiers relative to “some” (.35) quantifiers [$t(25) = 2.965$, $p = .007$, $SE_{diff} = .106$].

Differences between the quantifiers were not expected for the remaining problem types, and the pattern of responses was almost identical for the two premise types. The proportion of logical responses for “some” and “at least one” quantifiers was .99 and 1.00, respectively, for contrary problems [$t(25) = 1.124$, $p = .272$, $SE_{diff} = .013$]; .96 and 1.00 for contradictory problems [$t(25) =

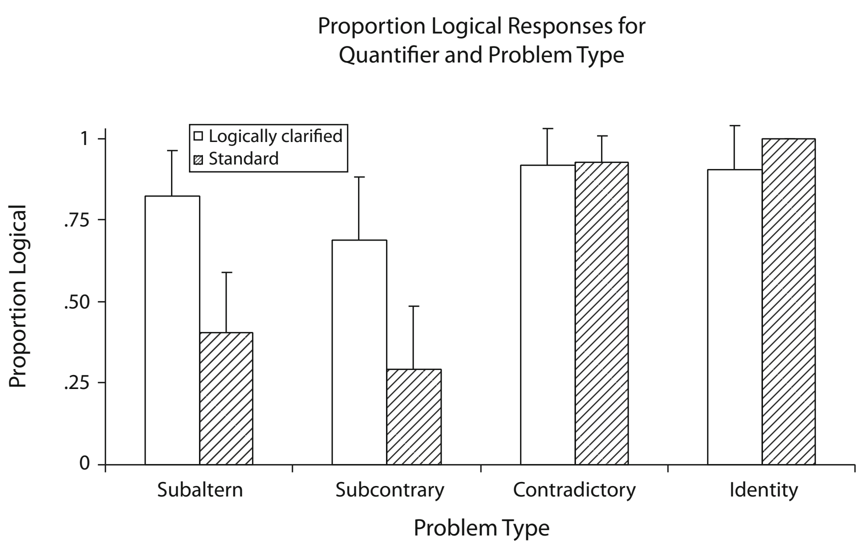

Figure 5. Proportion of logical responses and 95% confidence intervals for the four true particular premise problem types as a function of type of quantifier in Experiment 2.

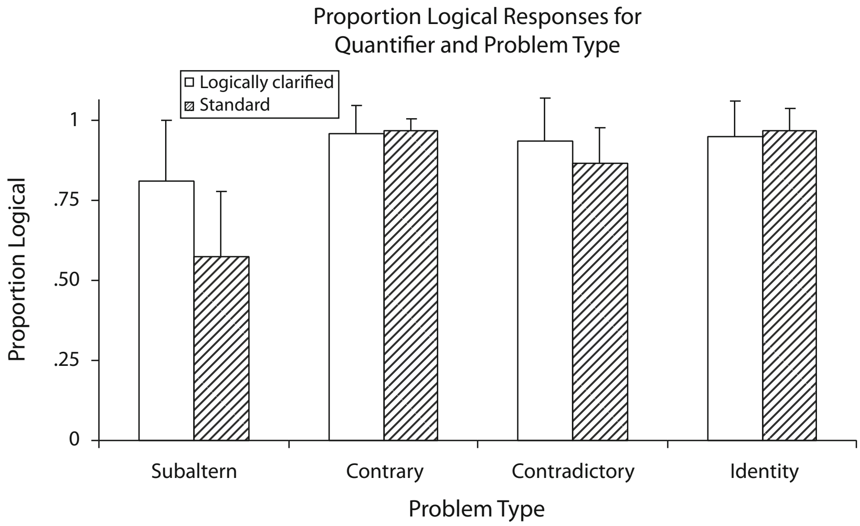

Figure 6. Proportion of logical responses and 95% confidence intervals for the four true universal premise problem types as a function of quantifier type in Experiment 2.

1.573, $p = .128$, $SE_{\text{diff}} = .026$]; and 1.00 and 1.00 for identity problems.

Discussion

These findings replicate and extend the findings from Experiment 1. For both false and true premises, "at least one" quantifiers reduced pragmatic responses and promoted logical responses on an immediate inference task. Moreover, the size of the effect was substantial. For the true premise data, logical responses were between 30% and 40% higher in the logically clarified than in the standard condition for the critical problem types, resulting in an increase in overall logical responses from about 50% to about 75%. In the false premise data, there were similar increases in logical responding in the logically clarified condition. Finally, consistent with other findings (Barres & Johnson-Laird, 2003), we observed that reasoners had difficulty working out the implications of false premises, many choosing to simply reverse the polarity of the premise (e.g., a false "all" implies a true "no").

EXPERIMENT 3

The previous two studies provide evidence that pragmatic responses in an immediate inference task can be reduced with logically clarified quantifiers. The goal of this experiment was to determine whether performance on the more complex syllogistic reasoning task can be facilitated by presenting the premises in logically clarified format. Recall that in the syllogistic reasoning task reasoners are presented with two premise statements followed by a conclusion statement. The premises and conclusions each contain one of four quantifiers used on the immediate inference task and are composed of three terms, called the A, B, and C terms. The B term is repeated in the premises; the conclusion joins the A and C terms thus:

All of the Beekeepers are Artists
Some of the Cyclists are Beekeepers
Therefore, some of the Cyclists are Artists

In the present study, half the reasoners solved syllogisms using the logically clarified premises, and half solved syllogisms with standard premises. If pragmatic interpretations are a source of error in syllogistic reasoning tasks, logical performance should be increased (and pragmatic responses reduced) using logically clarified premises instead of standard premises.

Method

Reasoners. Seventy-eight University of Saskatchewan undergraduates with no background in logic completed Experiment 3. Reasoners received course credit or C$5 for participating. None of the reasoners in Experiment 3 had participated in either of the first two studies.

Materials and Design. As in Experiments 1 and 2, the A, B, and C terms of the syllogisms were instantiated using combinations of hobbies and professions. Half of the reasoners were presented standard quantifiers for particular statements ("some," "some . . . not"), and half were presented logically clarified quantifiers for both the premises and conclusions ("at least one," "at least one . . . not"). There were 20 syllogisms for which a pragmatic interpretation of the premises predicted a response different from that for a logical interpretation. Each of the 10 premise pairs was accompanied by two conclusions, as illustrated below:

IF IT IS TRUE THAT:
Some of the chemists are not beekeepers
All of the beekeepers are musicians
THEN IS IT THE CASE THAT:
None of the musicians are chemists Y__ N__ M__
Some of the musicians are chemists Y__ N__ M__

Both of the provided conclusions were logically possible, but not logically necessary. That is, the conclusions were consistent with a logical interpretation of the premises, but were not necessitated by the premises. The conclusions differed, however, in terms of their status under a pragmatic interpretation; one conclusion was pragmatically impossible and the other pragmatically true. We will refer to these as "pragmatically false" and "pragmatically true" conclusions. For example, "None of the musicians are chemists" is a logical possibility, but only if the first premise is interpreted to allow "None of the chemists are beekeepers" to be true. On the other hand, under a pragmatic interpretation (in which some chemists must be beekeepers), the conclusion that "None of the musicians are chemists" is impossible, and the conclusion is false. Thus, reasoners who made a pragmatic interpretation should have chosen "no," and those making a logical interpretation should have chosen "maybe." Similarly, under a pragmatic interpretation, the conclusion "Some of the musicians are chemists" follows necessarily from the premises.

All of the syllogisms are presented in Table 1. Because the logical response to all of the critical syllogisms was "maybe," four simple filler questions were added that had non-"maybe" answers. The filler questions are also presented in Table 1. Thus, each reasoner was presented 14 unique problems, with two conclusions each. The problems were always presented in the same order, with filler problems strategically placed throughout (Problems 1, 4, 8, and 11). However, the order of conclusions (universal first or particular first) was randomly varied across problems and counterbalanced across reasoners.

Procedure. The procedure for Experiment 3 was identical to the previous two studies, but with a few exceptions. First, part of the sample was tested in a large group (half in the standard and half in the logically clarified condition). Second, the instruction page used a simple syllogism for explaining when "Y," "N," and "M" responses were appropriate (but was otherwise identical to Experiment 1). This problem is also presented in Table 1.

Table 1
Syllogisms Presented in Experiment 3

	Premise Pairs	Conclusions
Example syllogism	Aab–Abc	Aac, Eac, Aca
Filler syllogisms	Aba–Acb	Aca, Oca
	Aab–Abc	Aca, Oca
	Eab–Acb	Eca, Ica
	Aba–Abc	Eca, Ica
Critical syllogisms	Oab–Abc	Eca, Ica
	Eba–Ocb	Aca, Oca
	Aab–Icb	Aca, Oca
	Eba–Obc	Aca, Oca
	Oba–Abc	Eca, Ica
	Eab–Obc	Aca, Oca
	Aba–Ocb	Eca, Ica
	Eab–Ocb	Aca, Oca
	Aba–Obc	Eca, Ica
	Iba–Abc	Aca, Oca

Note—Lowercase *a* and *c* represent the terms presented in the premises and conclusions, and lowercase *b* represents the term that joins *a* and *c* in the premises. A = All, E = No, I = Some, O = Some . . . not. For instance, the premise pairs for "Oab–Abc" are "Some of the As are not Bs" and "All of the Bs are Cs."

Results

The dependent measures for Experiment 3 were proportion logical and pragmatic responses for the 10 critical syllogisms; again, however, we will focus our analysis on the logical responses. The logical response was always "maybe." The pragmatic response was always "yes" and "no," respectively, for pragmatically true and pragmatically false problems. For the four filler problems, reasoners had similar rates of logical responses in the "at least one" (.77) and "some" (.67) conditions [$t(28) = 1.555$, $p = .131$, $SE_{\text{diff}} = .067$]. These problems will not be discussed further.

The proportion of logical responses is presented in Figure 7. A 2 (quantifier: standard, logically clarified) × 2 (problem type: pragmatically true, pragmatically false) ANOVA for logical responses revealed a significant main effect for problem type [$F(1,76) = 9.098$, $MS_e = .024$, $p = .003$], indicating that more logical responses were made to pragmatically true than to pragmatically false conclusions (i.e., for the pragmatically false responses, reasoners frequently responded "no" rather than "maybe"). More important, the ANOVA also revealed a main effect for quantifier [$F(1,76) = 10.635$, $MS_e = .120$, $p = .002$], indicating that overall problems with logically clarified quantifiers were given logical responses more often than problems with standard quantifiers. There was no interaction [$F(1,76) = 2.612$, $MS_e = .024$, $p = .110$]. To verify that the difference between the quantifiers was observed for both problem types, planned *t* tests were computed. For pragmatically false problems, reasoners made significantly more logical responses to logically clarified (.44) than to standard (.22) quantifiers [$t(76) = 3.742$, $p < .001$, $SE_{\text{diff}} = .006$]. This was mirrored by a greater number of pragmatic responses for standard (.73) than for logically clarified (.51) quantifiers [$t(76) = 3.652$, $p < .001$,

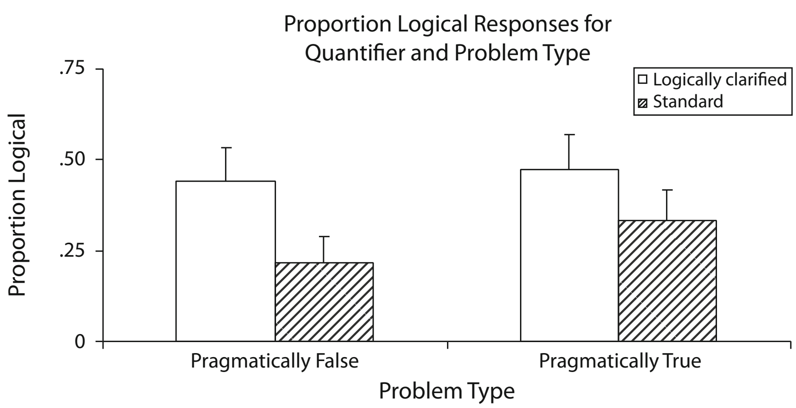

Figure 7. Proportion of logical responses and 95% confidence intervals for pragmatically true and pragmatically false syllogisms as a function of premise type in Experiment 3.

SE_{diff} = .006]. Similarly, for pragmatically true problems, reasoners made significantly more logical responses to logically clarified (.48) than to standard (.33) quantifiers [$t(76) = 2.250$, $p = .027$, $SE_{\text{diff}} = .006$]. Again, this was mirrored by a greater number of pragmatic responses for standard (.58) than for logically clarified (.40) quantifiers [$t(76) = 3.104$, $p = .003$, $SE_{\text{diff}} = .006$].

Discussion

The results of Experiment 3 showed that pragmatic responses decrease with the use of logically clarified "at least one" premises on those syllogisms that should produce different conclusions depending on whether a logical or pragmatic interpretation was made of the particular premises. This difference was also accompanied by an increase in logical responses. The present data show, then, that pragmatic responses *do*, on their own, influence the outcome of reasoning on the syllogistic inference task, in that the influence of pragmatics could not be reduced if pragmatics were not involved in the task in the first place. Thus, where previous reports (Newstead, 1995, 2003; Roberts et al., 2001) were unclear about the role of Gricean interpretations per se (as opposed to reversible Gricean interpretations), the present results demonstrate that pragmatic responses do occur in the syllogistic reasoning task and that using logically clarified quantifiers can reduce the inclination of reasoners to make these pragmatic responses.

GENERAL DISCUSSION

In three experiments, we demonstrated that logically clarified premises reduced pragmatic responses and facilitated logical responses in the immediate-inference and syllogistic reasoning tasks. Moreover, the effect of our quantifier manipulation was large (e.g., as high as 40% in Experiment 2). Most important, the logically clarified premises similarly facilitated logical responses on a syllogistic reasoning task, demonstrating that at least some of the "poor" performance on that task is attributable to the ambiguity of the premises.

There has been a long-standing debate over the degree to which "errors" reflect failures in logic or differences in interpretation. For example, Henle (1962) argued that there truly are no logical errors, but only misinterpretations of task premises—that is, participants (reasoners) always reason logically, but sometimes they use the wrong premises. Weaker claims have been forwarded by mental logic theories (see, e.g., Newstead & Griggs, 1999) and verbal reasoning theory (Polk & Newell, 1995), which also emphasize the role of encoding processes on task performance (see also Revlis, 1975). The fact that our experiments show that disambiguation of premises can substantially reduce errors can be considered support for these approaches, although it is also clear that reasoners make logical errors as well, including misunderstanding logical necessity (see, e.g., Evans et al., 1999) and failing to consider relevant alternatives (Newstead et al., 2002; Torrens, Thompson, & Cramer, 1999).

There are a number of non-mutually exclusive explanations for how this facilitation might occur. The first is that standard quantifiers are ambiguous in their meaning; some reasoners interpret them logically, and others interpret them pragmatically. The use of clarified premises may remove one of these interpretations and increase the probability that reasoners will adopt the desired interpretation. The findings of Experiment 1 support this interpretation, in that response patterns for the standard quantifiers were intermediate to the pragmatic or logically clarified quantifiers. Similarly, some reasoners may be aware of the ambiguity of interpretation, and this uncertainty in and of itself impedes their ability to solve capacity-demanding syllogisms.

Alternatively, use of the clarified premises may change the way in which the problems are represented. For example, the logically clarified ("at least one") version might facilitate a representation of concrete tokens that allows the set relationships of the premises to be clearly represented. Similar explanations have been proposed to explain why presenting information in the form of frequencies (i.e., 90 out of 100) as opposed to probabilities (i.e., 90%) increases accuracy on various probabilistic and statistical reasoning problems (Evans, Handley, Perham, Over, & Thompson, 2000; Girotto & Gonzalez, 2001; Sloman, Over, Slovak, & Stibel, 2003).

Regardless of the mechanism involved, our findings have immediate practical implications for studies using syllogistic reasoning. Specifically, given the ambiguity in the meaning of the traditional quantifiers, reasoning researchers would be better served by using clarified quantifiers in place of the standard quantifiers. The choice of whether to use pragmatically or logically clarified premises would depend on the goal of the study. If the goal is to gain a measure of logical ability, using logically clarified premises will eliminate an unwanted source of error variance. This is especially important when syllogistic reasoning is used as an index of logical reasoning—for example, when it is used to assess the role of working memory in reasoning (see, e.g., Capon et al., 2003; Copeland & Radvansky, 2004; Gilhooly et al., 1999; Quayle & Ball, 2000) or the effects of age and other variables on reasoning (see, e.g., Fisk et al., 2005; Fisk & Sharp, 2002; Gilinsky & Judd, 1994; Smeets & De Jong, 2005). In such cases, the extent to which variability in reasoning performance is due to logical competence or interpretive processes is not clear.

In contrast, it may be of interest to investigate the contribution of pragmatic factors to reasoning performance, and our methodology offers a means to do so. By comparing performance on pragmatically clarified, standard, and logically clarified versions of the premises, it is possible to gauge the contribution of interpretive factors to a reasoner's performance. Conversely, if a researcher wished to study failures in reasoning, then removing as much variability as possible from the encoding phase would allow a more accurate and unconfounded look at these errors. Thus, choosing whether to use standard or logically clarified quantifiers depends primarily on the researcher's goals.

It is important to note, however, that even with logically clarified premises, reasoning is far from perfect. There are at least two explanations for this: First, it is possible that (at least for some reasoners) the meaning of these logically clarified statements is still not perfectly clear. Alternatively, it is possible that there are other performance factors, such as working-memory limitations and misunderstanding of logical concepts, that impact performance. Further research is required to determine how many of these errors are due to misinterpretation of premises during encoding and how many are due to failures in reasoning. Further research is also warranted to discover new ways of clarifying the meaning of quantifiers in logic tasks. However, although it certainly does not seem to be the case that logically clarified premises resolve all pragmatic misinterpretations, it is our position that our logically clarified premises should be favored in further research, because they reduce a potentially irrelevant source of variance and thereby produce a purer measure of logical competence.

A further and perhaps more important practical implication of the results of the present investigation applies to the teaching of logic to students. Logic textbooks represent the particular affirmative and particular negative moods with the standard "some" and "some . . . not" statements, respectively. The present results suggest a refinement of this approach. Learning of the logical relations in the square of opposition would be greatly facilitated with the use of logically clarified "at least one" and "at least one . . . not" statements. A change of quantifier use is therefore justified for practical reasons.

A change in quantifier use in research and in teaching is also justified on theoretical grounds. The particular affirmative and particular negative moods are supposed to refer to *particular* instances of category members. Consistent with this, "at least *one*" refers to a *particular* member and indicates that there may be more particular members (with no upward boundary, thus not excluding the universal). "Some," on the other hand, is not consistent with the theoretical underpinnings of the particular moods, because "some" refers to a group of individuals. This is problematic for a number of reasons. First, this seems to rule out a singular (i.e., "one" or "one . . . not") interpretation, because "one" is less than "some," and "one . . . not" is more than "some . . . not." Second, this also rules out a universal (i.e., "all" or "no") interpretation, because "all" is more than "some," and "no" is less than "some . . . not." Both the singular and the universal are supposed to be possible interpretations of particular moods. Logically clarified quantifiers should, therefore, be favored over standard quantifiers for theoretical reasons, given that they are better representatives of the particular moods, and for practical reasons, given that reasoners understand them better.

CONCLUSIONS

The results of the three experiments reported here using the immediate-inference and syllogistic reasoning paradigms bring into question the continued use of standard "some" and "some . . . not" particular quantifiers in research and teaching. As demonstrated here, logically clarified "at least one" and "at least one . . . not" quantifiers have a meaning more pragmatically consistent with the logical meaning of the particular moods. This leads to greater logical performance by reasoners in immediate-inference and syllogistic reasoning tasks and would likely facilitate learning of logical relations greatly in the classroom.

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