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The effect of *some* and *all* on reaction time for semantic decisions*

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Two experiments tested a model proposed by Meyer (1970) to account for the times required to verify semantic-memory statements quantified by *all* or *some*. Each S was presented with both *all* and *some* statements in a mixed list, and the discriminability of false statements of the two quantifier types was controlled. In Experiment I positive subset statements ("horses are animals") were verified more quickly when quantified by *all* rather than *some*; the reverse ordering occurred for negative subset statements ("horses are not animals"). Sentences with pseudowords in subject or predicate position took longer to reject than false real-word sentences. These findings contradict Meyer's theoretical predictions and suggest that his earlier results were artifactual. Experiment II replicated the faster verification of positive subset statements quantified by *all*. This result was further shown to be predictable from the frequency with which Ss gave the predicate as a completion of *All/Some S are* ______. The production frequency of predicates which form subset statements was lower when the quantifier was *some* rather than *all*. However, holding predicate production frequency constant, sentences with different quantifiers were verified equally quickly.

This study tests Meyer's (1970) model of how statements quantified by *all* or *some* are verified. Meyer compared the reaction time (RT) to deal with these two quantifiers in statements which differed in the "set relation" of subject and predicate categories, as determined by the exemplars they have in common. In "subset" statements (e.g., *All/Some chairs are furniture*), all subject exemplars are also predicate exemplars; in "superset" statements (e.g., *All/Some stones are rubies*), all predicate exemplars are also subject exemplars; in "overlap" statements (e.g., *All/Some females are writers*), only some subject exemplars are predicate exemplars; finally, in "disjoint" statements (e.g., *All/Some typhoons are wheats*), subject and predicate categories have no exemplars in common.

Meyer found that sentences in which subject and predicate categories share some exemplars (subset, superset, and overlap conditions) were verified more quickly when quantified by *some* rather than *all*. However, the quantifier did not affect RT to reject disjoint statements, which are false for both *all* and *some*. Meyer concluded that when presented with an *all* statement, the S first implicitly verifies the corresponding *some* statement. If the *some* statement is true, the S proceeds to a second processing stage in which he determines if the *all* relation is satisfied. But if the corresponding *some* statement is false, the S is presumed to respond "false" at Stage 1 without requiring the second stage. In this model, *all* statements require an extra processing stage and, hence, take longer to verify for all sentence types except the disjoint case; for disjoint sentences, both *some* and *all* statements are presumed to be rejected at Stage 1.

Meyer hypothesized that Stage 1 involves a search through a stored list of *names* of categories that intersect (share exemplars with) the predicate. Stage 1 terminates with a positive decision if the name of the subject category is found on this list. In a disjoint statement such as *All/Some typhoons are wheats*, an exhaustive search would fail to find "typhoon" on the list of category names which intersect "wheat;" therefore, the S would exit from Stage 1 with a decision to respond "false."

This model strongly implies that the decision procedure in Stage 1 does not involve retrieval of the meaning of the subject word at all. The predicate-intersection list is scanned only for the "name" of the subject category; this is, presumably, a graphic or phonemic representation of a word. The purpose of Experiment I below was to check whether the quick rejection of disjoint statements could be attributed to a process that does not include retrieval of the meaning of the subject category. The time to reject disjoint sentences containing real words (e.g., *All typhoons are wheats*) was compared to the time to reject sentences in which the subject was a pronounceable pseudoword, e.g., *All/Some gipeds are wheats*. According to the predicate-intersection model, these two types will be processed in the same way. In either case an exhaustive search through the predicate-intersections list would fail to find the subject name, resulting in a "false" response. It follows that introducing a pseudoword subject in a disjoint sentence should not affect the time to decide "false."

Different predictions come from alternative models in

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which false decisions do not require exhaustive search procedures. As one alternative, suppose that one way the person can respond "false" is to discover an attribute of the predicate that contradicts an attribute of the subject concept. Thus, for our example above, "typhoon" implies "human," whereas "wheat" implies "not human," which information logically suffices for a false response. Assuming a self-terminating search, this model implies that real-word sentences would be rejected quickly due to rapid retrieval of word meanings and discovery of a contradiction. For pseudoword sentences, on the other hand, a false response would follow an extended but futile attempt to locate in memory an attribute set corresponding to the pseudoword's meaning.

This alternative model predicts identical slow RTs for sentences with pseudowords in either the subject or predicate position of the statement. Meyer's predicate-intersections model, however, makes no prediction about RT for sentences with predicate pseudowords, since it is not clear how long an S will search for a nonexistent set of predicate intersections for a pseudoword. To test this prediction of the alternative model, both positions of the pseudoword (subject or predicate) were tested in Experiment I.

In order to avoid requiring a false response for all pseudoword sentences in our experiment, each pseudoword sentence was matched with a counterpart containing the word "not," so that the counterpart was defined as true, e.g., *All/Some mafers are not animals*. True real-word sentences were also matched with negative statements (e.g., *All/Some horses are not animals*), which were false.

Superset and overlap statements have a different truth value depending on the quantifier; they are true for *some* but false for *all*. Accordingly, only subset statements (true for both quantifiers) and disjoint statements (false for both quantifiers) were used in Experiment I. It is possible that the use of superset and overlap statements in Meyer's experiment may have biased the results he obtained for the two quantifiers. His false *all* statements often used subject and predicate words which were closely related in meaning (e.g., *All mountains are Alps*), whereas his false *some* statements were generally semantically anomalous (e.g., *Some typhoons are wheats*). The longer RTs for *all* statements found by Meyer could, therefore, have been an artifact of the more difficult semantic discrimination required to separate true and false sentences for his *all* than for his *some* conditions. Such a difference in discriminability would have been accentuated insofar as Meyer presented only *some* or only *all* statements to different Ss. To avoid this issue of differential discriminability, we presented statements of both quantifier types to Ss in a mixed list. Experiment I tests Meyer's model by attempting to replicate his results for real-word sentences using a within-S design in which Ss were less likely to use different shortcut strategies for the two quantifiers.

EXPERIMENT I

Method

Ss were timed while they verified real-word and pseudoword statements quantified by *all* or *some*. Thirty-two positive real-word subset statements and 16 real-word disjoint statements were constructed. Sixteen of the subset statements were also used as negatives (e.g., *All/Some horses are not animals*). The same subject and predicate words were used in constructing both true and false sentences. Both positive and negative forms of 16 pseudoword sentences were used. These were formed by substituting a pseudoword equally often in either the subject or predicate position in half of the real-word subset statements. Pseudowords were composed by changing the first letter of a common two-syllable word. This design produced equal numbers of true and false responses within both real-word and pseudoword conditions. Both *all* and *some* quantifiers were used with each statement, producing a total set of 192 sentences.

Sentences were presented using a tachistoscope. The E initiated each trial. A red dot appeared in the center of the viewing field for 2 sec prior to the appearance of a sentence. The S pressed one of two buttons to indicate a true or false response; assignment of hand to true or false response was counterbalanced across Ss. The S's keypress removed the sentence and stopped a clock. The Ss were informed when they made errors.

The sentences were divided into four blocks of 48 items, with presentation order randomized within each block. All conditions were represented equally often in each block. Twelve practice trials, illustrating the different positive statement types, occurred at the beginning of the experiment. The types of sentences used were described to each S, and the correct responses for statements containing a pseudoword or "not" were carefully explained.

The Ss were told to respond as rapidly as possible without making errors. At the end of each block of 48 trials, the S was told she was responding too slowly if her error rate was less than 5% for the just completed block and below 10% overall. If her overall error rate for the experiment up to that point was over 10%, she was told that she was making too many errors.

The Ss were 24 right-handed females between the ages of 17 and 23 years, who were enrolled in introductory psychology at Stanford and participated in the experiment to satisfy a course requirement. Data from two Ss with error rates over 15% were excluded, and two additional Ss were tested as replacements.

Results

The overall error rate was 6.7%, and error rates were highest in the pseudoword and negative conditions. Error RTs and correct RTs that exceeded the S's mean RT for that item type by 2 sec (less than 2% of responses) were replaced by the S's mean RT for that condition. Mean RT and error rate for each statement type are given in Table 1. Three analyses of variance were performed on the RT data. Both items and Ss were treated as random variables and quasi F ratios were calculated (Winer, 1971). The symbol F' will be used to denote quasi F ratios, and t' will denote the related quasi t statistic. Conventional F ratios will also be occasionally reported, in which case the random variable on which they are based will be noted.

The first analysis examined only the data for real-word subset statements (Rows 1 and 3 of Table 1). The false negative sentences (Row 3) were verified more slowly than true positive sentences (Row 1) [$F'(1,35) = 96.0$, $p < .001$]. The effect of major interest was the

Table 1
RT and Error Rates for Real-Word and Pseudoword Sentences Quantified by *All* or *Some*

Statement Type	Example	Correct Response	Number of *All/Some* Pairs	*All* RT	*All* Percent Errors	*Some* RT	*Some* Percent Errors
Real-Word Positive Subset	Horses are animals	T	32	1139	0.4	1229	0.2
Real-Word Positive Disjoint	Horses are plants	F	16	1296	1.3	1332	3.4
Real-Word Negative	Horses are not animals	F	16	1844	8.9	1699	9.2
Positive Subject Pseudoword	Mafers are animals	F	8	1513	4.0	1608	2.5
Positive Predicate Pseudoword	Stallions are mafers	F	8	1474	12.5	1600	5.0
Negative Subject Pseudoword	Mafers are not animals	T	8	1808	16.3	1800	21.3
Negative Predicate Pseudoword	Stallions are not mafers	T	8	1925	13.8	2036	15.0

interaction between positive vs negative sentences (Rows 1 and 3) and quantifier type, which was significant [$F'(1,33) = 14.6$, $p < .01$]. Positive subset statements were verified more quickly when quantified by *all* rather than *some* (Row 1) [$t'(33) = 2.33$, $p < .05$], whereas the reverse ordering occurred with negative sentences (Row 3) [$t'(33) = 3.75$, $p < .01$].

A second analysis dealt only with RT to verify pseudoword sentences (Rows 4-7 in Table 1). The false positive sentences (Rows 4-5) were verified more quickly than were the true negative ones (Rows 6-7) [$F'(1,29) = 34.1$, $p < .001$]. In this analysis, the two quantifiers did not produce significant differences in RT. The interaction between negation and subject- vs predicate-pseudoword sentences was significant [$F'(1,29) = 8.11$, $p < .01$]. For positive statements, sentences with pseudoword subjects (Row 4) did not differ in verification latency from those with pseudoword predicates (Row 5); among the negative sentences, those with subject pseudowords (Row 6) were verified more quickly than those with pseudoword predicates (Row 7).

A final analysis compared RT to reject false positive real-word (Row 2) vs positive pseudoword sentences (Rows 4 and 5). Data from subject- and predicate-pseudoword sentences were pooled for this purpose. Pseudoword sentences required more time to disconfirm than did real-word sentences [$F'(1,26) = 12.0$, $p < .01$]. The shorter latency to reject false *all* statements was marginally significant in this analysis [$F'(1,25) = 4.65$, $p < .05$].

Discussion

The crucial finding of Experiment I was that, contrary to Meyer's earlier data and theoretical predictions, true real-word *all* statements were verified more quickly than the corresponding *some* statements. This suggests that the reverse ordering obtained by Meyer may indeed have been an artifact due to the greater difficulty in his study of false sentences quantified by *all* as opposed to *some*. Meyer's two-stage model of quantifier decisions clearly is disconfirmed by the present data.

The slower RTs for pseudoword sentences are consistent with the hypothesis that false sentences are normally rejected on the basis of a comparison of the meanings of subject and predicate words. The S does not search exhaustively for an uninterpreted "name" on a predicate-intersections list. In contrast to real-word sentences, pseudoword sentences cannot be rejected until an exhaustive search fails to retrieve a meaning for the pseudoword. An alternative explanation of the longer RT for pseudoword sentences is that real words are read faster than pseudowords, because the former have been seen many times before. While this explanation of a difference greater than 200 msec is possible, we do not consider it very plausible.

For negative real-word sentences, *some* statements were verified more quickly than *all* statements. This effect may be explained by extending the Clark and Chase model of negation (Clark, 1970; Clark & Chase, 1972; Just & Carpenter, 1971). According to this theory, a false negative *some* statement, such as *Some horses are not animals*, would first be represented internally as *false (All horses are animals)*; similarly, a false *all* statement, such as *All horses are not animals*, would be translated into *false (Some horses are animals)*. In each case the embedded proposition (which is true) would be verified first; the embedding negation would then reverse the computed truth value for the statement as a whole. Since the embedding negation is the same for both quantifier types, the overall RT should depend on the time required to verify the two embedded propositions. Formulated in this way, the pattern of results for negative sentences corresponds exactly to that

Table 2
RT and Error Rates for *All* and *Some* Statements as a Function of Production Frequency

High Frequency			Low Frequency		
Example	RT	Percent Errors	Example	RT	Percent Errors
		True Statements			
All gems are stones	1296	1.9	All women are adults	1369	4.7
Some guns are rifles	1283	2.8	Some planes are bombers	1356	7.5
All horses are mammals	1311	5.6	Some horses are mammals	1427	6.1
		False Statements			
All flowers are roses	1431	4.3	Some horses are cows	1432	5.3

of the positive sentences. False negative *some* statements involve, as a first step, the implicit verification of a true positive *all* statement, which was shown earlier to be verified more quickly than is the corresponding *some* statement; therefore, negative *some* statements require less time to reject than do negative *all* statements.

EXPERIMENT II

In Experiment II we sought an empirical measure that would predict the slower verification of real-word subset statements when quantified by *some* rather than *all.* Wilkins (1971) showed that the RT to verify that an instance is a member of a category (such as "A horse is an animal") is negatively correlated with the frequency with which Ss produce the instance as a constrained associate to the category in an instance production task. It seemed plausible that such production frequencies would differ depending on the quantifier attached to the category. That is, one would expect Ss to give different associates as completions to the sentence *All horses are* _____, as opposed to *Some horses are* _____. Completions such as "animal" (which correspond to subset statements) may be more common when the quantifier is *all.* In Experiment II we collected a set of norms based on predicate completions of such quantified sentences. These norms were then used to generate sentences for an RT verification task. We compared the RT to verify subset completions (e.g., *All/Some horses are animals*) when these were quantified by *all* and *some.* We also measured the RT to verify *all* and *some* statements using predicates that had been selected so as to be equated on their production frequency. Our purpose was to see whether *some* statements are more difficult in general to verify than *all* statements or whether the difference obtained in Experiment I is specific to subset statements.

Method

Materials. An initial 24 Ss completed sentences of the form *All S are* _____ and *Some S are* _____, writing as many nouns as they could think of in 30 sec that made each sentence true. Twelve common nouns (S terms) were paired with *all* and *some* to give 24 frames in all. The incomplete sentences were presented in two 12-page booklets, one representing each quantifier type. Order of pages within booklets and order of presenting the booklets were counterbalanced across Ss.

The Ss gave a total of 167 different words as *all* statement completions and 446 different words as *some* statement completions. Of these totals, 39 words were found which were used as completions for both an *all* statement and its counterpart *some* statement.

These norms were then used to construct a set of sentences for a verification experiment. Twelve subset statements were paired with both *all* and *some.* The predicates of these sentences were given as completions by an average of 15 of the 24 Ss when quantified by *all* but by only 0.9 Ss when quantified by *some.* In addition, for each quantifier type, six sentences with high-frequency predicates (given by 18 Ss or more) and six sentences with low-frequency predicates (given by only one S) were selected. Twenty-four false statements with semantically related subject and predicate words were generated for each quantifier type. False *all* statements were superset and overlap statements; some were formed by substituting *all* in the true *some* statements used, while other false *alls* were formed by reversing the subject and predicate words in the subset statements. False *some* statements were disjoint statements in which the predicate was closely related in meaning to the subject category. Examples of each sentence type are given in Table 2.

Procedure. The apparatus was identical to that of Experiment I. Forty practice trials preceded the 96 experimental trials. The Ss were instructed that *some* was to be interpreted as "*Some*, and maybe even *All*." The same procedure prevailed as in Experiment I, except that Ss were not told to go faster contingent on their error rates.

Eighteen Stanford undergraduates were paid $1.75 for 1 h of participation in the experiment.

Results

RTs and error rates for the different kinds of sentences are shown in Table 2. Error rates were positively correlated with RT. As RT was virtually identical for false sentences quantified by *all* (1431 msec) and by *some* (1432 msec), only the data for true responses were analyzed.

An analysis of variance was performed on the RTs for the 12 subset statements paired with *all* and *some* (Row 3 of Table 2). As in Experiment I, the *all* statements were verified more quickly than were the corresponding *some* statements [$F'(1,20) = 5.54$, $p < .05$]. The 24 *all* and *some* statements with high- and low-frequency predicates were analyzed separately. For these sentences, which control for production frequency, the difference in RT between the two quantifier types was an insignificant 26 msec ($F' < 1$) in favor of faster *some* statement verification. Sentences with high-frequency predicates were verified 73 msec faster than those with low-frequency predicates. This difference was significant treating Ss as a random effect [$F(1,17) = 8.11$, $p < .025$] but did not achieve significance across items [$F(1,10) = 2.46$, $p < .20$].

DISCUSSION

In our experiments, RT to verify true subset statements was longer when the quantifier was *some* rather than *all*. This is precisely contrary to the results and theoretical prediction of Meyer (1970). However, Experiment II demonstrated that this result can be predicted by the production frequency, or associative probability, of the predicate to the quantified subject. Sentences with less probable predicates were found to require more time to verify. The production frequency of predicates in subset statements is much lower, and verification RT is consequently longer, when the quantifier is *some* rather than *all*. But when predicate production frequency was held constant, there was no difference in RT to verify true sentences with the two different quantifiers.

The fact that the difference in RT between sentences with high- and low-frequency predicates failed to reach significance when tested against item variability is presumably due to the small item set used. Further experiments in our laboratory have showed a consistent negative correlation between production frequency and true RT, not only for the quantifiers *all* and *some*, but for *many* and *few* (Glass, Holyoak, & O'Dell, 1974). Production frequency measures which take account of the meaning of the quantifier appear to be useful predictors of RT to verify quantified assertions. While the theoretical basis of this effect is an open issue, a possible theory is presented by Glass et al. In that paper we propose that production frequency reflects the order in which the person compares subject attributes to attributes of the predicate during verification. A true response is made as soon as all predicate attributes have been matched with subject attributes. The attributes of high-frequency predicates will match subject attributes early in the search order and, hence, sentences with high-frequency predicates will be verified most quickly.

Within the framework of this model, the slower verification of subset statements when quantified by *some* rather than *all* suggests that search order is influenced by the quantifier. When the quantifier is *all*, only subject attributes true generically of all category members will be considered; for *some*, search will begin with attributes true of subsets or instances of the category. For example, when presented with the sentence *All horses are animals*, the person may first derive the attribute "animate" from the subject concept; this attribute will immediately be matched with the attribute "animate" which represents the predicate. For *Some horses are animals*, on the other hand, search might begin with an attribute like "male," which is true of only a subset of the subject category. Such attributes will be insufficient to produce a decision for subset statements. For our example, the search must continue until the generic attribute "animate" is found later in the search order. Consequently, the subset statement will take longer to verify when quantified by *some*. While other explanations of the present findings are clearly possible, this ordered attribute-search model has the advantage of relating our results for subset statements to other RT differences which correlate with production frequency.

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