Table 2
Number of Correct Responses* for Inputs 1 and 2 of the Control Condition and Inputs 1, 2, and 3 of the Experimental Condition

Subjects	Control Condition		Experimental Condition		
	Input 1	Input 2	Input 1	Input 2	Input 3
1	5	46	47	3	49
2	1	48	40	0	50
3	0	47	43	0	48
4	41	50	43	44	50
5	4	45	40	0	46
6	14	46	39	39	48
7	5	49	46	14	50
8	9	47	47	25	47
9	19	46	41	31	48
10	14	48	42	22	49

*Correct responses refer to S reporting correctly on the letters shown for Inputs 1, 2, or 3, with a score of 50 representing complete accuracy, i.e., on every one of 50 trials of each of the conditions of the experiment, S reported correctly on the letters being displayed. All values less than 50 represent the degree to which S failed to report letters being displayed, i.e., a score of 0 represents complete blanking on all 50 trials.

other control trials, in which Inputs 1 and 3 were presented alone, and where no blanking of Input 1 occurred, again results to be expected from our model's predictions (Mayzner & Tresselt, in press), because of the much longer time delay between Inputs 1 and 3 than would be found between Inputs 1 and 2 alone or between Inputs 2 and 3 alone. These results, particularly when contrasting the findings for Inputs 1 and 2 under the control and experimental conditions, would seem to demonstrate that the proper spatial and temporal configuration for Inputs 1, 2, and 3 can and do produce in the human visual system an analogue of the disinhibition effect found in *Limulus* (Hartline & Ratliff, 1954, 1957). The origin of this disinhibition effect would, however, have a central rather than a retinal or peripheral locus, as we have argued elsewhere (Mayzner & Tresselt, in press).

Overall, the findings of this study are in good agreement with our own previous results (Tresselt, Mayzner, Schoenberg, & Waxman, in press) and those of others (e.g., Dember & Purcell, 1967; Robinson, 1966, 1968; Schiller & Greenfield, 1969). However, these findings do not correspond with a recent study of Uttal's,¹ but as we have suggested earlier (Tresselt, Mayzner, Schoenberg, & Waxman, in press), Uttal's failure to find a disinhibition effect is a result, we believe, of the particular experimental paradigm he employed, rather than total absence of the phenomena to occur in man's visual system.

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NOTE

1. Uttal, W. R. On the physiological basis of masking with dotted visual noise. Unpublished manuscript, 1969.

Linguistic operations in the analysis of pairs of class-membership statements*

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The ordering of solution times and error rates in a task comprising the comparison of statements that were logically equivalent but linguistically different was successfully predicted by a model involving two operations capable of transforming the linguistically differing forms into each other.

The binary universal class-membership relation expressed as "All As are Bs" may also be asserted by three other logically equivalent linguistic forms; Fig. 1 shows the forms in a particular arrangement labeled a logical diamond. In addition, the negation or logical contrary of each form may be expressed in two ways; thus, the negation of the statement "All cats are mammals" may be expressed either as "No cats are mammals" or as "All cats are nonmammals."

The first type of negation involves a change in the universal or operator word, in this instance from "All" to "No." The second type of negation involves an operation in the predicate of the assertion, the placement of a "non" in front of the predicate class name.

A glance at Fig. 1 shows that these two kinds of operations are also involved in changing one logically equivalent form to another. In one case, as with the transitions from Form 1 to Form 2 or from Form 3 to Form 4, the operator word is changed and

nons are added or deleted as necessary to keep logical equivalence. This total operation is called, for simplicity, an operator change. In the other case, the predicate is acted upon, with the predicate and subject class names being interchanged and with the insertion or deletion of nons from the class names as required by the operator word. This second type of operation is called, in its totality, a subject-predicate interchange.

With these two operations thus defined, it is possible to convert any of the forms of Fig. 1 to any of the others by using either an operator change or a subject-predicate interchange, or both; the 1-3, 3-1, 2-4, and 4-2 transitions are the cases where both operations are required.

If Ss actually use these operations to analyze class-membership statements, then, by the simplest model, were Ss to be presented with pairs of equivalent statements, the time necessary for Ss to determine the status of the pair should vary in proportion to the number of operations required to convert one member of the pair to the other.

A second assumption would be that the likelihood of making an error is correlated

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Fig. 1. Logical diamond, with the four equivalent forms and type of operation for each transition between forms.

with the number of operations. A third possible assumption is that only the number and not the type of operation is instrumental; hence, an operator-change transition such as 1-2 should take about as much time as a subject-predicate interchange such as 4-3.

This type of model for cognitive processing—a hypothesized set of operations assumed to be applied in sequence to stimuli of graded complexity, with times to solution and/or errors monotonic functions of the complexity—is in the same spirit as those used by, among others, Miller (1962) in his account of experimentation in psycholinguistics, where in all cases the postulated operations came from the transformational grammar of Chomsky (1957), by Huttenlocher (1962) for concept attainment strategies, by Krossner (1967) for the evaluation of strings in an artificial language, and by Huttenlocher (1968) for three-term series problems.

The purpose of the present experiment was to see whether or not the operations implied by Fig. 1 possessed any predictive power for the way in which Ss actually deal with pairs of class-membership statements.

METHOD

Each of the four forms of Fig. 1 generates four equivalents, one being a simple repetition of the form itself, and two contraries, one from an operator change and one from a predicate change. There are thus 24 possible transitions or pairs of forms.

Each pair was typed onto an index card as two lines, one statement below the other; the class names were three-letter CVC nonsense syllables of low association value. The 24 pairs of forms were

duplicated twice with fresh nonsense syllables to give a total of 72 stimulus cards.

Ss were 24 undergraduate Harvard and Radcliffe students. They were instructed that the statements on a card were either the same logically or were contradictory, and that their task was to tell E the status of the pair. After instructing an S, E turned up a card while simultaneously starting a timer. When the answer was given, E recorded it and the time to solution and then proceeded to the next card. The order of stimulus cards was rerandomized for each S.

RESULTS AND DISCUSSION

Harmonic means of the three trials with each S on the 24 pairs were computed. Table 1 presents these harmonic means averaged across Ss. As may be seen, an overall time of 2.33 sec was required by the Ss to read pairs of duplicated statements. The overall average time to analyze statement pairs requiring an operator change was 4.77 sec, extremely close to the 4.80 sec for pairs involving a subject-predicate interchange. Transitions necessitating both operations required 5.86 sec. For the contraries, those involving a change in the operator word required 3.06 sec, while those requiring a predicate change took 3.14 sec.

The error rate was quite low, going from 0% in the four pairs of duplicated statements to a high of 6.2% for the 4-2 both-operations transition. The Pearson correlation coefficient between times to solution and errors was .57 ($p < .01$).

The hypotheses made by the model are strongly substantiated: the higher the number of operations, the more time required; error likelihoods are correlated with times.

Within the body of Table 1 there appear some differences in solution times due to source, i.e., the linguistic form the first statement of a pair took. There is a general tendency for the solution times to increase going down the columns for equivalents, with the main exception being the 3.63 sec for the 4-1 transition. Movement across columns within Table 1 is exactly in the predicted direction, save for the 5.12 sec of the 3-1 transition being less than the average of the 5.46 sec of the 3-4 and the 6.09 sec of the 3-2 transitions.

With the data for equivalent statements only, a three-way analysis of variance (Lindquist, 1953) with operations, source, and Ss as factors showed that operations ($F = 27.1$, $df = 3/69$, $p < .001$), source ($F = 16.6$, $df = 3/69$, $p < .001$), and the Operations by Source interaction ($F = 7.51$, $df = 9/207$, $p < .001$) were all significant.

Since the presence of the Operations by Source interaction renders possibly suspect the model-predicted independent significance of operations, Mosteller's test of predicted order (Mosteller, 1955) was performed on the harmonic means vs the number of operations for each source set separately. In these tests, the average of the Op and S-P scores was used for the one-operation score. The Mosteller tests were significant for all four sources ($p < .001$ for Sources 1, 2, and 4, and $p < .05$ for Source 3), thus confirming that the hypothesized trend in solution times as a function of number of operations is independent of the form of the first statement in the pair.

The elucidation of linguistically-based metrics such as the one described herein that account for some aspects of cognitive ability lends support to the contention of Clark (1969) that general forms of linguistic processes exist mediating human reasoning.

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Table 1
Average Harmonic Mean Solution Times in Seconds

Source	Equivalent				Contrary	
	0—Read	1—Op	1—S-P	2—Both	1—Op	1—S-P
1	1.78	3.73	3.73	5.02	2.37	2.27
2	2.62	4.51	5.74	6.28	3.05	3.51
3	2.44	5.46	6.09	5.12	3.24	3.78
4	2.48	5.37	3.63	7.03	3.58	3.01
Average	2.33	4.77	4.80	5.86	3.06	3.14