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COGNITIVE STYLE AND REPRESENTATIONAL STRATEGIES IN CATEGORICAL SYLLOGISTIC REASONING

By

TAKANORI MATSUNO (松野隆則)[1]

(*Tohoku University*)

The present study focuses on various mental representations adopted in categorical syllogistic reasoning. Twenty-four under-graduates solved multiple-choice categorical syllogistic problems and were classified into three representation groups by forcedchoice strategy selection. Reasoning accuracy of these groups differed only on the problems in which none of the presented propositional conclusions was valid. And the subjects of these groups showed differences in their scores on Richardson's (1977) Verbalizer-Visualizer Questionnaire completed beforehand. It is suggested that the individuals' cognitive style influenced their preference to representational strategies in reasoning.

Key words: cognitive style, mental represontation, strategy, categorical syllogism, deductive reasoning, Verbalizer — Visualizer Questionnaire

Introduction

In solving a problem people may take various approaches according to their dispositions and environmental conditions. Some researchers reported that individuals spontaneously adopt a number of strategies which differ in the way to represent task information mentally, in the sentence-picture verification task (MacLeod et al., 1978; Mathews et al., 1980) and the three-term series problem (Egan et al., 1982). So it would be not surprising if the same is true of a more complex but essentially similar task, the categorical syllogism.

Matsuno (1986) analyzed retrospective protocol of 15 undergraduates who had just solved categorical syllogisms, and differentiated three kinds of representational strategies labeled as "Diagrammatic", "Elemental", and "Verbal" strategies. Moreover, each subject was classified into one of the three representation groups, and the group performances were compared. The error rates of those groups did not differ on the problems in which at least one of the presented propositional conclusions is logically followed from the given premises, but did differ on the problems in which non of such conclusions is valid. The error rate on these latter problems was highest for the Verbal group and lowest for the Diagrammatic group, and the differences among the

1. Department of Psychology, Faculty of Arts and Letters, Tohoku University, Kawauchi, Sendai, 980, Japan.

three groups were statistically significant.

The first purpose of the present study is to re-examine the validity for differentiating the representational strategies, with a modified procedure for classifying subjects. In the previous experiment the classification of the subjects was done by the experimenter on the basis of subjects' protocol. But in the present experiment, written descriptions of the representational strategies are prepared and subjects are asked to choose the most similar one to their own way. A more objective evidence for the differentiation will be obtained if the above-mentioned results are replicated in this experiment.

The second purpose of this study is to examine a tentative factor which may influence the individual's preference to a representational strategy. It is the individual's habitual mode of processing cognitive events. Richardson (1977) constructed the "Verbalizer-Visualizer Questionnaire (VVQ)", picking up 15 items from Paivio's (1971) "Individual Difference Questionnaire (IDQ)". Nine of those 15 items could reliably discriminate between left-movers ands right-movers of lateral eye movements in answering various questions. Such preference of direction was explained with reference to the functional asymmetry of the brain hemispheres. Thus a score of VVQ is regarded as an index of an individual's position at the Verbalizer-Visualizer dimension of cognitive style. By measuring VVQ scores of the subejects who belong to each representation group, the relationships between cognitive style and the representational strategies will be investigated.

Method

Subjects : Twenty-five male undergraduates at the Tohoku University participated as subjects and were tested individually.

Materials :

VVQ

Verbalizer-Visualizer Questionnaire (Richardson, 1977) was the 15-item questionnaire. Respondents could answer "True" or "False" to each item. Thus possible scores ranged 0 to 15. It was assumed that a low score indicates strong verbalizing tendencies and a high score indicates strong visualizing tendencies.

Categorical Syllogism

Thirty-six categorical syllogistic problems were presented on a microcomputer display. Each problem had a pair of premises and five response alternatives. The

2. Traditionally, these letters refer to the four kinds of propositions: universal affirmative (A), universal negative (E), paticular affirmative (I), and paticular negative (O).

alternatives were four propositional conclusions (i.e. A[2], E, I, and O) and one non-propositional conclusion (i.e. "None of these are valid."). The subject's task was to select a response alternative that logically followed from the premise pair.

The premise pairs of the problems were consisted of two types. At 18 pairs (AA-3[3], AA-4, AE-2, AE-4, AI-1, AI-3, AO-2, EA-1, EA-2, EA-3, EA-4, EA-1, EI-2, EI-3, EI-4, IA-3, IA-4, OA-3), at least one propositional conclusion out of four can logically follow from each pair on a basis of the standard logic interpretation. At the remaining 18 pairs (AE-1, AE-3, AI-2, AO-3, EE-2, EE-3, EO-1, EO-3, IA-1, IE-2, IE-3, II-2, II-3, OA-4, OI-1, OI-4, OO-1, OO-4), the non-propositional conclusion is regarded as the correct answer. These were called as "Propositional Conclusion (PC)" problems and "Non-propositional Conclusion (NC)" problems.

Each problem referred to hypothetical sets of geometric figures. The subject-term described the shape of a set ("circle", "triangle", or "square"), the middle-term described the marking of a set ("vertically striped", "horizontally striped", or "checked"), and the predicate-term described the color of a set ("red", "blue", or "yellow").

Procedure: At the beginning of the experiment, the subjects were told to complete VVQ. Then the experimenter explained about the syllogistic tasks and the operation of keyboard. The AA-1 problem was provided as a practice. The experimental trials were presented in two blocks. In each block 9 PC-type problems and 9 NC-type problems were presented in random order. Between blocks a 5-minute break was given. After the second block was over, written brief descriptions of three kinds of representational strategies were given to the subjects. These were "A. I imagined several concrete figures.", "B. I thought intuitively on the basis of verbal expressions of premises.", and "C. I imagined diagrams which represent the set relations (e.g. Venn's circle).". The subjects were asked to arrange these descriptions in the order of similarity between each description and their own way twice on both experimental blocks.

Results

Classification of the subjects

At first the subjects were classified into three kinds of representation groups according to their ordering of the strategy descriptions. Table 1 presents the number of subjects who chose each description as most similar with his own way on the first and the second experimental blocks. Nine subjects who chose the B on both blocks were placed in the Verbal group. Ten subjects who chose the A on at least one block were placed in the Elemental group. Five subjects who chose the C on at least one block were placed in the Diagrammatic group. One subject who chose the A on the

3. In this notation, the first and the second letters identify the propositions in the first (major) and the second (minor) premises, respectively. And the number refer to the figure of the syllogism.

Table 1. Number of subjects who chose each description as most similar with their own way on the first and the second expermiental blocks.

First	Second	Classification	
B	B	Verbal	9
A	A	Elemental	4
C	C	Diagrammatic	3
A	B	Elemental	3
B	A	Elemental	3
C	B	Diagrammatic	1
B	C	Diagrammatic	1
C	A	(eliminated)	1
A	C	————	0

first block and the C on the second block was eliminated from further analysis.

Response accuracy

Table 2 presents the mean number of errors made by each group on each type of the problems. The groups did not differ in accuracy on PC problems but did differ on NC problems. Two-way mixed analysis of variance was conducted with group and problem type. The main effect of group was significant (F (2, 21)=5.484, p=.012). And the interaction between group and problem type was highly significant (F (2, 21)=7.446, p=.004). In addition, the group difference on NC problems was examined by a Tukey test. The Diagrammatic group and the Elemental group differed at the .05 level, and the Diagrammatic and the Verbal group differed at the .01 level. The difference between the Elemental group and the Verbal group was not statistically significant.

VVQ score

The mean VVQ score, by groups, was 10.5 for the Elemental, 8.9 for the Verbal and 8.0 for the Diagrammatic group. A one-way ANOVA showed a significant group difference (F(2, 21)=12.118, p=.009). And the Elemental group differed from the other groups at the .05 level by a Tukey test.

Table 2. Mean number of errors of each representation group in each problem type.

Group	PC	NC
Verbal	5.7	9.2
Elemental	5.2	6.6
Diagrammatic	5.6	2.2

Discussion

In terms of the accuracy of responses, the results of this experiment had the same tendencies as those of Matsuno (1986) did, although the difference between Elemental and Verbal groups was not so clear. The groups differed only on the problems in which none of the presented propositional conclusions was valid. To use non-verbal additional representations (especially Venn's like diagrams) seems to improve the efficiency in rejecting invalid conclusions. A related finding was provided by a study focusing the difference between the good and poor reasoners in categorical syllogistic reasoning. Galotti et al. (1986) reported that novice good and poor reasoners and experts did not differ in accuracy on the problems which had a logically necessary conclusion but did differ on the problems which did not have. The results of the present experiment suggest that the difference between good and poor reasoners could be attributed not only to different degrees of proficiency in a strategy, but also to different representational strategies.

It might be a matter of course that the individuals' VVQ scores were higher in the Elemental group and lower in the Verbal group. Those who reported much use of images of elements had more visualizing tendencies, and those who claimed to have reasoned verbally had more verbalizing tendencies. However it was rather unexpected that VVQ scores were relatively low in the Diagrammatic group. Because the Venn's like diagrams in mind were in a sense "visual", as well as the images of elements. But such diagrams were derived from a formal symbol system which the subjects had been taught in school, while the images were more content specific and the subjects naturally learned to use them. That is, they were products of the two different types of abstraction "Abstraction by Recoding" vs. "Content-based Abstraction", named by D'Andrade (1981). The "Visualizer" indicated by VVQ may have a closer relation to the latter process.

In conclusion, the differentiation of the representational strategies was generally re-confirmed. And it seems that the Verbalizer-Visualizer dimension of cognitive style has a substantial influence on the individual's preference to a representational strategy in categorical syllogistic reasoning.

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