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ABSTRACT

In the pair of experiments reported here the authors investigated the relationship between meaningfulness of problem statements and subjects' use of these statements in problem-solving tasks. Subjects (96 university students) were required to memorize meaningful formulae such as "volume = area x height" or corresponding symbolic formulae such as "v = a x h." Formulae were memorized in three sets of three. Some subjects were tested on one formula from each set, while others were tested on an entire three-formula set. In the first experiment subjects were asked to compute values using the formulae, or were asked unanswerable (incomplete or inconsistent) questions about the formulae. In the second experiment subjects were asked to judge computability of a quantity given several others. In both experiments analysis of variance revealed a three-way interaction between meaningfulness, problem type, and grouping. Symbolically stated problems involving more than one formula took much longer when the formulae came from different sets; for meaningful problems no such difference occurred. The authors conclude that subjects reorganize meaningful material for themselves, but use the instructor's organization for symbolic material. (SD)

RESTRUCTURING OF MEANINGFUL INFORMATION IN PROBLEM SOLVING

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Problem: Previous results involving learning a mathematical concept (Mayer, 1973; Mayer & Greeno, 1972) have encouraged the idea that (1) Ss whose instruction emphasized meaning of variables in terms of previous experience acquired new cognitive structure which re-organized and integrated the new variables within existing cognitive structure, and (2) Ss whose instruction emphasized purely symbolic algorithms for calculation acquired new structure which retained the formal relations among the variables as presented in instruction but which was not well tied to other concepts in Ss' cognitive structure. This interpretation was supported by a pattern of treatment x posttest interaction (TPI) in which Ss in the former group excelled on interpretitive problems and Ss in the latter group excelled on more straightforward, near transfer items.

The present experiment investigated a related idea concerning the meaningfulness of statements, expressed as formulas, which were learned by subjects and used in problem solving. The above results suggest that meaningful presentation in terms of situations in S's general experience (e.g., Work = Weight x Distance) results in restructuring the material to fit existing cognitive structure while purely symbolic presentation (e.g., W = P x D) results in storage and processing of information in the same organization as presented.

Method: The Ss were 96 University of Michigan students. In each of two experiments S studied three sets of formulas; with three formulas in each set, such that S had to reach criterion of errorless recall on one set before studying the next. Some Ss studied and were tested on formulas presented in a meaningful format (Meaningful Group) as shown below:

A1: Volume = Area x Height
A2: Height = Stopping Point - Starting Point
A3: Area = Length x Width
B1: Work = Weight x Distance
B2: Potential Energy = Weight x Height
B3: Power = Work/Time
C1: Density = Weight/Volume
C2: Weight = Mass x Acceleration
C3: Pressure = Weight/Area

Other subjects (Nonsense Group) studied and were tested on the same formulas except that a letter was substituted for each variable (e.g., V = A x H).

Using appropriate counterbalancing some Ss (One-Set Test) in each group were given test items based on three formulas that had all been studied in the same set, while other Ss (Three-Set Test) in each group received test items about three formulas that came from three difference presentation sets.

In Experiment I the test involved computing answers for several types of problems: some gave values for two or three variables and asked S to compute the value of an unknown variable and others asked questions about the formulas or posed problems as above but which could not be answered due to incomplete or inconsistent information.

In Experiment II the test involved making judgements of computibility of the form, "If you know the value of Work, Distance and Height, could you find the value for

Potential Energy?" There were three problem lengths varying the number of givens from 2 to 3 to 4, and there were two problem types varying whether the correct answer was yes or no.

Results: The main finding of Experiment I was a reliable three-way interaction involving meaningfulness, problem type and grouping ($F(5,55) = 7.3$, $p<.001$) in which problems involving more than one formula (i.e. more than two variable given) took much longer to solve for Three-Set grouping that One-Set for the Nonsense Group, but presentation grouping had no effect for the Meaningful Group. The same pattern of interaction among meaningfulness, number of givens and grouping was found in Exp. II with computibility judgements ($F(2,80) = 5.85$, $p<.005$).

Conclusion: These results provide clear support that deductive judgements of computability and actual problem solving performance is influenced by the organization in which information was learned for nonsense material but not for meaningful material. If meaningfulness influenced only the quantitative learning ease or solution ease, with meaningful and symbolic information stored and processed in the same way, no differential effect due to organization of presentation would be predicted. Howe er, the present findings suggest that material which can be related to meaningful experiences in S's cognitive structure is stored and processed in a qualitively different way than purely symbolic information. One interpretation is that the meaningful formulas were re-organized and integrated into the body of existing knowledge thus insuring rapid processing for all variables during problem solving, while the nonsense formulas produced cognitive structures which retained the formal relations among the aspects of information as presented and were not tied to other concepts in S's cognitive structure.

References

Mayer, R.E. and Greeno, J.G. Structural differences between learning outcomes produced by different instructional methods. Journal of Educational Psychology, 1972, 63, 165-173.

Mayer, R.E. Acquisition and resilience under test stress of structurally different problem solving procedures. University of Michigan: Human Performance Center Technical Report No. 42, 1973.

Footnote

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TABLE 1

EXAMPLES OF POSTTEST ITEMS

In Experiment I, there were six problem types:

Type F (Familiar): used a memorized formula directly. Example: "Weight = 25, Height = 4, Find Potential Energy."

Type T1 (Transformed): used a single formula, but the unknown was not the left-side member of the memorized equation. Example:"Work = 20, Weight = 10, Find Distance."

Type T2 (Transformed): required the use of two formulas. For example: Work = 20, Distance = 10, Height = 5, Find Potential Energy."

Type Q (Question): asked for information about the formulas. Example: "Given Power, Time and Weight, what else is needed in order to find Distance?"

Type U1 (Unanswerable): gave incomplete or inconsistent information so no answer could be computed, and used two givens. Example:"Weight = 25, Distance = 5, Find Potential Energy."

Type U2 (Unanswerable): gave incomplete or inconsistent information so no answer could be computed, and used more than two givens. Example: "Weight = 20, Mass = 10, Work = 5, Find Stopping Point."

In Experiment II, there were six problem types:

+2: correct answer was yes, presented two givens. Example: "Given Weight and Height, can you find Potential Energy?"

+3: correct answer was yes, presented three givens. Example: "Given Weight, Potential Energy and Stopping Point, can you find Starting Point?"

+4: correct answer yes, presented four givens. Example: "Given Power, Time, Height and Potential Energy can you find Distance?"

-2: correct answer was no, presented two givens. Example: "Given Weight and Height, can you find Power?"

-3: correct answer was no, presented three givens. Example: "Given Work, Time and Mass, can you find Weight?"

-4: correct answer was no, presented four givens. Example: "Given Mass, Acceleration, Height and Potential Energy, can you find Stopping Point?"

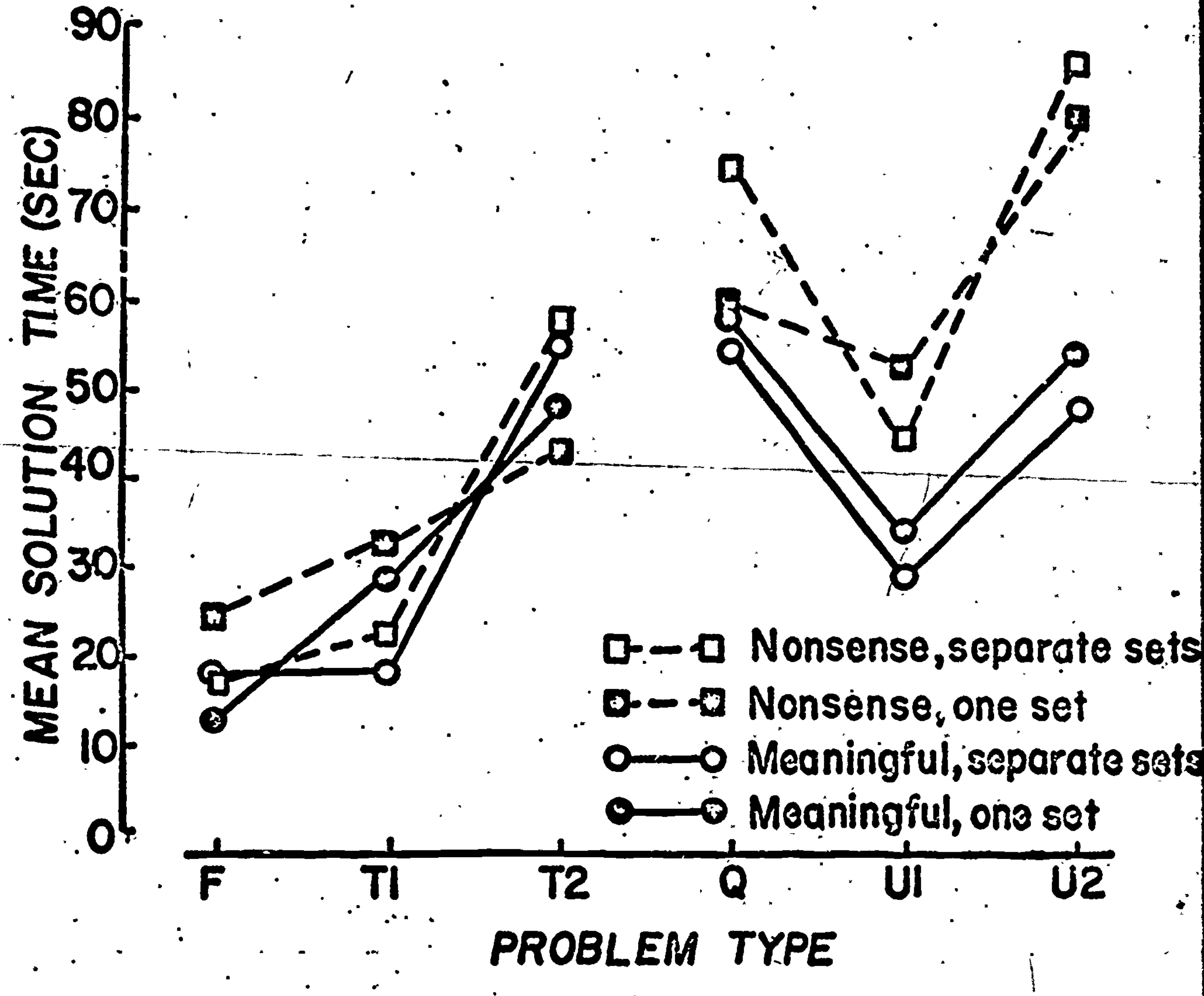

Fig. 1 Mean times to solve problems -- Experiment I.

fig 3
mayer + b

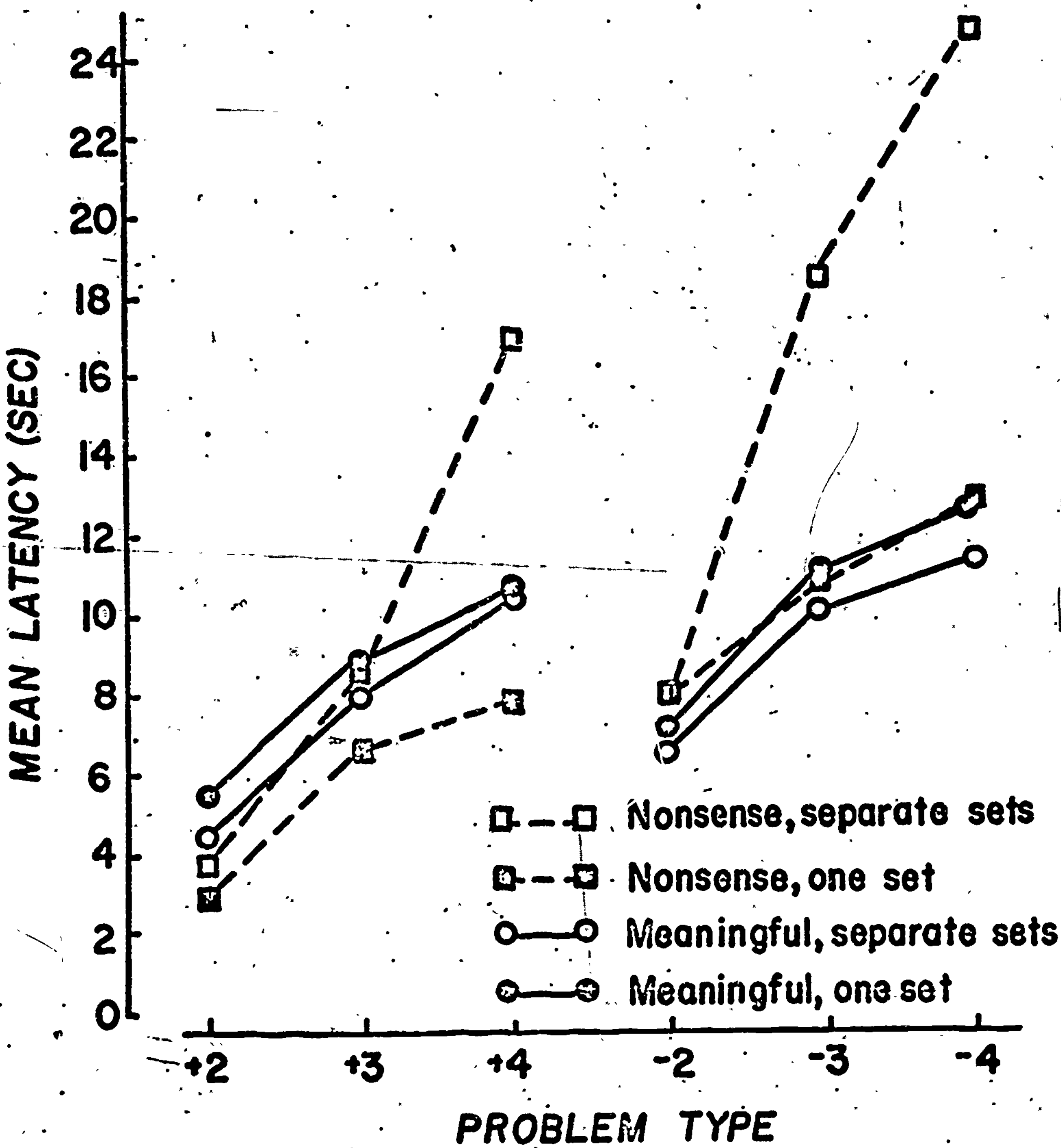

Fig. 2 Mean latencies of judgements of computability -- Experiment II. Problem types labelled + were computable, - were not computable. Numbers 2, 3, and 4 denote number of given variables.