Effects of Mnemonics, Imagery, and Practice on the Retention of Rules

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Considerable research has been conducted to investigate factors that may serve to increase the retention of rules. The effects of practice on the retention of rules have been examined by several researchers. Studies of the effect of overlearning, i.e., additional practice beyond the occurrence of original learning, have failed to find any significant differences in the retention of rules (Gagne and Bassler, 1963; Reynolds and Glaser, 1964; Bassler et al., 1971; Hannum, 1975).

Research has been conducted in which students received varying amounts and varieties of practice examples. However, these factors produced no significant differences in the retention of rules (Gibson, 1969). Practice that immediately follows the original learning, overlearning, does not seem to increase the retention of rules regardless of amount or type of practice. Practice that occurs at a time after the original learning, delayed practice, has been found to be effective in facilitating the retention of rules (Horwitz, 1976); Bousell and Moody, 1972; Gay, 1971). Apparently, the role of practice in the retention of intellectual skills is not related to the notion of strengthening the original learning through repeated associations and reinforcement, but rather seems to be related more to improving search and retrieval processes. Thus, there is an effect of delayed practice, since it causes the subject to engage in

search and retrieval schemes to locate the previously learned rule. The common failure to find an effect from additional practice at the time of original learning may be because the subject is not required to engage in any search or retrieval processes since the rules are immediately available.

More recently, several researchers have begun to investigate the role of mnemonic devices to improve retention. The use of various techniques such as the method of loci, peg system, rhymes, analytical substitution, and key words can improve the organization of learning and facilitate retrieval at a later date (Bower, 1970). Coding processes such as mnemonics have been shown to be more effective in learning and retention than associative strengthening processes (Bandura, Jeffery, and Bachicha, 1974). Most of the research that demonstrates facilitating effects of the use of mnemonics have learning tasks that could be classified as verbal learning, generally, the learning of word lists.

The use of imagery is another factor that can be used to increase retention. Recent research seems to document facilitating effects of imagery on learning and retention (Pressley, 1977).

Apparently, having the learners form mental pictures or visual images of material to be learned can have a facilitating effect on retention. Much of the research on imagery has dealt with the recall of verbal units rather than intellectual skills. Such research typically finds positive effect as a result of the use of imagery (Paivio, 1971; Bower, 1972; Pressley, 1977).

The use of imagery seems particularly well suited to the learning of concrete items or "picturable" items as Paivio (1971) calls them whereas more abstract concepts and relations are perhaps remembered through the use of semantic verbal processes. A dual system of memory has been proposed by Paivio (1971) in which information stored as visual imagery and information stored as verbal statements interact with each other so that an image could

facilitate the recall of verbal statements and vice versa. Support for the storing of concrete sentences and pictures as images and verbal storage for abstract sentences has been obtained by other researchers (Sasson, 1971; Sasson and Praisse, 1972). Rigney (1975) supports a view of the interaction between imagery and language in long-term storage. The assumption of semantic memory theorists is that semantic networks in long-term storage represent propositional knowledge and that both imagery and language can be generated from this base (Rigney, 1975). Other support for the role of imagery follows from the work of Pompi and Lachman (1967), Yuille and Paivio (1969), Begg and Paivio (1969(, Begg (1971), Luria (1968), and Dyer and Meyer (1976).

Another factor that should be considered in research on the retention of rules is that of availability versus accessibility. Tulving and Pearlstone (1966) distinguished between items that had been learned in the sense of being available for recall; i.e., present in long-term storage, but were not accessible. That is, the items could not be reproduced in a free recall situation. These researchers indicated that the failure to reproduce the previous learned material, in this case word lists, could result if the information was indeed lost from a subject's memory (was not available) or if the information was stored (was available) but the subject was not able to retrieve the information from his memory (was not accessible). By the use of a retrieval cue, category name, the accessibility and hence recall of the information was greatly improved. Research conducted subsequent to this study tends to support this distrinction (Earhard 1967a, 1967b; Mandler, 1967; Stroud, 1971; Tulving and Osler 1968; Tulving and Psotka, 1971; Weist, 1970). Retrieval cues have been found to facilitate recall when they are present during both original learning and recall. When presented only for recall, retrieval cues seem to have a facilitative effect only if the pre-established association between the cue and the information to be recalled is of considerable strength (Thomson and Tulving, 1970; Wood, 1967).

A number of studies have investigated the effects of teaching students how to provide their own retrieval cues through the use of retrieval plans. There is substantial evidence that the use of retrieval plans can markedly facilitate recall (Bower, 1970; Bugelski, Kidd, and Segman, 1968; Senter and Hauser, 1968; Wood, 1967). The tasks used in these studies involved the learning and recall of verbal information rather than intellectual skills.

In two studies that examined the retention of mathematical rules the inability of the majority of subjects to reproduce the rule learning was seen as a failure to retrieve previously learned rules rather than a loss in the rules themselves (Hannum, 1975). In these studies the presence of a retrieval cue at the time of retention measurement greatly enhanced the performance.

The present study sought to extend the research investigating the retention of rules by examining the effects of retrieval instructions, (mnemonics and imagery), practice, and cueing on the retention of previously learned rules.

Method

Subjects

The subjects were 158 students enrolled in the seventh grade of public schools in Leon County, Florida. Data were analyzed for 109 subjects who were present on each of the three days of testing.

Experimental Tasks and Materials

Tasks. The experimental tasks in the present study were the learning of mathematical rules for multiplication, division, and raising to powers integers with exponents. These tasks were selected since they had not been previously introduced to the subjects and these rules required prerequisite skills that were available to the subjects (multiplication facts and the concept of exponentiation). The three rules are:

$$X^a \cdot X^b = X^{a+b}$$

$$\frac{X^a}{X^b} = X^{a-b}$$

$$(X^a)^b = X^{a \cdot b}$$

Original learning materials. The three rules were taught using a linear programmed text of twenty four frames. The mimeographed text contained three sections, one for each rule. The text was developed and revised on the basis of field testing prior to use in this study. In completing the text, students were required to apply each rule to solve an equation and they received immediate confirmation. At the end of the section for each rule a criterion problem involving the application of the rule was used to assess mastery of the rule.

Mnemonic materials. The mnemonic treatment condition was established by a six-step procedure presented in a mimeographed form: 1) a completed example was given for each rule; 2) subjects were instructed to examine the relationship of the operation on the integers and the operation on the exponent (e.g., to multiply numbers you add exponents); 3) subjects were instructed to form a mnemonic by taking the first letter of each power (multiply-add, divide-subtract, raise to a power-multiply,); 4) the mnemonic (MADS PM) was related to the operations; 5) the mnemonic was repeated; and 6) subjects were encouraged to think about getting mad at night or having the MADS in the PM to help them remember the mnemonic.

Imagery materials. The imagery treatment condition was established by instructing students in forming a specific image in a five-step procedure: 1) a completed example was given for each rule; 2) subjects were instructed to examine the relationship of the operation on the integers and the operation on the exponent (e.g. to multiply numbers you add exponents); 3) subjects were instructed to examine the specific symbols for each operation (e.g., $3^4 \times 3^5 = 3^{4+5}$); 4) the symbols for the operations were presented without the numbers (e.g., to X you +); and 5) the symbols were repeated alone (e.g., X+) and subjects were instructed to form a mental picture of these symbols to help them remember how to work the problems.

Practice materials. The practice condition was established by presenting five problems for each rule to the subjects. The five problems for each rule were presented separately rather than mixed and confirmation was not provided.

Cue. The cued condition was established at the time of retention measurement by providing subjects with a brief summary statement of each of the rules. The following statements were used:

to multiply, add

to divide, subtract

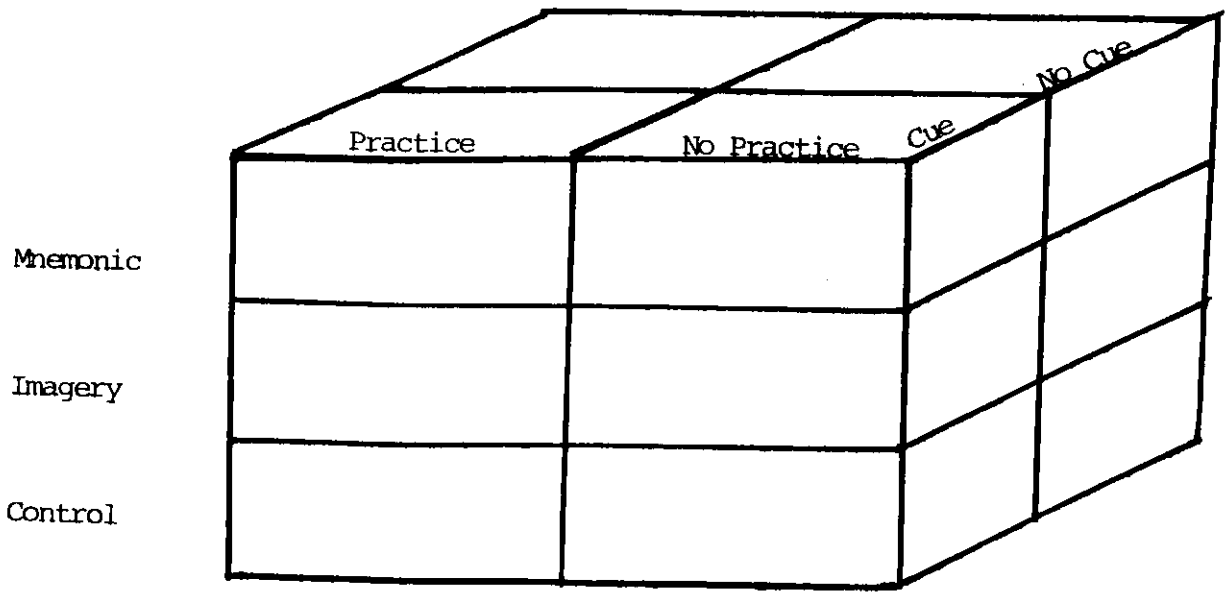
to raise to a power, multiply

Measurement instruments. Two measurement instruments were constructed, since subjects' retention was to be measured twice. An item pool was constructed for the measurement of each of the rules used in this study. Items from the pool were assigned at random to the two measurement instruments. Each item required the subject to apply the rule to the solution of a problem. Items from the item pool were also used in the practice condition in which subjects were to practice the application of each rule. At no time was the same item used in original learning, practice, or on either of the two retention tests. Each retention test consisted of 12 problems (4 for each of the 3 rules) presented in random order.

Experimental Design

A 3x2x2 factorial design shown in Figure 1 was used in the present study. The factors are retrieval instructions (mnemonic, image), practice and cueing.

Figure 1. Experimental Design



Subjects were assigned at random to retrieval instructions and practice conditions. Each subject particpated in both non-cued and cued retention. At the time of retention measurement each subject first received a retention test without the cues, completed it and then was given the second retention test that had the three cues printed at the beginning of the test.

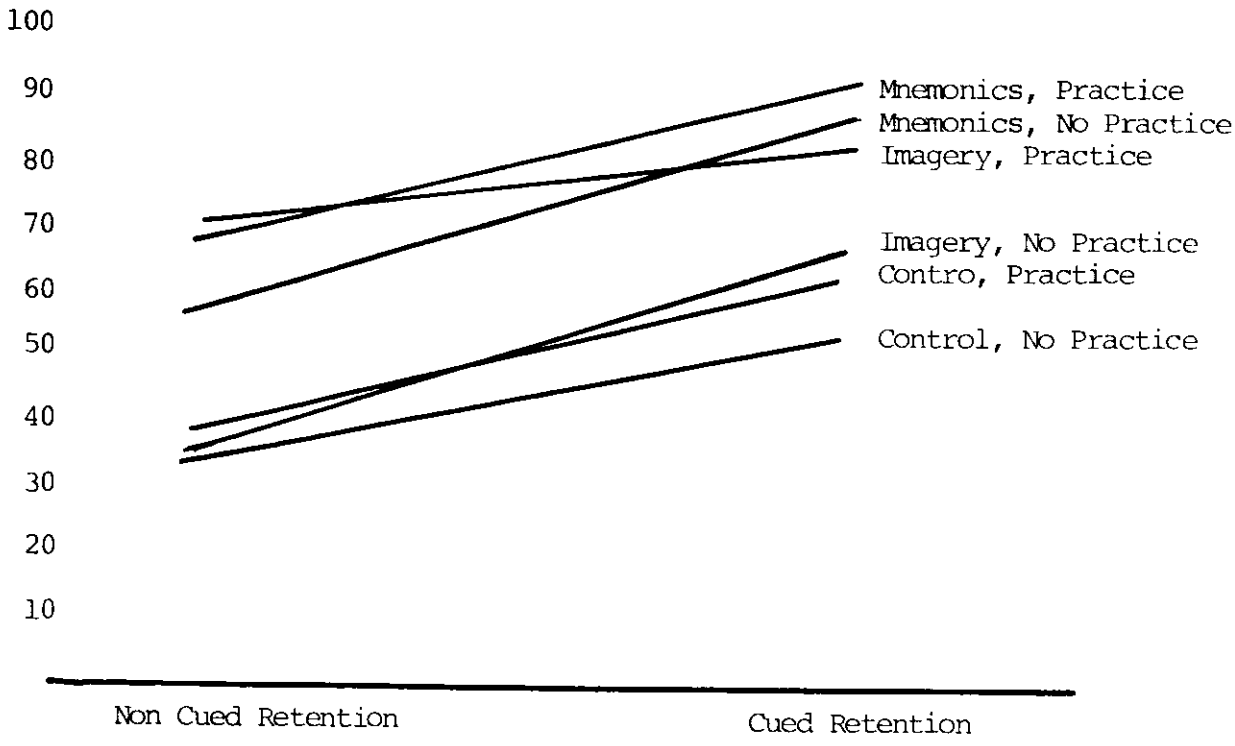
Procedures

The original learning using the programmed texts was conducted during regularly scheduled mathematic classes and was monitored by the regular classroom teacher and the experimenter. When each subject completed the section of the original learning materials for a rule he was required to demonstrate mastery by correctly applying the rule to solve a criterion problem. Their mastery was checked by the teacher or experimenter. If they were successful they were told to proceed in the text to the section for the next rule.

Subjects who were unsuccessful were given the correct answer, instructed to review the text, and allowed to attempt another criterion problem. As the programmed texts were completed and the criterion problems correctly worked, the texts were collected.

Results

The percentage of rules retianed under the various experimental conditions is shown in Figure 2.



Scores on the retention tests were analyzed using a 3x2 factorial ANOVA with two repeated measures. Each student received a 0 or 1 for each rule to indicate whether he correctly worked at least three out of four problems for that rule. Thus, for each subject the score could range from 0 to 3. The results of

the ANOVA indicate significant effects on retention of rules as a result of retention instructions, $F(2, 105)=7.11$, P .01, practice, $F(1,105)=4.39$, p .05, and cueing, $F(1, 105)=58.87$, p .01. None of the interactions among these variables was significant at the .05 level.

Discussion

One experimental condition in the present study was the use of mnemonics and imagery to facilitate retention. Previous studies have reported facilitating effects of these two conditions on retention of learned material (Paivio, 1971; Pressley, 1977; Bower, 1970). In most of these studies the learning task could be classified as information or verbal learning. The present study extended this research into the learning of rules and found a significant effect on the retention of rules as a result of mnemonics and imagery. Apparently these conditions can be used to facilitate the retention of rules as well as information. The mnemonic and imagery conditions in the present study differed from some previous studies in that the specific mnemonic and image to be used were supplied by the experimenter rather than developed by the subjects. In some other studies the mnemonic or imagery condition was formed by providing subjects with instructions in how to form mnemonics or images and encouraging them to do so. The data from the present study tend to support the effectiveness of experimenter-supplied mnemonics or images, or more specifically the actual mnemonic and image used, and do not address the issue of the effectiveness of supplying instructions to subjects in forming mnemonics or images and having them devleop unique mnemonics or images.

In interpreting these results one should be aware that some researchers consider that imagery is but one of the forms of mnemonics. In this light the study examined two forms of mnemonics, a pictorial or image mnemonic and a verbal or key word mnemonic. The results could be interpreted to indicate the

effectiveness of mnemonics in aiding the retention of rules regardless of the form of the mnemonic. In this interpretation the effect of the verbal and pictorial mnemonic on retention is assumed to be the same. From a practical standpoint whether an image is considered to be mnemonic is of little significance, the important finding is that the use of imagery seems to facilitate the retention of rules.

The finding of a positive, although lesser, effect of practice on the retention of rules is consistent with some previous studies (Gilbert, 1957; Slamecka, 1959; Underwood, 1964) and inconsistant with others (Cierpilawski, 1971; Dopra, 1973). Perhaps the timing of the practice could have produced the higher levels of retention. Previous studies of delayed practice, such as used in the present study, have found a facilitating effect on retention of rules (Reynolds and Glaser, 1964; Gay, 1971; Bousell and Moody, 1972) whereas practice immediately following the learning does not seem to produce greater performance on tests of rule retention (Hannum, 1975; Gibson, 1969; Bassler et al., 1971). It should be noted that external feedback was not supplied by the experimenter for the practice condition in the present study. In previous studies practice followed by feedback seemed to be superior to practice that was not accompanied by such feedback (Gilman, 1969; Berglund, 1969; Kulhavy, 1977). It is possible that greater effects of practice could have been found had corrective feedback been supplied. Also, it is questionable whether practice immediately following the original learning would have produced the same results.

In the groups receiving mnemonics or imagery plus practice it is not known if the subjects used this opportunity to practice using the mnemonic or image to help them retrieve the rules and apply them to solving the problems. Since the groups receiving mnemonics or imagery plus the practice exhibited greater performance on the retention tests than groups receiving either practice,

mnemonics, or imagery alone, there may be some effect due to subjects employing the mnemonic or image during the practice problems. The failure to find significant interactions, however, makes such an interpretation very tentative.

The finding of a significant effect on retention resulting from retrieval cues is consistent with previous research (Tulving and Pearlstone, 1966; Earhart, 1967; Stroud, 1971; Thomson and Tulving, 1970). Apparently when rules have been previously learned, i.e., the subject can demonstrate performance of the rule to a criterion, they are not forgotten in the sense of being unavailable, but rather they most probably are just not assessible. The use of abbreviated rule statements as cues such as used in the present study has been shown to be sufficient to cause the subject to be able to perform at a high level on retention tests. This is interpreted to indicate that retrieval cues facilitated the subjects' ability to locate the previously stored rules in long-term storage and retrieve them to solve the problems given on the retention tests since previous research has demonstrated that presence of retrieved cues alone do not enable an uninstructed group to perform as well on retention tests (Hannum, 1975).

Results of the present study indicate that certain activities following the original learning can have a significant effect on the retention of rule learning. The failure to find a high level of retention of rule learning seems to be a function of problems with retrieval (accessibility) and not with the true loss or availability of the rules. In order to further explore factors affecting retention of rules additional studies might be done to investigate techniques that might improve the accessibility of rules. Such factors might include instructions in forming mnemonics or images, using different conditions of original learning that might improve accessibility, use of other strategies to help the subjects encode the rules in a form more suitable for retrieval, delayed practice in applying

mnemonics or images, and teaching rules in a more meaningful form. The research might be extended to other intellectual skills such as concept learning and problem solving.

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