Verbal Ability, Previous Practice and Load on Short-Term Memory as Determiners of Differences in a Complex Learning Task: An Experimental Study

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ABSTRACT

Traditional psychometric theory and practice classify people according to broad ability dimensions but do not examine how these mental processes occur. Hunt and Lansman (1975) proposed a 'distributed memory' model of cognitive processes with emphasis on how to describe individual differences based on the assumption that each individual possesses the same components. It is in the quality of these components that individual differences arise. Carroll (1974) expands Hunt's model to include a production system (after Newell and Simon, 1973) and a response system. He developed a framework of factor analytic (FA) factors for the purpose of describing how individual differences may arise from them. This scheme is to be used in the analysis of psychometric tests.

Recent advances in the field of information processing are examined and include: 1) Hunt's development of differences between subjects designated as high or low verbal, 2) Miller's pursuit of the magic number seven, plus or minus two, 3) Ferguson's examination of transfer and abilities and, 4) Brown's discoveries concerning strategy teaching and retardates.

In order to examine possible sources of individual differences arising from cognitive tasks, traditional psychometric tests were searched for a suitable perceptual task which could be varied slightly and administered to gauge learning effects produced by controlling independent variables. It also had to be suitable for analysis using Carroll's

framework. The Coding Task (a symbol substitution test) found in the Performance Scale of the WISC was chosen.

Two experiments were devised to test the following hypotheses. 1) High verbals should be able to complete significantly more items on the Symbol Substitution Task than low verbals (Hunt, Lansman, 1975). 2) Having previous practice on a task, where strategies involved in the task may be identified, increases the amount of output on a similar task (Carroll, 1974). 3) There should be a substantial decrease in the amount of output as the load on STM is increased (Miller, 1956). 4) Repeated measures should produce an increase in output over trials and where individual differences in previously acquired abilities are involved, these should differentiate individuals over trials (Ferguson, 1956). 5) Teaching slow learners a rehearsal strategy would improve their learning such that their learning would resemble that of normals on the same task.(Brown, 1974).

In the first experiment 60 subjects were divided into high and low verbal, further divided randomly into a practice group and nonpractice group. Five subjects in each group were assigned randomly to work on a five, seven and nine digit code throughout the experiment. The practice group was given three trials of two minutes each on the practice code (designed to eliminate transfer effects due to symbol similarity) and then three trials of two minutes each on the actual SST task. The nonpractice group was given three trials of two minutes each on the same actual SST task.

Results were analyzed using a four-way analysis of variance.

In the second experiment 18 slow learners were divided randomly into two groups; one group receiving a planned strategy practice, the other receiving random practice. Both groups worked on the actual code to be used later in the actual task. Within each group subjects were randomly assigned to work on a five, seven or nine digit code throughout. Both practice and actual tests consisted on three trials of two minutes each. Results were analyzed using a three-way analysis of variance.

It was found in the first experiment that 1) high or low verbal ability by itself did not produce significantly different results. However, when in interaction with the other independent variables, a difference in performance was noted. 2) The previous practice variable was significant over all segments of the experiment. Those who received previous practice were able to score significantly higher than those without it. 3) Increasing the size of the load on STM severely restricts performance. 4) The effect of repeated trials proved to be beneficial. Generally, gains were made on each successive trial within each group. 5) In the second experiment, slow learners who were allowed to practice randomly performed better on the actual task than subjects who were taught the code by means of a planned strategy.

Upon analysis using the Carroll scheme, individual differences were noted in the ability to develop strategies

of storing, searching and retrieving items from STM, and in adopting necessary rehearsals for retention in STM. While these strategies may benefit some it was found that for others they may be harmful. Temporal aspects and perceptual speed were also found to be sources of variance within individuals.

Generally it was found that the largest single factor influencing learning on this task was the repeated measures. What enables gains to be made, varies with individuals. There are environmental factors, specific abilities, strategy development, previous learning, amount of load on STM, perceptual and temporal parameters which influence learning and these have serious implications for educational programs.

I am greatly indebted to Dr. S. Irvine for his assistance in guiding the development of this paper. Thanks are also due Dr. R. Crane and Dr. M. Richards for their efforts on my Advisory Committee.

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CHAPTER I

Statement of the Problem and Literature Search

Introduction: Psychometric vs Cognitive Psychology

There are presently two broad disciplines of psychology the psychometric approach, which measures differences between individuals without regard for the processes by which individuals solve problems, and the cognitive approach which focuses on information processing. Whereas traditional psychometric theory and practice provide a means of classifying people according to various broad ability dimensions, these dimensions do not necessarily give us any insight into the ways in which mental processes occur. Traditional psychometric approaches indicate that some people are superior or inferior to others in doing certain tasks but they do not tell us why. Psychometric tests are good predictors of academic achievement and indicate possible individual aptitudes but they leave many questions unanswered. One such question to be examined in this study concerns the nature of individual differences and their implications.

Factor analysis was developed to analyze results mathematically to determine the underlying abilities which would explain a large part of the variance in results on psychometric tests. Spearman (1927) argued for a single general ability (g) along with a specific factor for each test. Vernon (1961) and Catell (1971) argued for a hierarchy of abilities containing Spearman's (g) plus visual, numerical and spatial factors with related factors of each. Thurstone

(1938), however, identified seven distict abilities while Guilford (1967) strongly believes that more than 120 separate abilities exist. Obviously there is much disagreement.

In the search for possible alternatives to these methods, Earl Hunt and Marcy Lansman (1975) proposed a model of cognitive processes. Hunt indicates that there are many ways in which individuals differ in their cognitive abilities and provides insight into a possible explanation of how these are possible. While pursuing a computer analogy he says that the principles governing operational procedures are universal but there are individual differences in the "quality of the components" (Hunt, 1975, p.87) in processes such as coding and retrieving operations. The way in which data is held in memory, problem solving techniques, the role of motivation, rehearsal strategies, and the knowledge of when and how to use these 'components' are likewise subject to individual difference. Hunt's main concern was with how to describe these individual differences. His "distributed memory" model (Hunt, 1975, p.92) is his answer. (This is shown in Figure 1 below.)

Hunt's system is designed to address certain memories based upon Atkinson and Shiffrin's Model of Memory (1968). It includes a short term memory (STM) and long term memory (LTM). STM holds from two to seven items while LTM has an infinite capacity. Items are held in STM by a process of rehearsal; hence these items can be dropped

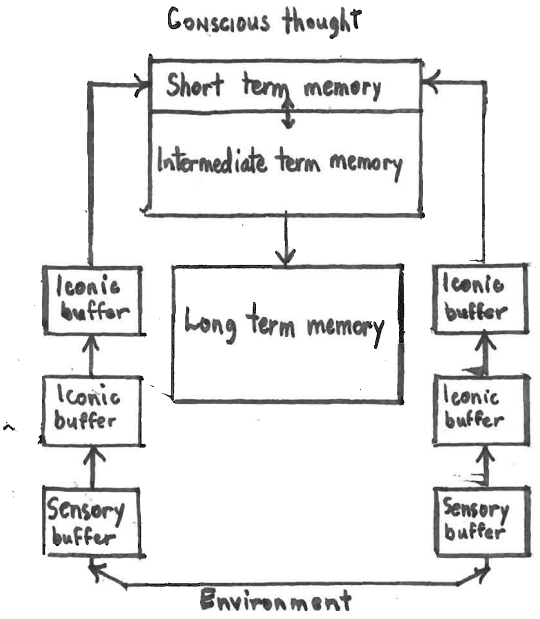


Fig. 1. A schematic model of human cognitive processing.

by being replaced with a new item or by failing to rehearse them. STM is under the subject's control. Strategies developed determine how the system works. Hunt also includes an intermediate memory (LTM) in his adaptation. Hunt sees problem solving as a "sequence of transformations of information in the STM-ITM system under the control of transformation rules (productions) which are stored in LTM" (Hunt, 1975, p.93). Individual differences arise through the subject's ability to code information from the real world. Hunt argues that individual differences are logical consequences of the differing of the components. Whereas each individual possesses the same components, they may differ in quality, thus giving rise to individual differences.

John B. Carroll (1974) is concerned with somewhat the

same problem. He asks the question: What does a test really measure? He considers psychometric tests as cognitive tasks, which reflect the operation of integrated 'programs' for the processing of information. Carroll was seeking a general methodology and theory for interpreting psychometric tests as cognitive tasks and for characterizing factor analytic (FA) factors, previously mentioned, according to a model of cognitive processes. He started from Hunt's model of 'distributive memory' which assumes that information from the environment enters STM, then passes to ITM and into LTM. He then added a production system (after Newell and Simon, 1973) which controls the processing of information by "specifying the program (rules and strategies) for any given cognitive task" (Carroll, 1974, p.11). A provision for responding to the result of the operation was further included. Carroll hopes to interpret and characterize FA factors according to this model. The production systems are one place where individuals may differ depending on past experiences. The elements in the system are probably universal but may differ with respect to the strategies and to the kinds of data available to different individuals. Carroll hoped to be able to identify sources of individual differences on cognitive tasks with particular aspects of information processing behavior. He developed a framework for analyzing cognitive tasks which appear in psychometric tests with the belief that the scheme would give reasons why individuals differed on the tasks. That scheme appears in Table 1 of

the Appendices.

The contribution of Hunt, Carroll, and others to problems of definition of the cognitive process is the implication from their studies that 'global' intelligence ('global' in the sense that they are measured by psychometric tests) or ability measures are inadequate for uncovering individual differences in the processing of information and learning of complex concepts. They also suggest that experimental rigor be used in the analysis of psychometric tests. Test scores should be seen as dependent variables subject to experimental control as emerging from the results of analysis.

Recent Advances Combining Psychometric and Information Processing

One recent approach that bears investigation is proposed by Earl Hunt (1975). Hunt's information processing paradigm points to possible areas of individual differences. One such area is in the association between "preconscious information processing and the processes measured by psychometric tests of verbal factors in intelligence" (Hunt, 1975, p.95). It was found by Hunt through experimentation that subjects designated "high verbal" scored faster in code access time than subjects designated "low verbal" on the Posner-Keele same-different identification task (Hunt, 1975, p.95). Hunt also found that "high verbal" subjects were able to recall more information from STM than "low verbal" subjects in the "Sperling paradigm" (Hunt, 1975, p.96).

"High verbals" were found to be more accurate at attending to a particular channel and blocking out others (Hunt, 1975, p.96). These results were explained in either of two ways, "High verbals may have slower rates of decay or more rapid coding processes" (Hunt, 1975, p.97). In another study high verbals were also found to be more sensitive to pro-active inhibition release than low verbals (Hunt, 1975, p.199). The results of further studies have shown that high verbals have a better short term memory (Hunt, 1975, p.206), that high verbals are more sensitive to the order in which speech information enters STM (Hunt, 1975, p.209), that low verbals take twice as long as high verbals to "process a negation" (that is True/False, Absent/Present, Above/Below etc.; Hunt, 1975, p.211). It was suggested in Hunt's study of verbal ability that it is possible to distinguish high verbal subjects by the use of psychometric tests and also by the use of information processing tasks (Hunt, 1975, p.224). If this is the case, it should follow that high verbals should do significantly better on information processing tasks (develop coding access to use rehearsal of information from STM) than low verbals.

A recent experiment on information processing of visual figures in a digit symbol substitution task (DSST) was performed by F. L. Royer and reported by W. K. Estes (1974). In conducting the experiment Royer did not vary the size of the set of symbols but rather varied the symbols themselves by rotating them through 360 degrees and associating them

with the numbers. This task can be viewed as a measure of information processing capacity and can also be related to verbal ability in that Royer found "skill in DSST involves verbal encoding as a major component" (Estes, p.745).

How could these ideas be utilized in our investigation of traditional psychometric tests so that they might shed light on the above assumptions as well?

Short Term Memory in Information Processing

Another consideration in information processing experiments has been the emergence of the notion of short term memory and a realization that its related capacity is different within individuals. The notion of limits on information processing later attributed by others to STM, was first reported by George Miller in 1956. His examination of the "magic number seven" (Miller) suggests "some limits on our capacity for processing information" (Miller, 1956, p.81). Miller suggests that although human beings vary in the amount of information they can process, certain limits seem to be reached quickly. Input to the system is correlated with output. If we measure the results of information processing it gives us insight to the "input-output correlation" (Miller, 1956, p.82). As a result of exhaustive experimentation and review of existing literature on the subject Miller found that the number seven kept reoccurring as the point above which individuals started making errors in various categories of judgment. In some cases this number dropped to five and at times rose almost to nine, hence the judgment that seven,

plus or minus two, imposes limits on the amount of information that a person can process in STM. It was also discovered that regardless of the type of information that the individual was required to process, the most frequent mean number obtained was seven. For example in tests of judgments of auditory pitch, it was found that a person could identify accurately four tones without confusion but with five or more, confusions were evident. In experiments with hue and brightness and skin capacity Eriksen and Hake and Geldard (1955) found that individuals could identify about "four intensities, about five durations and about seven locations" (Miller, 1956, p.84). Experiments involving absolute judgments showed results of seven to nine as being the capacity for accuracy. Miller himself asks how reproducible his results are and proceeds to gather data from other studies done in different labs with different techniques and methods of analysis. Such results only supported his already well-documented evidence. There is a limit which he calls the "span of absolute judgment" (Miller, 1956, p.90), beyond which individuals begin making errors. This span is found to be in the neighborhood of seven. It is suggested that there are ways to increase this capacity. One way is to "make relative rather than absolute judgments, to increase the number of dimension along which the stimuli can differ, or to arrange the task in such a way that we make a sequence of several absolute judgments in a row" (Miller, 1956, p.90). By grouping or reorganizing the material into units or chunks

we can increase the capacity. He calls this process "recoding" (Miller, 1956, p.93). In the end Miller suggests that this information could be useful in a number of ways, one of them being in the study of learning and memory. How could these studies of limits to human performance be incorporated into our investigation of information processing? What limits do they suggest on the system itself? How do these limitations affect being high or low verbal or vice versa?

Transfer and Learning in Information Processing

This leads us to the realm of learning, that of transfer and abilities. George Ferguson (1954,1956) advanced what many still regard as the definitive statement of the relationship between transfer and the abilities of man. In examining abilities he ascertains that the main features include: 1) developmental stages marked by stability in behavior at particular age levels; 2) the influence of both environmental and biological factors; 3) the formation of abilities through a process of "differential transfer" (Ferguson, 1956, p. 182); 5) learning processes whereby each successive stage is influenced by abilities previously established.

In his operational definition of 'ability', Ferguson refers to Thurstone's statement that "an ability is a trait defined by what an individual can do" (Ferguson, 1956, p.183). When considering ability one must also be concerned with the concept of transfer. By transfer Ferguson implies change, based on performance resulting from practice from one task

to another. What is the function of transfer?

> "In general the introduction of the idea of a transfer function argues very simply for the use of the concept continuous covariation in the study of transfer, and the discarding of discrete concepts."
> (Ferguson, 1956, p.187)

Futher, Ferguson suggests that transfer is important when considering experimental design, which leads to a variety of problems to be met with within each design, because people's systems undergo changes in state. These changes may be the result of environmental circumstances, such as the performance of a task, and can lead to an infinitely large number of other changes which can affect performance.

Experimentation has shown that changes do occur in the "factor structure" (Ferguson, 1956, p.190) over practice, and that abilities also differ from one stage of learning to another. Fleishman's results show that specific task factors (abilities) become more important from stage to stage, suggesting that they are functions of the <u>task</u> rather than of "previously established abilities" (Ferguson, 1956, p.190). It follows that while adult learning requires reorganizing or integrating, some of the variance between individuals results from the ability to organize or integrate in order to cope with a new task. Hence it follows that there must be certain integration abilities which may be important in adult learning.

Implications of this theory include the notion that the study of abilities is related to learning theory and

that methods used in the former may be used in the latter. It follows that particular learning tasks can be described in terms of ability patterns. An underlying approach to such studies should include the description of the response in terms of the stimulus and the conditions under which the response occurs. Environmental factors are also very important in studying abilities. It is also evident that society can control the environment and educative process to determine the abilities that are considered desirable, given that objectives and methods are clear and explicit.

An interesting question arising from this idea of transfer concerns just what is transferred while changes occur over practice. Is it strategies that are developed within the individual that transfer from one task to another? Is it a physical or mental process or a combination of both that is required? Does being high or low verbal affect what is learned? How best can one adapt these ideas to experimental control and testing?

Rehearsal Strategies in Slow Learners

Brown, Camione, and Murphy found that if retardates were taught strategies to be used in the learning tasks, it would aid their performance. However, the same process did not aid normals. Conversely, introducing procedures which interfered with rehearsal affected the performance of normals but not of retardates. It was concluded that the difference was due to the tendency of retardates to adopt "active rehearsal strategies" (Brown, from Hunt, 1975, p.91)

whereas normals did not. Brown at al., conclude that while retardates obviously have "poor memory" it is poor in a particular way, and it appears to be due to using different strategies for encoding procedures. A question of interest to teachers of slow learners is whether teaching slow learners a specific strategy in a perceptual task aids their performance in such a way that they appear to act as normals on the same task.

Summary

Thus far I have reviewed four current ideas about the categorization of human cognitive behavior. In summary they are: 1) Hunt's information processing approach and his reference to what it means to be high and low verbal; 2) Miller's magic number seven, plus or minus two, relating to restrictions imposed on a person's STM; 3) Ferguson's description of abilities and what is actually transferred over practice and; 4) the assertion by Hunt-Brown et al., that retardates are aided on tasks by being taught strategies. Each of these studies has presented questions which have arisen out of context. Questions to be investigated by this present study are: 1) Does being high or low verbal make any difference to performance or cognitive tasks? Is learning different if one is high verbal than it is for those who are low verbal? 2) What effect does practice have on learning, both on the task itself and over successive trials? Is learning different for those receiving practice? What is the effect of repeated measures

on the task? 3) What is the effect of the size of the load on STM over successive trials? 4) Does teaching slow learners a strategy on a perceptual task make their learning resemble that of so-called normals?

CHAPTER II

Experimental Design

Intelligance Testing and Mental Processes

A re-examination of traditional psychometric tests was conducted. One in wide use for the purpose of identifying fast and slow learners is the Weschler Intelligence Scale for Children (1949). It contains both verbal and performance tasks. Within the Performance tests is a subtest of Coding, elsewhere defined as a symbol substitution test, containing nine items as shown in Figure 2.

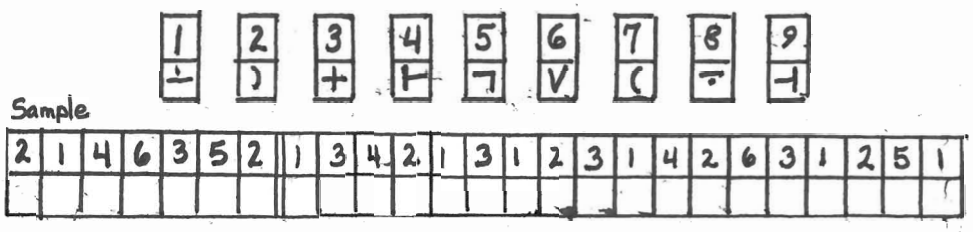


Fig. 2. WISC Performance item: Coding

The SST has several advantages over other types of intelligence tests as a starting point to such an investigation. First it is a task that can be varied in length by increasing or decreasing the number of symbols to be coded. It can be administered to gauge learning effects created by alterations in the structure of the task. It can be analyzed by the Carroll framework (p.24 and Appendices, Tables 1 and 2) for the study of information processing <u>implicit</u> in psychometric tests. All of these advantages

converge to allow its use as a means of discovering some process parameters in psychometric tests of ability. Questions that arise from subjecting tests of this kind to closer scrutiny by alternative methods are: What are the causes of variance applicable to the test? What independent variables are at risk?

Since the Carroll framework is to be used in analysis of the experimental task, an examination of the WISC task as it appears in the battery itself is of benefit here. What follows is first an explanation of the scheme for analysis as presented by Carroll, and second a description of the Coding task as it appears in the WISC in view of the Carroll scheme.

Carroll's Framework In Detail

Carroll's scheme was built around measuring 24 different FA factors, dealing with a single item at a time. An item was defined as any stimulus or group of stimuli considered as a unit, on the basis of which one or more responses are to be made. He developed a uniform system for coding the characteristics of the task represented by the items of each test. The coding system was programmed for computer analysis. It consisted of 48 tests as raw material for constructing "production systems" for the test tasks. An actual production system was not constructed. Instead, a detailed analysis of codings for the 48 tests was constructed. It was hoped that common elements in the codings and patterns of codes for given factors would be found. Nearly all pairs were found to have one or more codes in common, as well as individual

differences and there was a distinct pattern of these codes over factors. Similarities between the test-factor pairs were considered with respect to types of stimuli and responses involved.

The essential results are the cognitive processes identified as being characteristic of each of the 24 FA factors. These processes turned out to be quite diverse with respect to type, memory store involved, temporal parameters, etc. Also most of the FA factors differ markedly from one another. The system thus identifies mental processes associated with these factors. It identifies the role of these processes with particular attention to the role of individual differences.

As a result of this study Carroll lists types of memory and discusses the nature of individual differences and the modality or contents of memory. Few individual differences in ITM or LTM store are seen. The table of factors indicates only the operations in which individual differences are great and are usually associated with storage and retrieval operations for ITM (see Appendices, Table 2). Individual differences in LTM are associated with search and retrieval operations connected with previous learning which is stored in LTM. Further the table of factors specifies operations and strategies that involve individual differences. Operations are implicit with task instructions and must be performed for successful completion of the task, while strategies are not specified in the task,

but may or may not be used by the subject, and may or may not be helpful.

Storing, searching and retrieval operations involving ITM or LTM point to individual differences in the efficiency of such storage, rate of search, and success of search (usually based on the contents of the memory being searched). Timed tests however, produce scores that are primarily a function of the rate of search and also of individual search strategies. Provision is also made for individual differences in the speed of writing the response, which may or may not affect measurement. A special strategy that may apply is image formation of some item in STM in order to help search. Individual differences appear in "capacity and predisposition to form such images" (Carroll, 1974, p.33).

The implications of such a scheme suggest that cognitive tasks are complex, involving different memories and control processes, and that there is much difficulty with identifying all the factors of individual differences by using group individual tests.

Based on his findings, Carroll refers to the impossibility of constructing a "structure of intellect" model (Carroll, 1974, p.34) because there are too many factors involved in each cell of classification. But since many types of psychometric tests are cognitive tasks that lead to individual differences, we should be concerned with studying these differences which will help us understand how these differences develop and will add to our knowledge

of the underlying cognitive processes.

Application of Carroll's Framework to the SST

According to the Carroll scheme the Coding task (SST) is identified in terms of general headings such as Stimulus Materials, Overt Response to be Made, Task Structure, Operations and Strategies and Individual Differences. (See Appendix, Table 1 for Carroll's complete Coding Scheme.) The task is a one stimulus class which is complete and unambiguous. It involves STM. Its contents are visual operations, reproducing digit symbols by means of lines and curves. In STM individual differences associated with this task include temporal aspects of the operation (time taken for search), capacity of the system and visual search for specified items. The subject is required to select a response from presented alternatives by producing a single symbol. Each item is completed on a single occasion and the subject is required to move on to the next item quickly. Operations and strategies include identifying, recognizing and interpreting the stimulus, which is the printed digit. Strategies that may develop but are not necessary to the completion of the item include the storage of the item in memory, retrieval of associations from memory, adoption of rehearsals, development of a special search strategy (e.g., holding each stimulus in STM and searching the key for the possible solution). This operation is not specified or implied in the instructions and may be of dubious advantage to the individual. Short term

memory and possibly ITM in successive trials are involved in this operation. Contents may involve nonverbal semantics, digit symbols with meanings and recognizing visual shapes. Wide individual differences are likely and may or may not be beneficial to all. Temporal aspects of the operation or strategy require very short duration searching and writing. Large individual differences are probable here as well. The operation terminates upon arrival at a recognizably correct solution.

Characterizations of the factors involved in the process point to some individual differences. Spatial scanning requires that the subject address sensory buffers to make a visual search of the items; both temporal parameters and capacity of STM and the visual sensory buffer are involved. Individual differences may be developed in strategy formation, which may or may not be helpful. Perceptual speed involves temporal parameters of a visual search for specified elements and is another source of individual differences. Memory span involves storage and retrieval of information in STM. Individual differences arise through the capacity of STM. Strategies or chunking or grouping stimulus elements may or may not be beneficial.

The Task

To explore the questions that have arisen out of the literature a task was devised to include the independent variables of high and low verbal ability, previous practice, load on STM and repeated measures, in one experimental

design. Interaction of the above independent variables would give rise to other questions such as: 1) Does being given practice on a task make any difference if one is also either high or low verbal? 2) Does the size of the load on STM make any difference if one receives practice on the task beforehand or not? 3) Does the load on STM produce performance differences depending on whether one is high or low verbal? 4) Does learning over trials differ if a) one is high or low verbal, b) one has had previous practice or not, c) there is a larger load on STM or d) any combination of a,b, or c?

What kind of an experiment could be devised to observe these five effects? Mention has already been made of a perceptual task in common use today within the traditional psychometric test known as the WISC, that of Coding. It has also been shown that it is a task which can be subjected to Carroll's analysis. If we took subjects , divided them into high and low verbal, further divided them randomly into a practice and a nonpractice group within each verbal area, arranged the code into three categories of five, seven and nine digits, and gave them three successive trials on the task we would have incorporated four of these effects. The development would look somewhat like the following (see Figure 3).

The fifth effect (differential strategy teaching) could be dealt with as a second smaller experiment using slow learners, giving one group a devised strategy practice on

the actual task while the other group receives a random practice on the task. Load on memory would presumably be the same as in the first task: five, seven or nine digits. The effect of repeated measures is again tested by the use of three successive trials of two minutes each. The development of the experiment would appear as follows (see Figure 4).

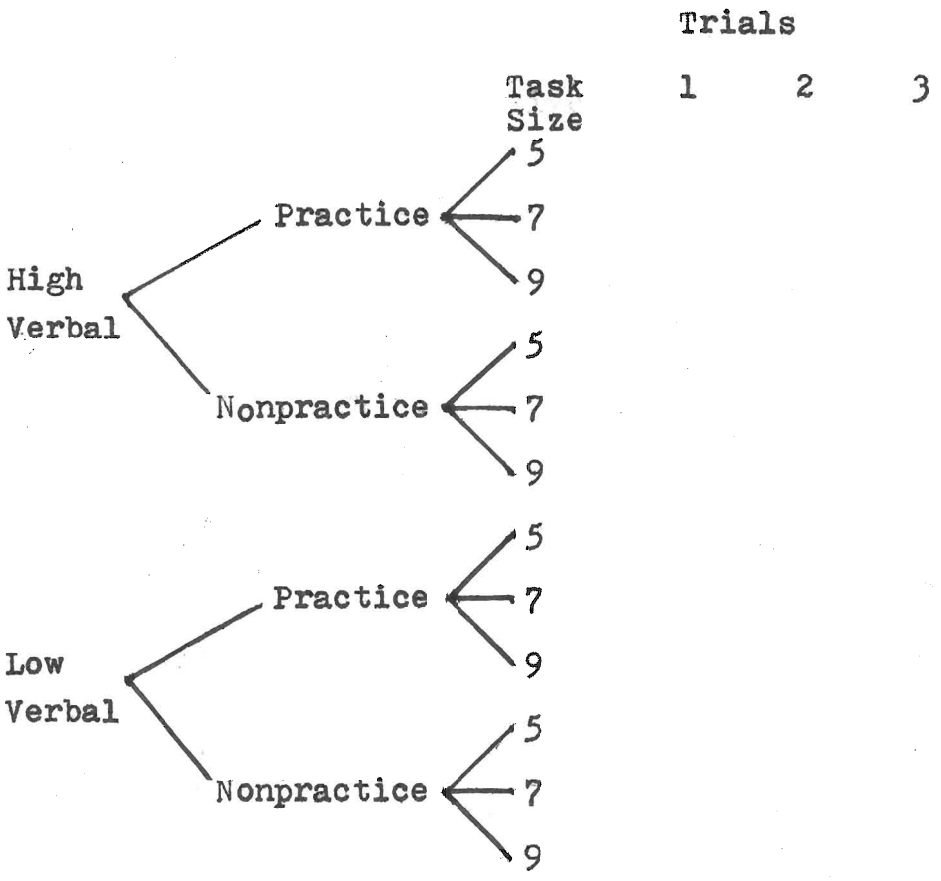


Fig. 3. Schematic Diagram of Main Experiment

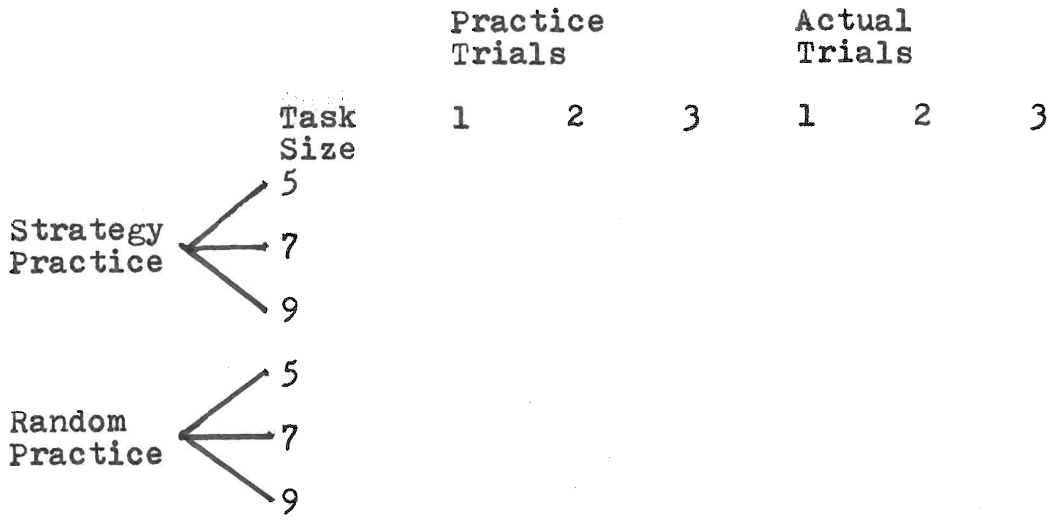


Fig. 4. Schematic diagram of the second experiment.

The Experiment

It was hypothesized that, based on Hunt's information, those who are high verbal should be able to do better than those who are low verbal. That is, the high verbals would be able to do significantly more items on the SST than low verbals (from Hunt and Lansman). To test this hypothesis a digit symbol substitution test was administered to two homogeneous groups of subjects, consisting of 30 boys and 30 girls presently in grades seven and eight from the same school. They were randomly assigned to each treatment after they had been categorized as high and low verbal (30 in each group) according to independent estimates submitted by their Language Arts teachers. In order for a subject to be rated as high verbal, four out of six standards had to be met; less than four rated them as low verbal. Standards used for this rating were provided the teachers by the experimenter and are shown in Table 1. A Mill Hill vocabulary test was

administered as a further check of teacher estimates as to whether subjects were high or low verbal. In one case it was found that teacher estimates did not agree with the results of the Mill Hill. This subject, who scored high on the Mill Hill, was shifted to the high verbal category while the vacancy created in the low verbal category was filled by another candidate from among those not previously chosen.

TABLE 1

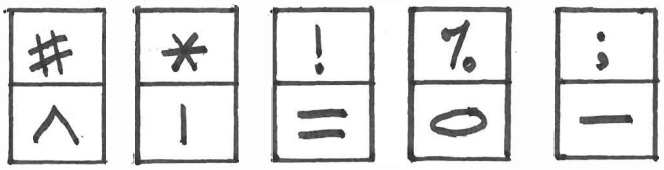
Verbal Attributes For Teacher Estimates

Of High And Low Verbal Ability

High Verbal	Low Verbal
1. Extensive Vocabulary	1. Limited Vocabulary
2. Writes and Speaks Fluently	2. Not Fluent in Speaking and Writing
3. Seems to Punctuate Naturally	3. Difficulty with Punctuation
4. Makes Few Spelling Mistakes	4. Spells with Difficulty
5. Fast Reading Rate	5. Slow Reading Rate
6. Good Comprehension	6. Poor Comprehension

The second hypothesis was that those who received previous practice on the task should do better than those who had no previous practice, if "strategy" transfer occurred. In other words having previous practice on a task, where the elements of transfer are identified, increases the amount of output on a similar task. This hypothesis arises out of the work done by Ferguson and Carroll. To test this hypothesis the high verbal group was randomly divided into two

sub groups of 15 each (groups I and II). Similarly the low verbal group was divided into two sub groups of 15 each (groups III and IV). Groups I and III were given practice on the task while groups II and IV were not given this practice. The test being used for practice sessions contained no items that would be similar to the test used in the actual task. In this way there could be some control over transfer. No symbols or substitutions could be learned and carried over from the practice task to the actual task. If these subjects benefited from the practice test, the benefit must be attributable to something inherent to the task or within themselves rather than to the actual symbols or their subsequent substitutions. No attempt to define what these in-subject attributes are called is made. We are not in a position to say nor can we say if it develops in all individuals. A sample of the practice test is shown in Figure 5 and a sample of the actual task is shown in Figure 6.



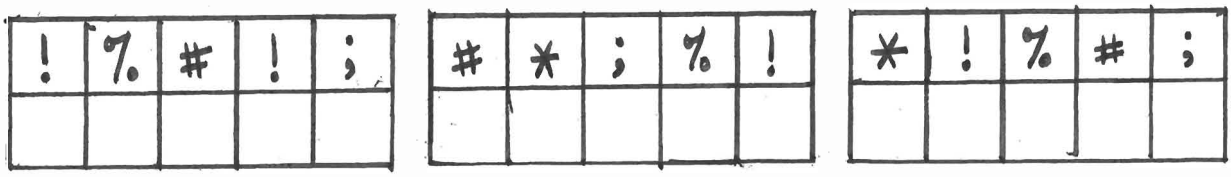


Fig. 5. Sample of the practice task.

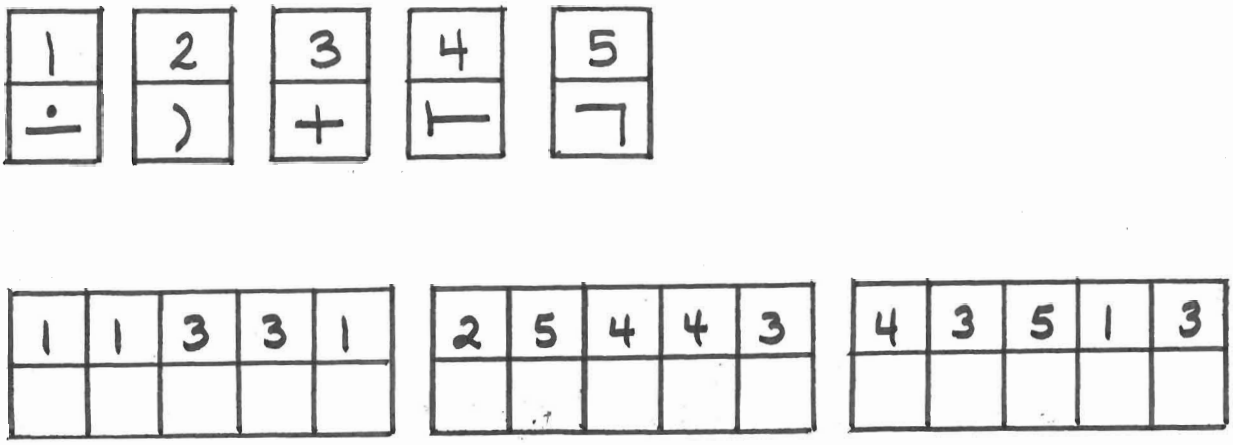


Fig. 6. Sample of the actual task.

It was hypothesized that those subjects working on a five digit code would do better than those working on a seven digit code, who would, in turn, exceed the levels of those working on a nine digit code. In other words, there should be a substantial decrease in the amount of output as the load on STM is increased. This follows from the work done by Miller. To test this hypothosis five subjects within each of groups I, II, III, IV were randomly assigned to process a five, seven, or nine digit code, consistently, throughout both practice and actual tests. For example, five persons of high verbal ability, assigned to the practice group, would work on a five digit code throughout both practice sessions and actual test situations. Similarly, five people in each of the other three groups worked on a seven and nine digit code throughout the experiment. Some received the practice effect while others did not, as previously explained.

It was hypothesized that there should be an increase in the amount of work done in each successive trial. That is, the repeated measures effect would produce an increase in output over trials, showing that the skill involved was reaching a "crude level of stability" with overlearning (after Ferguson, 1954,56). To test this hypothesis further treatment was provided by a repeated measures effect. In both the practice and actual test situations, subjects were given three successive trials, each of two minute duration. Each successive trial was followed by a short rest during which subjects were encouraged by the experimenter to keep trying their very best and if possible, better their last performance. There was a short rest between the practice tests and the real tests while booklets were collected and new ones distributed.

During the test, the code on which each candidate was working was clearly visible at the top of each page within their booklet. The booklets contained several pages of randomly generated numbers (from tables of random numbers) in sufficient quantity so that no matter how quickly the subject worked they would not run out of items to be done. The items were arranged in blocks of five (see Figures 5 and 6) only for ease of scoring later.

The subjects were seated in a large room and in such a way so that no one was seated next to another person working on an identical code. The group receiving the

practice effect was called at a different time than the nonpractice group. The task was explained to the subjects by the experimenter, who encouraged them to work as quickly as possible across the page from left to right starting at the top, filling in each square with its appropriate symbol as indicated at the top of their page. On a signal from the experimenter, subjects were instructed to proceed. At the end of two minutes they were told to stop. A brief rest was given while the experimenter encouraged them to look at how much they had done and to see if on the next trial they could beat their previous score. The practice group therefore, was administered three trials on the practice code and then, after a pause, three further trials on the actual test code were administered. The nonpractice group simply received three successive trials on the actual test code. As a further check to the possible learning of the task, each subject in both groups was required to reproduce his particular code, from memory, on the back of the test booklet, immediately upon completion of the final trial. The results were tabulated using a four-way analysis of variance. These are tabulated in Table 2.

TABLE 2

Analysis of Variance Between

Verbal, Trials, Practice and Code Effects

According to Number of Correct Responses *

	Source	SS	Df	MS	F	
1.	Between Subj.	24767.25	59	-------	------	
2.	A	572.45	1	572.45	1.60	
3.	C	2240.14	1	2240.14	6.28	+
4.	D	3236.41	2	1618.21	4.54	+
5.	AC	601.34	1	601.34	1.69	
6.	AD	394.42	2	197.21	----	
7.	CD	468.86	2	234.43	----	
8.	ACD	126.61	2	63.31	----	
9.	Subj w groups	17127.02	48	356.81		
10.	Within Subj	11071.48	120			
11.	B	6819.41	2	3409.71	123.81	+
12.	AB	291.89	2	145.95	5.30	+
13.	BC	503.21	2	251.61	9.14	+
14.	BD	626.56	4	156.64	5.69	+
15.	ABC	37.91	2	18.96	-----	
16.	ABD	21.49	4	5.37	-----	
17.	BCD	67.64	4	16.91	-----	
18.	ABCD	59.59	4	14.90	-----	
19.	Bx Subj w groups	2643.78	96	27.54		
20.	Total	35838.73	179			

+ Significant at .01 level

* I am grateful to Dr. Crane who verified this analysis by computer.

Key to Symbols: A- High/Low Verbal B- Trials
C- Practice/Nonpractice D- Code Size

CHAPTER III

Results of the First Experiment

Results

Upon inspection of Table 2 it is readily seen that the "A" condition (being high or low verbal) was not significant in producing differences by itself. The "C" factor (having previous practice or not) was significant at the .01 level suggesting that learning was different for those who received previous practice than it was for those who did not. The "D" variable (size of the code) also proved significant at the .01 level. As the size of the task was increased, so output of the subjects decreased. Learning was different for those who received a five digit code than it was for those with a seven digit code and their learning was different from those working on nine digits. Trials (B) was highly significant at the .01 level as was the interaction of trials with the other conditions of verbal, previous practice and code size. All other interactions proved nonsignificant. This is more readily seen upon inspection of the tables of means and their related graphs (see Table 4, and Figures 7,8,9,10).

Table 3 is a statement of the hypotheses tested by the first experiment and also shows whether or not they were accepted by the results of the analysis and to what level of significance. As seen the first hypothesis was rejected and the other three were accepted at the .01 level of significance.

TABLE 3

Hypotheses Accepted or Rejected

Hypotheses	Accepted or Rejected	Level of Significance
1. High verbals should be able to do significantly more items on the SST than low verbals.	No	---
2. Having previous practice increases the amount of output on a similar task.	Yes	.01
3. There would be a substantial decrease in the amount of output as the load on STM is increased.	Yes	.01
4. Repeated measures would produce an increase in output over trials.	Yes	.01

TABLE 4

Overall Means for High and Low Verbal, Practice/Nonpractice, Trials and Code Size *

Condition	Mean
High Verbal	31.82
Low Verbal	28.25
Practice	33.57
Nonpractice	26.51
Trial 1	21.40
Trial 2	33.43
Trial 3	35.28
Code 5	34.85
Code 7	30.73
Code 9	24.53

*Means should be read with a constant of +40. This applies to all mean values in this study.

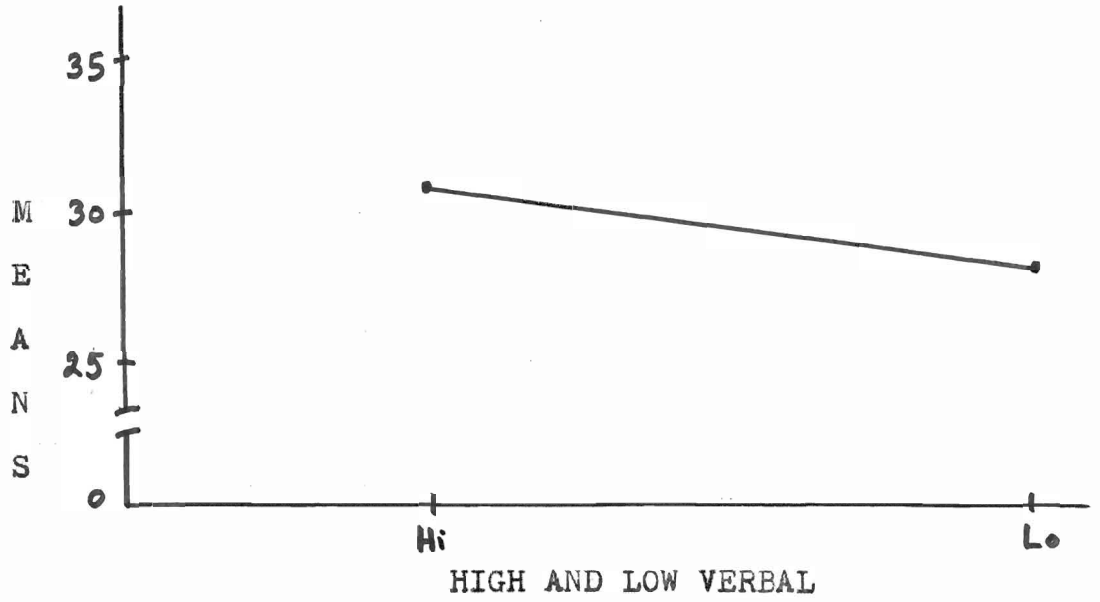


Fig. 7. Overall means of high and low verbal effects, based on number of correct responses.

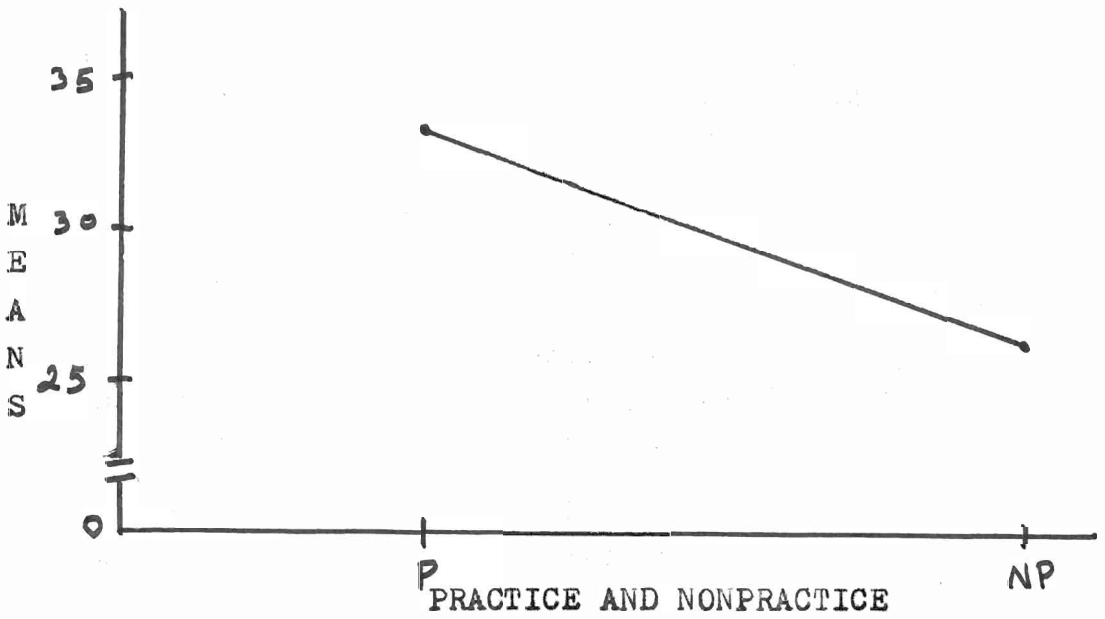


Fig. 8. Overall means of practice and nonpractice effects, based on number of correct responses.

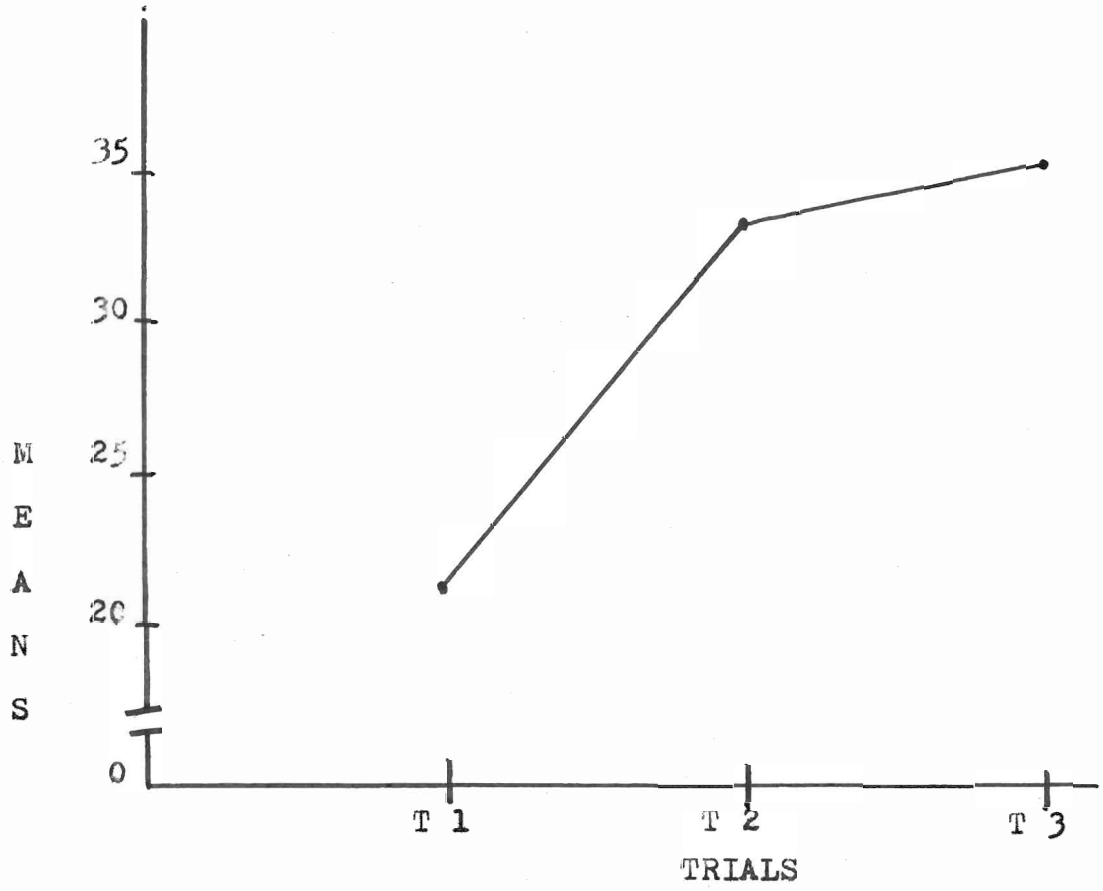


Fig. 9. Overall means of trials effect based on number of correct responses.

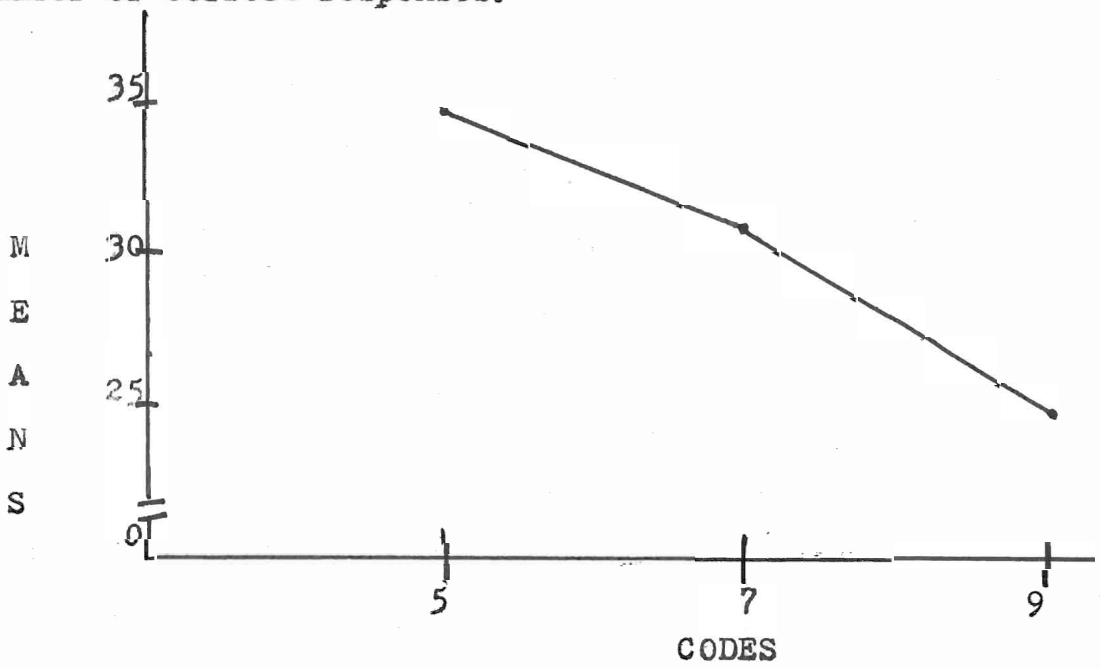


Fig. 10. Overall means of codes based on number of correct responses.

Second order effects were not significant for the interaction of high and low verbal with previous practice. While being high or low verbal did not make any difference by itself, it does make a difference in a learning context. This finding is concurrent with Ferguson's framework of learning and ability in that:

> "Learning itself is viewed as a process whereby the abilities of man become differentiated, this process at any stage being facilitated by the abilities already possessed by the individual."
> (Ferguson, 1956, p.182)

It would appear that high verbals learned more from the trials than did low verbals. Inspection of Table 5 and Figure 11 showing the interaction of high and low verbal conditions and trials shows that high verbals never reached their limit while low verbals reached asymptote after the second trial, although initial levels were not that different.

TABLE 5

Means of High and Low Verbal, Practice/Nonpractice and Code Size Over Trials

Condition	T 1	T 2	T 3	(Means)
High Verbal	22.23	34.47	38.87	
Low Verbal	20.57	32.50	31.70	
Practice	26.37	37.87	36.47	
Nonpractice	16.43	29.00	34.10	
Code 5	26.55	37.45	40.55	
Code 7	18.80	35.70	37.70	
Code 9	18.85	27.15	27.60	

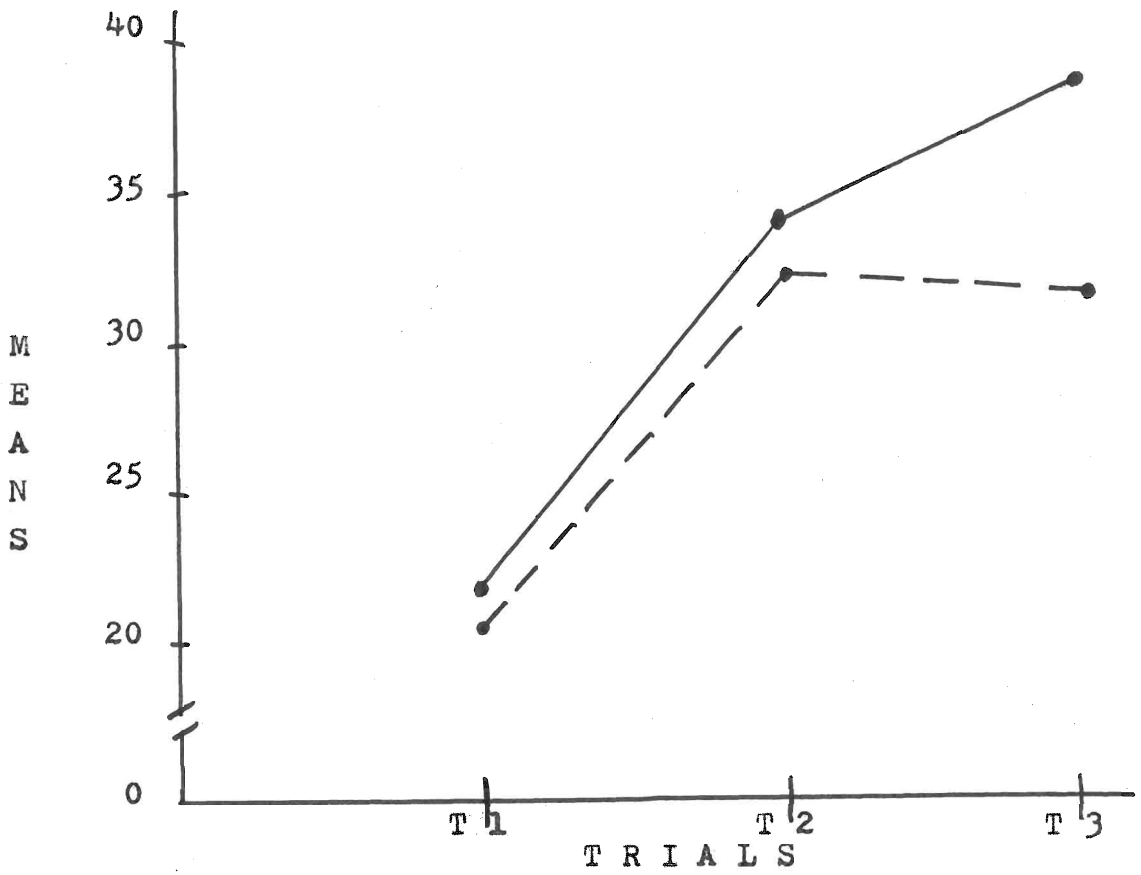


Fig. 11. Means comparing high and low verbal correct responses over trials: ____ for high verbals; _ _ _ for low verbals.

The interaction of the previous practice condition with the trials variable also produced a significant effect. It is seen that those who received the practice treatment reached maximum output after the second trial while those who did not receive practice were still learning after the third trial (see Figure 12). It would appear that although practice made a difference at the beginning, the effect of trials was to overcome the effect of practice and by the third trial, both groups were almost equal.

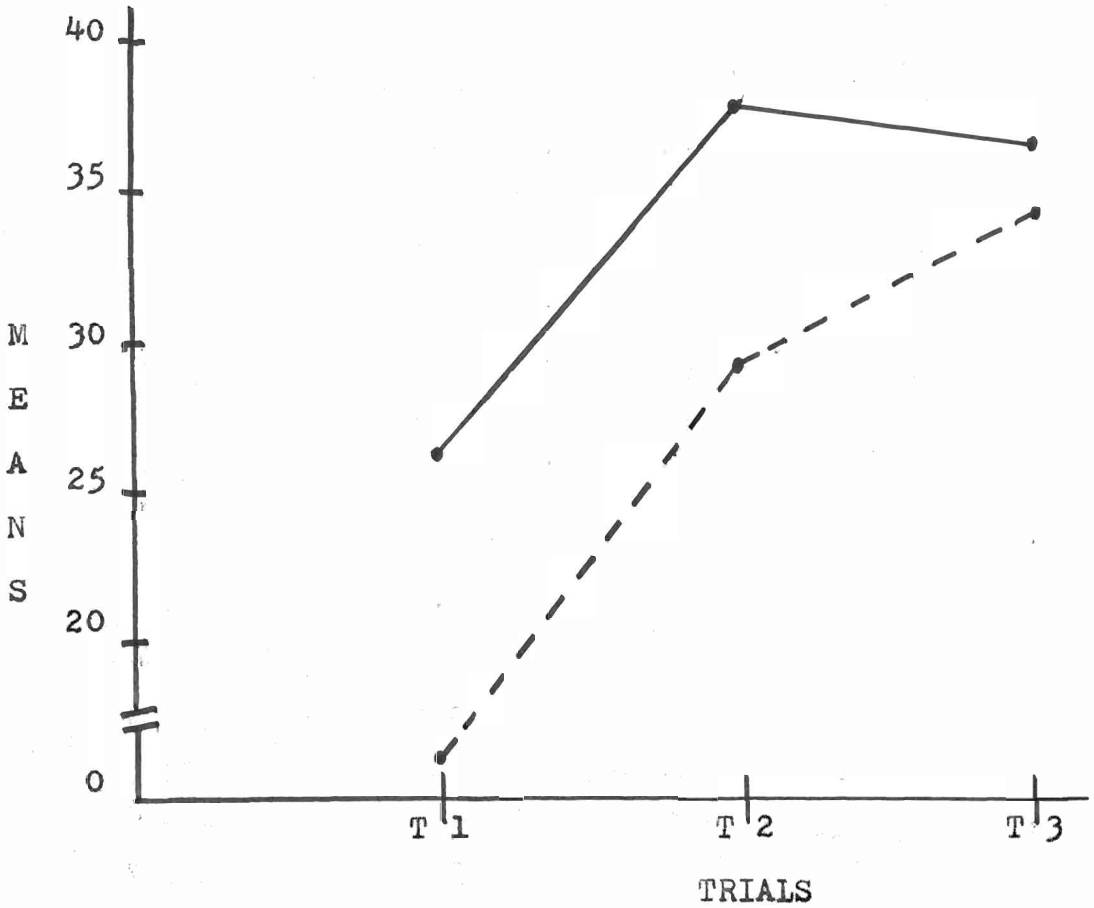


Fig. 12. Means comparing effect of practice and nonpractice correct responses over trials: _____ for practice; _ _ _ for nonpractice.

When code size interacted with the trials effect, a difference again was noted. However, the largest difference is seen when the load is increased to nine digits. There is very little difference in output between the five and seven digit groups over trials (Mean 5=40.55 vs Mean 7= 37.45) in comparison to the level of output of the nine digit group (Mean = 27.60) by the third trial (see Figure 13).

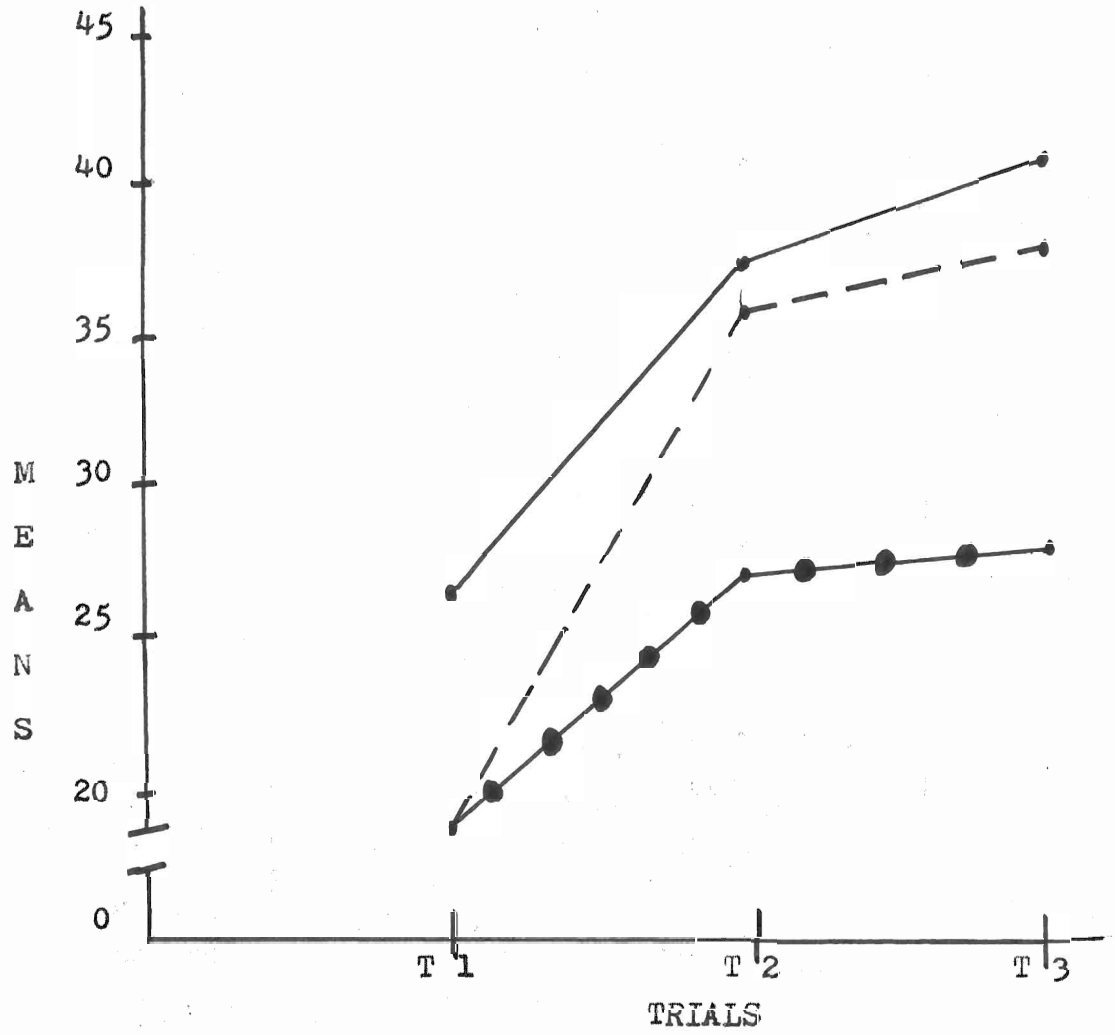


Fig. 13. Means comparing the effect of the size of the code with trials for correct responses: _____ for Code 5; _ _ _ for Code 7; _●_ for Code 9.

While the overall verbal and code size interaction effect was insignificant, inspection of Figure 14 seems to reveal a trend. Further research may be needed to establish the tendency for the differences between high and low verbal groups to be most favored at the five digit task, and least favored for the nine digit task. This agrees with Miller's findings that performance is severely limited as the

information processing load goes beyond the magic number seven.

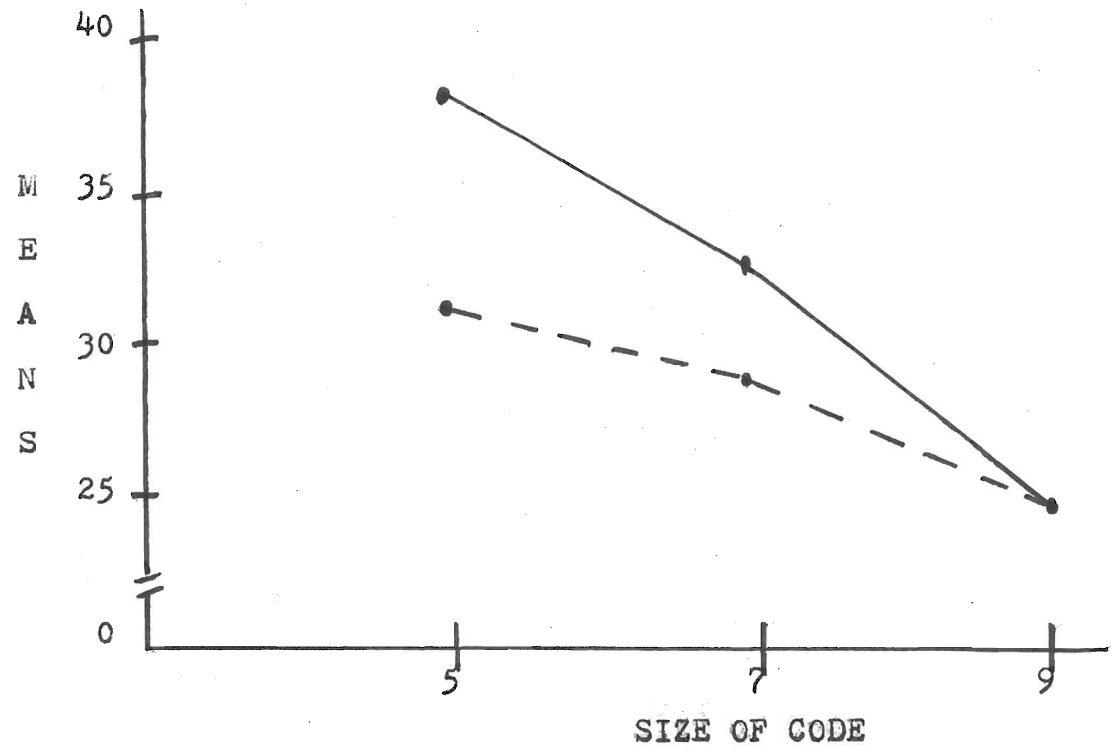


Fig. 14. Means comparing high and low verbal with size of code for correct responses: _____ for high verbal; _ _ _ for low verbal.

Upon examination of the interaction of the practice effect with the code size in searching for further trends, it appears that the practice effect makes a difference initially (Practice mean = 40.53 vs Nonpractice mean = 29.17) but the difference is diminished as load on STM is increased (Code 9 Practice mean = 27.63 vs Code 9 Nonpractice mean = 21.43). Inspection of Figure 15 makes this clearer. However, more research is needed to clarify or substantiate this trend.

While no third order interactions were significant,

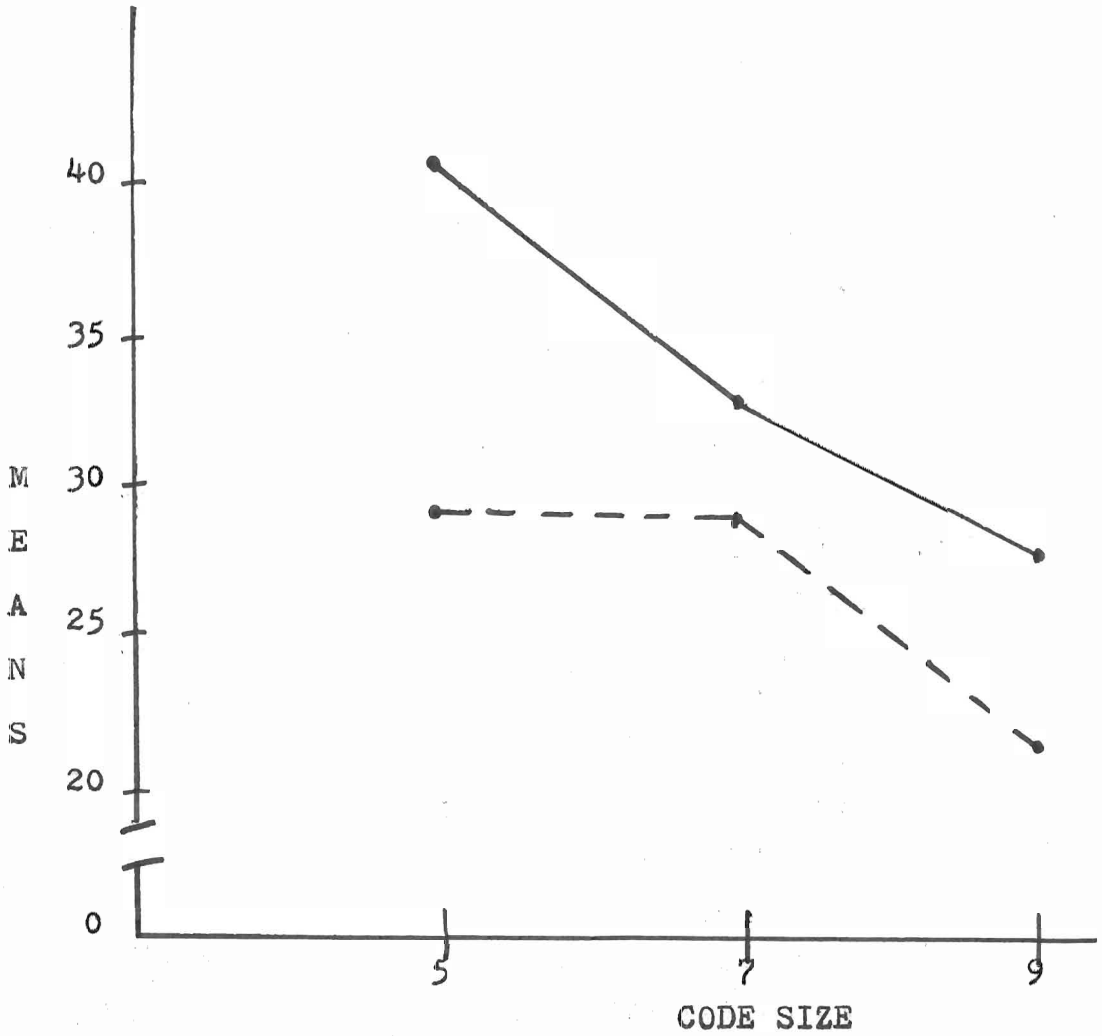


Fig. 15. Means comparing the effect of practice and nonpractice with the size of the code for correct responses: _____ for practice; _ _ _ for nonpractice.

inspection of Figure 16 shows trends that might bear investigation. It would appear that being high verbal and receiving previous practice is advantageous to learning. This agrees with some of Hunt's findings. Initial gains are very large for the high verbals who received previous practice on the smaller code size (Mean = 46.67) but the larger code size would appear to have placed severe limita-

tions on learning (Mean = 29.73). This is parallel with previous theories presented by Miller and Hunt.

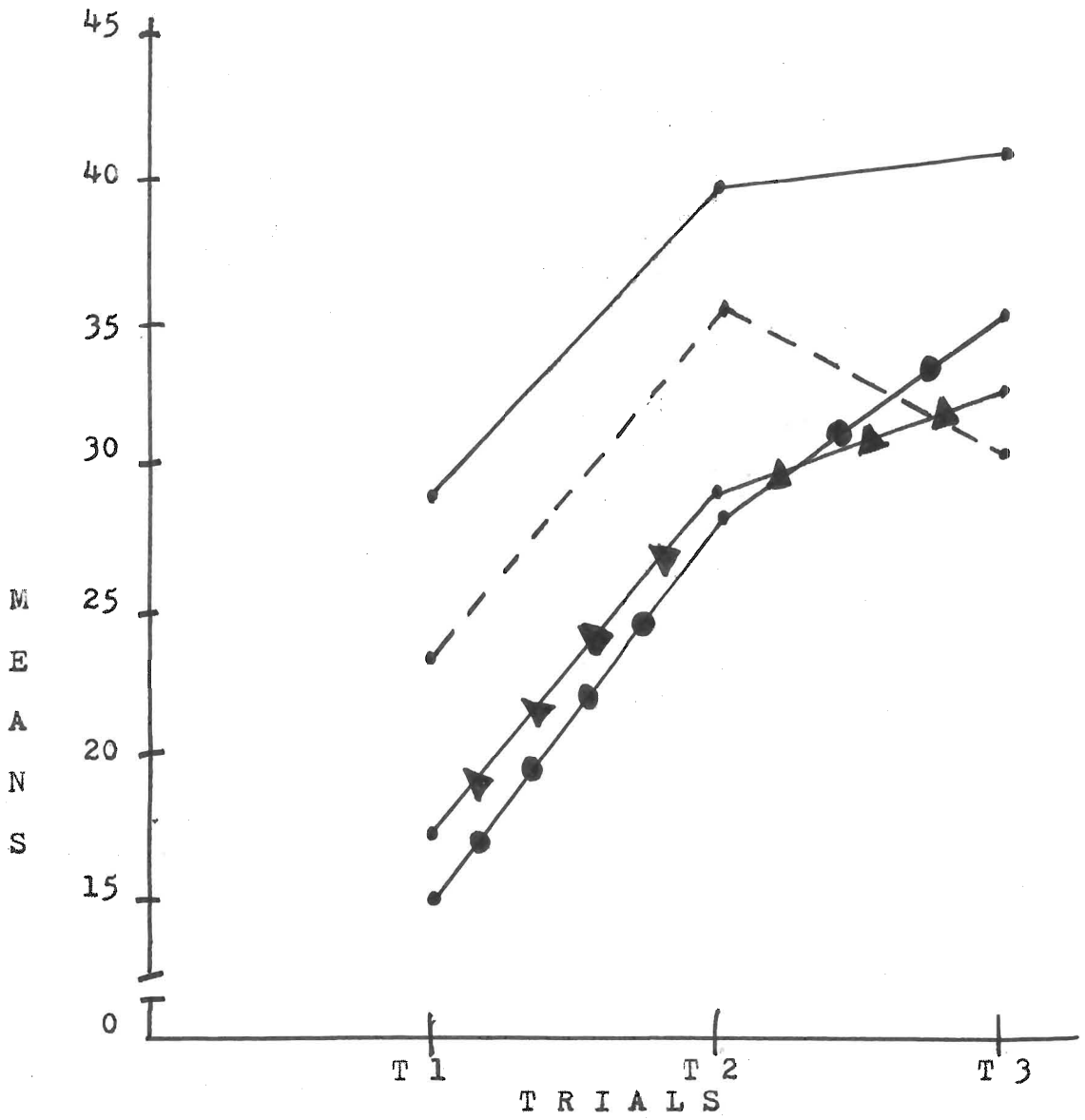


Fig. 16. Means comparing effect of high and low verbal with practice/nonpractice and with trials for correct responses: ____ for high verbal practice; _ _ _ for low verbal practice; —●— for high verbal nonpractice; —▲— for low verbal nonpractice.

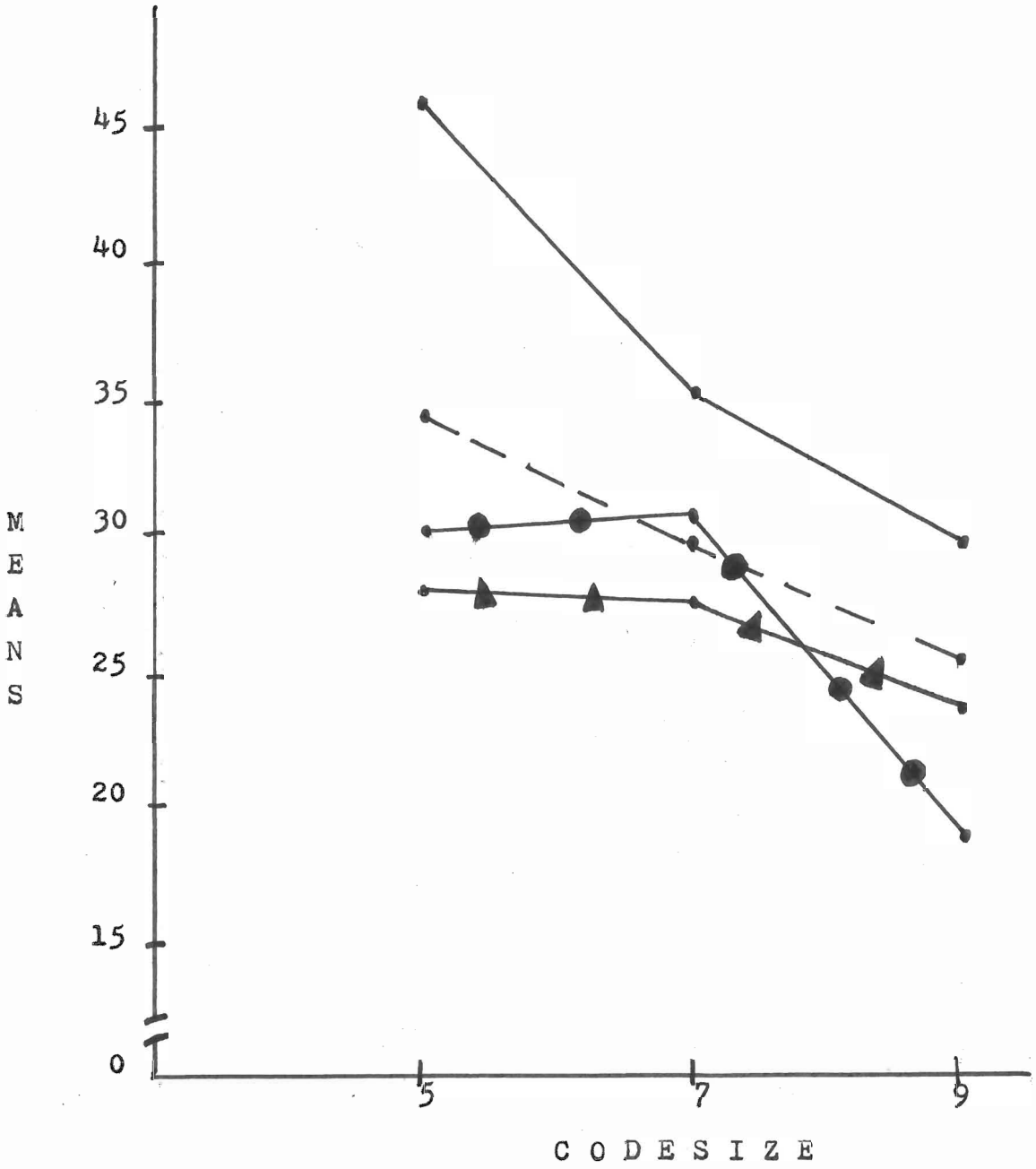


Fig. 17. Means comparing the effect of high and low verbal with practice/nonpractice and with size of code for correct responses: _____ for high verbal practice; _ _ _ for low verbal practice; —●— for high verbal nonpractice; —▲— for low verbal nonpractice.

Further trends are seen from examination of Figures 18 and 19. While not significant, being high verbal and working on a five digit code through several trials produced the best conditions for optimum output (Mean = 45.30 by third trial). Learning curves show that being high verbal, however, does not give an advantage when the load is increased to nine digits as seen before. When comparing trials effect with code size and practice it was found that receiving practice on five digits was the most advantageous condition. Again it was seen that the nine symbol task produced the lowest results over trials.

As previously seen from Carroll's analysis of the coding task, individual differences can be accounted for in several dimensions. It is suggested that individual differences may lie in the ability to develop strategies to store the item in memory, search the memory for possible answers, retrieve associations from memory, adopt necessary rehearsals for holding items in STM. This is one source of individual differences and confounding this is the suggestion that adoption of these strategies may be of benefit to some while they might not be for others. It is suggested that high verbals might benefit from or readily adopt strategy measures (Hunt). If this were true, there should have been a difference in the overall performance between the effect of high and low verbals. That there was no such difference, suggests that while some subjects in each group may have developed these strategies, there were others who

did not.

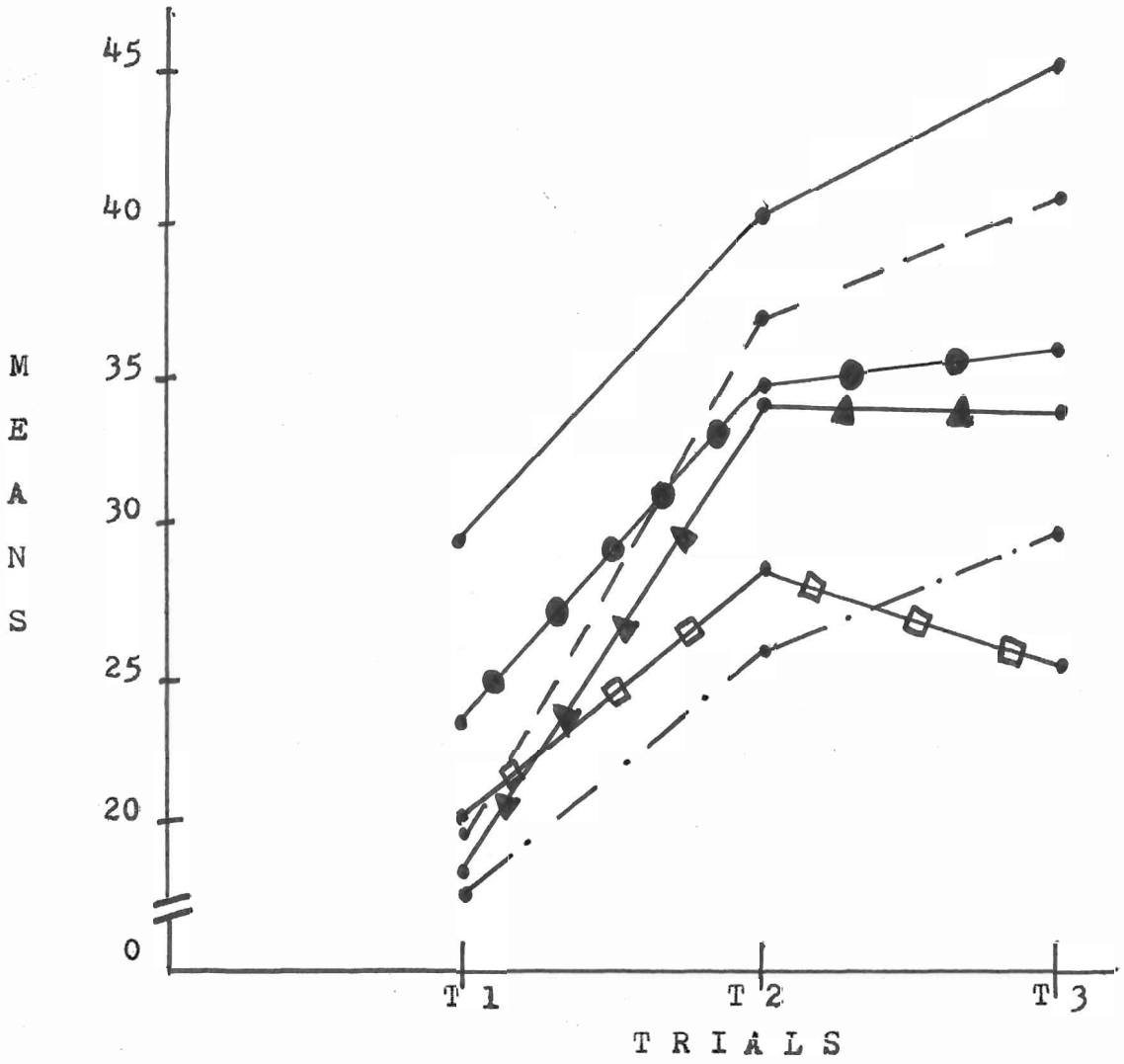


Fig. 18. Means comparing the effect of high and low verbal with the size of the code and with trials for correct responses: ____ for high verbal code 5; _ _ _ for high verbal code 7; __ . __ . for high verbal code 9; ___●___ for low verbal code 5; ___▲___ for low verbal code 7; ___⊟___ for low verbal code 9.

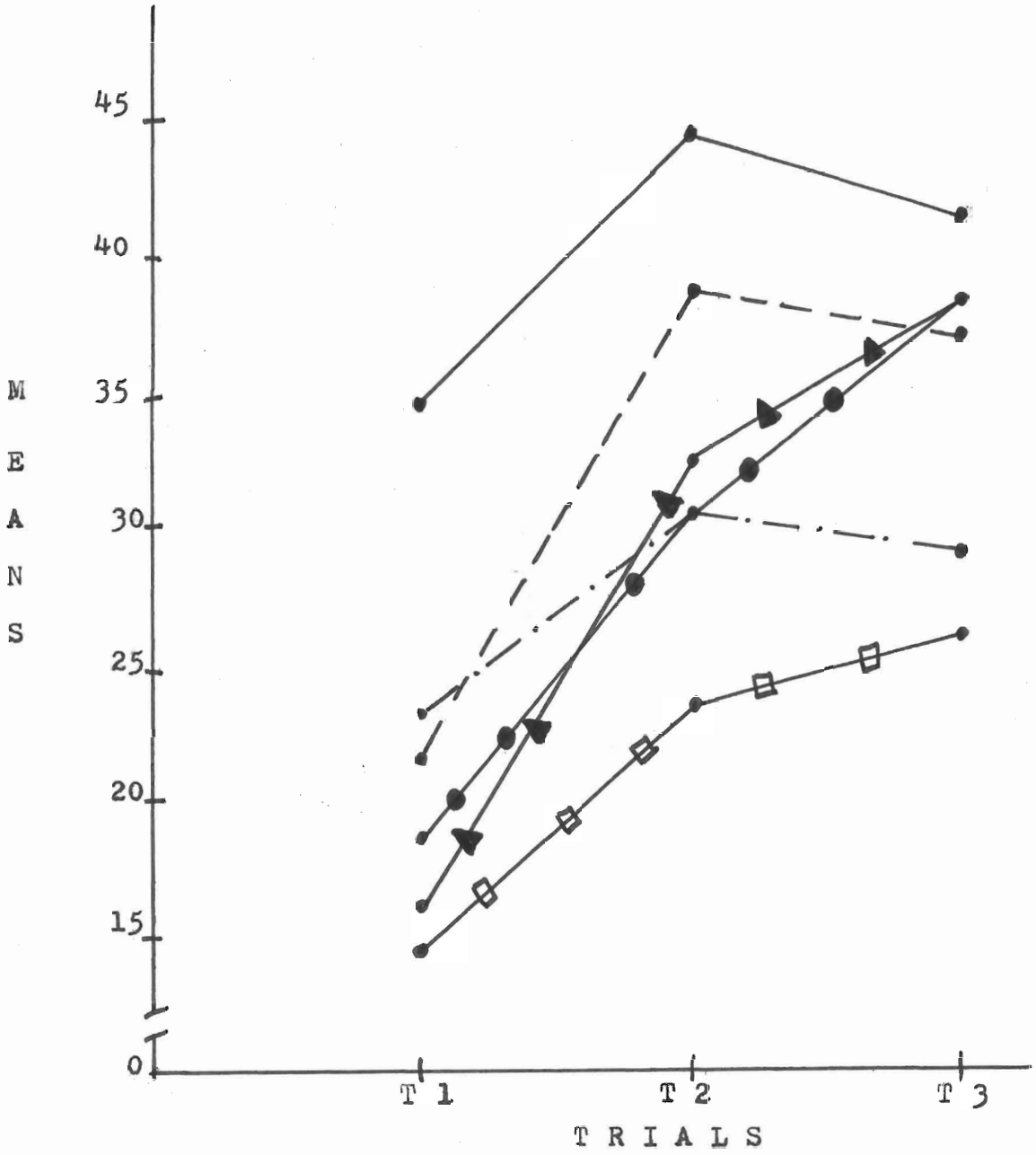


Fig. 19. Means comparing the effect of practice/non-practice with the size of the code and with trials, for correct responses: ____ for practice, code 5; _ _ _ for practice, code 7; __.__. for practice, code 9; —●— for non-practice, code 5; —▲— for nonpractice, code 7; and —⊟— for nonpractice, code 9.

Temporal aspects are a source of individual differences as well. Hunt has suggested that high verbals scored faster in code access time than low verbals. As we have seen this may not always be the case. By itself being high verbal was not important. When interacting with other variables a difference was seen. The fact that high verbals made large gains over the first two trials may be accounted for by individual differences in the time taken to carry out the task. They succeeded quickly in reaching maximum output while low verbals climbed at a slower rate and were still learning after the third trial.

Capacity of STM is another parameter involving individual differences and may account for some of the variance seen in our measures. While Hunt has stated that high verbals were able to recall more from STM, there may be differences in size of STM as seen among individuals. This might account for the poor main effect of high and low verbal. The other confounding variable is the size of the SST, imposing restrictions on STM.

Perceptual speed is also pointed to as a source of variance. If one of the strategies was to commit the symbols to memory (also referred to as isomorphic strategy), the time taken to search the memory for the correct response, as well as the time taken to recognize the stimulus, may account for differences. If the subjects did not use a "memory" strategy at all, that is did not commit any of the symbols to memory, but instead used a perceptual-speed

strategy of remembering the single SST task (9 = ⊣) and then searched the array of alternatives at the top of the page for the correct symbol, then that might actually be a very effective strategy for smaller SST arrays (five digits) than it might be for larger SST arrays (nine digits). We see two sources of individual strategies: one attempts to learn the symbols (isomorphic) and the other attempts to search the task array (also referred to as iconic search). Individual differences can then be also accounted for in the development of individual strategies. This may not necessarily apply to high or low verbals as such but may reflect previous learning patterns (Ferguson's theory of transfer).

When comparing groups for possible strategies it will be remembered that upon completion of the task the subjects were instructed to reproduce their particular code from memory on the reverse of their test booklets. Inspection of their reproduced codes might yield us further information as to who might have used an isomorphic rather than an iconic search. If subjects remembered all of the code, they might have used the isomorphic strategy rather than the iconic one but this does not necessarily imply actual adoption. What it does tell us is that, because they could reproduce the code from memory, there is cause to believe that they had committed the code to memory and therefore could have used the isomorphic strategy. On the other hand, if the subject could reproduce only part of the code, this

suggests that possibly they could have used partly isomorphic strategy for the remembered items and partly iconic strategy for the remainder of the items. The other possibility arises that if subjects could remember very few code items, they might have used an iconic strategy, having committed too few items to memory for isomorphic search. Inspection of Table 6 reveals that the majority of subjects could reproduce their codes with accuracy, especially those working on the five and seven item codes. These are the ones who might have possibly used the isomorphic strategy.

TABLE 6

Number of Subjects Who Remembered Code Items, By Categories

Code	Few	Several	All
5	0	1	19
7	1	3	16
9	3	6	11

Key:

Few	Several
Code 5 (0-1 items)	Code 5 (2-4 items)
Code 7 (0-2 items)	Code 7 (3-6 items)
Code 9 (0-3 items)	Code 9 (4-8 items)

Very little difference exists between the practice and non-practice groups in this respect. A difference is noted, however, in the nine digit group. Barely more than half the group could remember their code accurately, suggesting that there is a greater chance that those working on the largest code had the least opportunity to use an isomorphic search. The possibility is greater that they might have used an

iconic strategy instead.

When a chi-square test is performed on the frequencies of individuals able or unable to recall the memory set perfectly and the frequencies by set size (five, seven, nine) the result is significant (6.16 with Yate's Correction). This means that the nine symbol set is a more severe learning task than the other two.

TABLE 7

Chi-square of Frequencies

Based on Subjects' Recall of Codes

Code	Some	All	Total
5&7	5	35	40
9	9	11	20
Total	14	46	60

We may also conclude that the memory set for the five and seven digit task can be accessed by nearly everyone. Hence, if the test becomes,for the subject, a memory task, it implies that STM be accessed for any digit-symbol pair (in the five and seven digit sets). Should this be found to happen during the third trial the results should show performance linked linearly with memory-subset size as in Sternberg's (1966,1969) item-recognition experiments. In these experiments a memory subset is accessed by a probe and the search time to correct (yes-no) response is a linear function of the size of the subset. When learning occurs, the SST could well be an analogue of the Sternberg item-

recognition task. If it is, we expect that, when a memory subset is accessed (as in the SST) the output will be a linear function of the size of the subset (see Figure 20). A second assumption is also made. If, as Sheperd and Metzler (1972) suggest, search time in access is what it is because the process is a kind of isomorph of what the organism would physically have to do in a situation where the memory code were unlearned (in the first trial), then the underlying linear relationship in access to memory subset should not be disturbed by those subjects who had, physically, to search the subset (in the nine digit set). If there were an isomorphic analogue between 'outside search' (iconic) and 'inside search' (isomorphic) the linear relationship would not necessarily be maintained in the nine item access task where over half the subjects could not totally use an access-isomorphic strategy for retrieval. When the analogue is confined to those subjects who recalled all nine of the subsets, in relation to the means for the five, seven or nine 'recall' categories, these form a linear relationship (see Figure 21).

The striking finding, indeed, is the clear evidence of linearity at all trial levels. Division of the total time per trial by number of items completed would, of course, give an access and response time per item. The resulting values are, by inspection, close to trends (for two member sets) reflected in a card sorting analogue of the Sternberg task reported by Rothstein (1974, p.74).

We now hypothesize that the SST fills the role of a complex learning task. By this we mean that sources of variance change probably in kind and in emphasis with learning. In the latter stages, set size is related in linear fashion to performance, suggesting that each new item learned becomes a probe in the learned memory subset. A solution to each item must also be located in STM and this time to solution does not apparently affect the linearity of the relationship. Further experimentation is needed to explore the possibility of these findings.

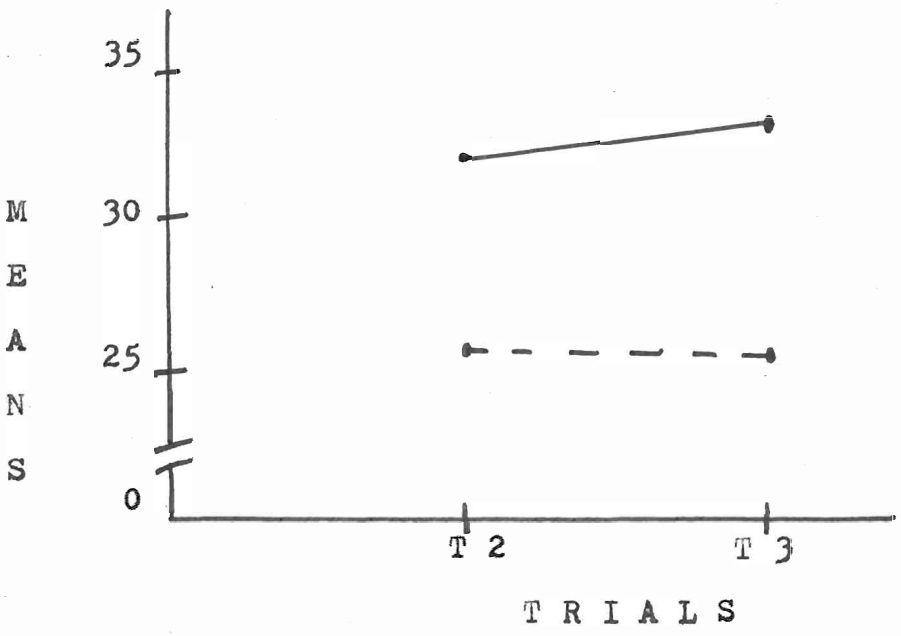


Fig. 20. Means comparing those within the nine code who said they remembered with those who did not remember; _____ for those who remembered all; _ _ _ _ for those who remembered some.

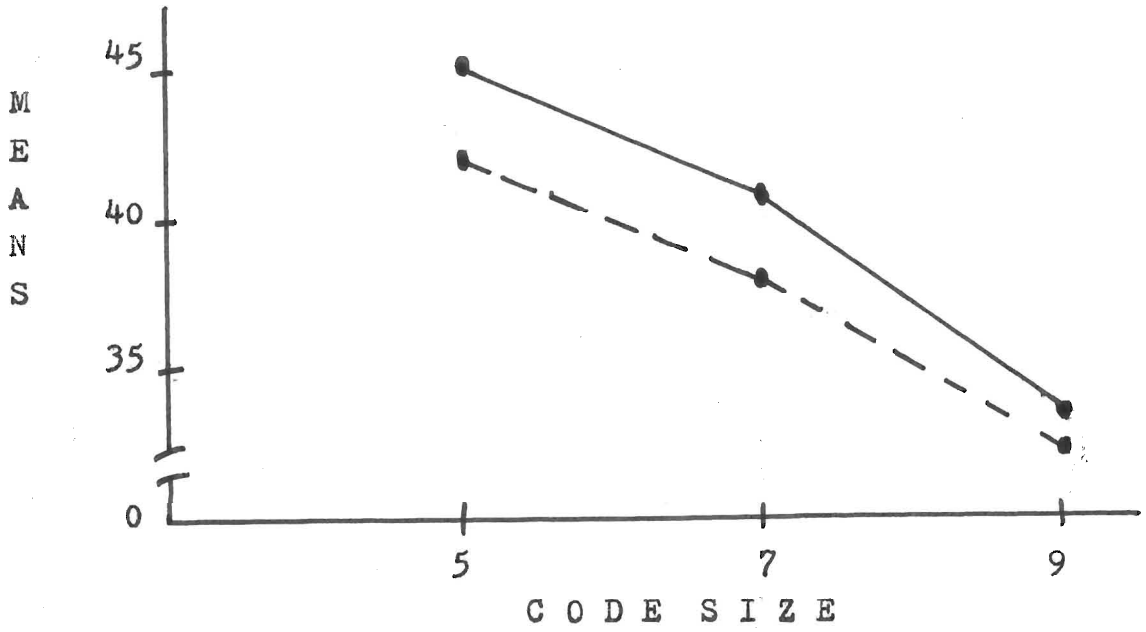


Fig. 21. Means comparing those who remembered their code with results on the second and third trials: ____ for trial 2; _ _ _ for trial 3.

Conclusions

The original hypotheses were substantiated except for that predicting the effect of being high or low verbal. It was hypothesized that those who were high verbal would score significanly above low verbals. However, it was seen that the condition of being high or low verbal did not by itself produce results in that direction. It was discovered that overall results for high and low verbals were almost identical. However, when the verbal effect was combined with other variables such as practice and repeated measures and load size, it was found that high verbals did possess an advantage, with the exception of the effect of increasing the load

on STM to nine digits. Therefore, while some of our data supports the original hypothesis, it also suggests that there is more involved. For instance, it might be possible that high verbals gain more originally from previous practice than do low verbals but that under conditions of increased load on STM this advantage is nullified. Over trial, high verbals with previous practice on the SST scored above high verbals with no previous practice but the learning curve is steeper for high verbals with no previous practice. They are learning at a faster rate. This, indeed, is what Ferguson predicts.

The second hypothesis, that previous practice on the SST should produce an advantage, was supported by the data. Both high and low verbals scored higher with previous practice than without. The effect of previous practice over trials showed support for the hypothesis as well, but interestingly enough, by the third trial the non-practice group had almost reached the same level as the practice group. This suggests that the repeated measures was successful in almost overcoming the practice effect pointing to the strength of repetition - a result which is not surprising to educators. When the interaction of previous practice and code size is considered, support for the hypothesis is seen. The previous practice group scored higher over all three load ranges, with the nine digit level producing the lowest scores. This offers evidence that even though previous practice

on the task does indeed enhance learning, if the load on STM is increased the effect of previous practice is diminished.

The third hypothesis was that output would decrease as the load on STM was increased. This hypothesis was supported by the findings. As shown, those on a five digit code produced higher results than did the seven digit group who in turn showed greater processing than the nine digit group. Comparing the effect of the interaction between code size and repeated trials, it was shown that learning curves were very similar, but the nine digit group was well below the others, and that the deficit increased especially by the third trial. This suggests that increasing the size of the load on STM may reduce the effects of repetition on current learning.

The fourth hypothesis, that the repeated measures effect would produce an increase in output levels over a series of trials, was also supported by our results. By itself, repetition showed increases over successive trials, with the sharpest increase occuring between the first two trials. Upon examination of the interaction of trials with verbal ability, this same pattern is seen; a sharp rise between trials one and two, although at different levels of performance for the high verbals than for the low verbals. Interestingly, the high verbals increased slightly more on the third trial while the low verbals seemed to have done all their learning by the second trial

and fell back slightly during the third trial, Hunt made the observation that high verbals have "more rapid coding processes" and that they have a better short term memory (Hunt, 1975, p.95 and 1975, p.206). The effect of interaction of trials with practice is seen again for both groups (at different levels) in the sharp rise between the first two trials. The practice group, however, appears to have done its learning at this point and regresses slightly on the third trial, while the non-practice group continues to progress. Upon inspection of the interaction of the trials effect with load on STM, the same conditions prevail; the sharp rise between first and second trials and a gradual increase on the third trial, except for the nine code group which does not change between second and third trials. This would suggest that the increase on STM has influenced the effect of the repeated measures variable such that the repetition is not strong enough to overcome the strain on memory. This agrees with Miller's findings that above the magic number seven severe limitations are placed on memory processes.

CHAPTER IV

Slow Learners' Experiment

Design

It will be remembered that at the outset two experiments were being incorporated into the design of this study. The first experiment dealt with students of normal learning ability who had first been categorized as high or low verbal on the basis of their Language Arts Teachers' estimates. The second experiment deals with the critical area of students with learning difficulties, the slow learners. As the WISC is primarily designed to seek out those with learning difficulties it was felt that this second experiment should of necessity be incorporated into the overall design, in the hopes that something substantial could be learned in the area of individual differences in this category as well.

In reviewing the current literature on the subject of slow learners, the study previously reported by Brown et al. gives rise to the question concerning the teaching of strategies to slow learners on a perceptual task. It will be recalled that as previously described on p.21, it was found that teaching actual methods of rehearsal strategies aided retardates in the performance of a task. The question raised here is whether teaching slow learners a strategy on a perceptual task, such as the SST, causes their learning to resemble that of so called "normals". In order to test this, it was hypothesized that teaching slow learners

a strategy would indeed improve their learning in such a way as to resemble "normals".

Following the original task structure, a symbol substitution task was administered to two groups of homogeneous groups of 18 slow learners. These people were part of the Special Education classes within the school and therefore already were defined as slow learners by the education system's Psychological Assessment Services. One group was designated to receive practice on a planned strategy of the actual task which was designed to help them learn the actual code to be used, while the other group received a random practice of the actual task. The actual strategy test is shown in the Appendices, Figure 3. The random task is similar to that used on the first experiment as in the Appendices, Figure 2. Three subjects within each group were randomly assigned to receive a five, seven or nine digit code, consistently, throughout both practice and actual tasks. The repeated measures effect was also incorporated into the design. During the practice trials, subjects were given three successive trials each of two minute durations. Again each trial was followed by a short rest during which subjects were encouraged by the experimenter to continue the task to the very best of their ability. There was a short rest between the practice session and the actual task while booklets were collected and fresh ones were distributed. Again subjects were seated so that no two people working on the same code were seated side by side.

The task was explained to the subjects who were encouraged to work as quickly as possible, filling in each square with the appropriate symbols as indicated at the top of their pages. On a signal from the experimenter, subjects were instructed to proceed. At the end of each two minute segment they were told to stop, allowed a short rest while receiving encouragement then were told to start again. The strategy group received three trials of planned practice then three trials of the actual random task. The non-strategy group received three trials of random practice then three trials of the actual random task. The results were tabulated using a three-way analysis of variance as shown in Table 8.

Results

The most meaningful result obtained was in relation to the size of the code. Again this relationship between load on STM and output is very significant. Also significant is the relationship of the trials effect to learning. As before in the first experiment, the repeated measures are having a meaningful effect on learning. The surprising result of this experiment was that the effect of the rehearsal strategy development was not significant. When comparing means showing the interaction between strategy/non-strategy and code size (see Table 10) it is found that the nonstrategy group means are slightly higher than the strategy group. Between strategy/nonstrategy and trials the same pattern persists (see Table 10). Inspection of this inter-

TABLE 8

Analysis of Variance Between

Strategy, Trials and Code Size

According to Number of Correct Responses *

Source	SS	Df	MS	F
1. Between Subj	13402.30	17		
2. A	93.35	1	93.35	
3. C	7089.82	2	3544.91	7.04 +
4. AC	174.03	2	87.02	
5. Subj w groups	6045.10	12	503.80	
6. Within subjects	6429.80	36		
7. B	1016.04	2	508.02	2.88 ++
8. AB	67.58	2	33.79	
9. BC	796.07	4	199.02	1.13
10. ABC	320.51	4	80.13	
11. Bx subj w groups	4229.60	24	176.23	
12. Total	19832.10	53		

+ Significant at .01 level

++ Significant at .05 level

* I am grateful to Dr. Irvine for verifying this analysis by hand.

Key to Symbols: A- Strategy/nonstrategy B- Trials
C- Code Size

TABLE 9

Overall Means for Variables of Strategy, Code Size and Trials for Correct Responses

Variable	Mean
Strategy	73.81
Nonstrategy	76.44
Code 5	79.67
Code 7	86.33
Code 9	59.39
Trial 1	69.11
Trial 2	79.17
Trial 3	77.11

TABLE 10

Means Comparing Effect of Code and Trials with Strategy/Nonstrategy for Correct Responses

Variable	Strategy	Nonstrategy
Code 5	80.89	78.44
Code 7	82.67	89.00
Code 9	56.89	61.89
Trial 1	68.44	69.78
Trial 2	78.78	79.56
Trial 3	74.22	80.00

action shows the results of increasing the load on STM as pointed out earlier by Miller. Very little difference is seen between the five and seven digit group, but the nine digit group shows a significant drop in performance, as was observed in the first experiment.

CHAPTER V

Discussion of the Experimental Findings

Both experiments have presented several interesting results. The largest single factor which influenced learning on the SST was the repeated measures variable. Clearly, practice does influence learning on the SST. Ferguson pointed to transfer as being important during the learning experience. Changes in the organism during the performance of a task can lead to a large number of other changes which can, in turn, affect performance. Fleishman showed that specific abilities become more important over practice, suggesting that they are functions of the task rather than of general abilities. Since the task was structured in such a way that nothing on the practice task could be transferred to the actual test, then it must be assumed that what is transferred are the strategies developed within the individual as he is performing the task. Just what these strategies are is unknown but one can speculate that there is some transfer of the pattern of information processing which the individual develops during the task. It could possibly be a method of looking at the item to be coded, referring to the array at the top of the page quickly, then writing in the answer and proceeding to the next item quickly (an iconic

process). The other possibility is an 'isomorphic' strategy in which the subject is actually committing the array to memory, looking at the item, searching the memory for the proper cue, then transferring the information to the page. The question now becomes, which method is superior? Is iconic faster than isomorphic search? Under what conditions would an individual adopt an iconic process rather than an isomorphic one? Are either of these two systems actually developed in individuals or are there other possibilities? There will be individual differences in the choice of systems. What determines the choice? Does previous learning determine the choice as Ferguson believes? Does the structure of the task become a determiner? Ferguson also suggests that some variance on tasks is due to the differing abilities to organize or integrate data in order to cope with a new task.

Hunt has stated that being high verbal implied that high verbals exhibited more rapid coding processes. Our findings have suggested that by itself being high or low verbal <u>on this task</u> was not effective in producing different results. The question is why? Was it something inherent in the task, or have we uncovered new phenomena in the high/low verbal paradigm? Only when verbal ability interacted with other independent variables (repeated measures), was a meaningful difference noted, although possible trends for other interaction were observed. Hunt has also reported that high verbals were more sensitive to proactive inhibi-

tion release. This may be the reason why the high verbals who received practice in our study showed early gains above low verbals. Perhaps they developed either the iconic or isomorphic strategy during practice and were then able to quickly drop the original code from memory, adopt the new one and apply their methods quickly. Further investigation is needed to validate this idea.

The hypothesis that previous practice in the development of individual strategies increases learning was upheld in the study. By itself it was a significant factor and when interacting with trials it was also a significant factor, producing superior results. For example those with previous practice reached asymptote after the second trial while the nonpractice group never did reach that level. An interesting question is how many trials it would take for the nonpractice group to reach asymptote. A further question is whether the practice group would increase their output after this plateau. What would be the results of extended trials? Clearly, we have the beginnings of much further research from our findings.

Results have also shown that by itself, task size produced results in the predicted direction. As load on STM was increased, information processing exhibited a decline in output. The nine digit code size by far produced the most significant difference in performance on this task. Output declined sharply in all areas of interaction with other variables. There was not much difference noted

between the five and seven digit groups. This is in support of Miller's findings that above seven, individuals start making errors in processing information. It also supports the idea that there is definitely a limit on the amount of information an individual can process in STM and that this limit most frequently occurs with the number seven.

This experiment has shown that further causes of individual differences can be found by examination of certain perceptual tasks using John Carroll's coding scheme for cognitive tasks. Several instances of these differences would not have been suggested by other research used in this report and might have gone unsaid had Carroll's scheme not been applied. Such dimensions were found to lie in the ability to develop strategies for storing, holding and retrieving items or associations in STM. Temporal and perceptual differences were also suggested by Carroll's analysis. It has been found to be a worthwhile asset in the development of the design and explanations of this experiment.

The results of the slow learner experiment are not really surprising. While levels are lower than in the first experiment patterns involving load on STM and repeated measures are very similar between the two. So it would seem that the same principles hold true for subjects of lesser ability as they do for so-called "normals". Repetition tends to enhance performance and increasing the load on STM produces lower output. This follows the arguments of the main body of theory on which this paper is based.

However, the result obtained from the strategy effect will require some possible explanations. It was suggested by Brown (1974) that teaching retardates actual strategies for learning would aid their performance, and that retardates tend to adopt "active rehearsal strategies" (Hunt, 1975, p.91). Our results may actually support rather than refute his data. Consider the possibility that although we were helping the students to learn the code, we may not necessarily have been teaching them the proper strategy for encoding that type of material. We may have been hindering the process by forcing them to think only in one direction. Also, as was the case, subjects were forced to stop the active rehearsal at the end of two minutes when in reality they may not have completed the exercise, especially those doing a seven and nine digit code. If they had been allowed to work through the booklet until completion, possibly different results may have been attained. This is material for further experimentation.

Finally, upon first examination of the correlations of the WISC Coding task, it was noted that it had a relatively low correlation with the other tests of the same battery(see Appendices, Tables 3,4 and 5). A question presented itself initially. Why was the Coding task considered a significant test of intelligence in view of its low correlations? As shown by the results of this study, clearly it must correlate with other criterion of intelligence and provide a somewhat distinct dimension. In view of Carroll's analysis light

has been shed on some of these dimensions that together produce a measure of intelligence.

Implications for Education

What does this research say about the usefulness of verbal ability as a concept in schools? What kind of classifications does such a concept produce? In what contexts does high or low verbal ability make a difference? When learning activities are being designed, what allowances should be made for high and low verbal ability in confounding situations? What do system limits on STM suggest in the learning of items such as tables, vocabulary, etc.?

Clearly, the possible independent variables related to the tasks must be carefully considered. Where the load of the task on STM is small, more variance is produced. Allowing previous practice also gives high verbals the edge. Care must be taken in structuring the task to allow for individual differences in developing strategies for learning.

What are some of the implications from this research for associative memory tasks? Individual differences will develop in adopting systematic searches of the referent items. Some may develop iconic strategies while others will find it more advantageous to use isomorphic strategies. Building on previous practice will enable similarities to be seen more readily, allowing strategies to be developed. Previous practice on related tasks does suggest sources of variance attributable to prior ability or experience levels. The development of habits of study and strategies is suggested

but they should not be regarded as the same for different kinds of tasks or for different people.

With respect to practice and slow learners, our findings suggest the opposite of Brown. We find that the attempt to teach a particular strategy (a rehearsal strategy for the class of task) is not more effective than a random strategy. Clearly, much research needs to be done before laws of learning can develop into individual strategies.

Increasing the load on STM severely restricts the capacity of the system to process information (store, search, retrieve). This suggests that tasks such as the learning of tables, vocabulary, speeches or lists of items should involve the teaching of multiple rehearsal strategies, chunking, reorganizing, association, etc., to enable the systems of different individuals to absorb larger pieces of information. Several methods should be practiced so that individuals may develop a preferred strategy.

Summary

This study has set out to examine the information processing abilities of individuals in light of present theories and findings. By means of experimentation and analysis of data, in the light of existing methods, its major hypotheses have been tested and evaluated. It has shown support for three of its four hypotheses and has shed some further light on the construct of verbal ability in experimental settings on an experimental level. In particular, the development of individual strategies and

interaction of verbal ability, with repeated trials in a complex learning task have verified some of Carroll's formulations concerning structure of intellect and confirmed the centrality of the role of transfer in complex learning as hypothesized by Ferguson. Many questions remain unanswered, but this method of analysis may prove to be most fruitful for others to follow when they seek solutions to the practical and theoretical issues that remain.

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Appendices

TABLE 1

A Provisional Coding Scheme for Cognitive Tasks Appearing in Psychometric Tests

STIMULUS MATERIALS (as provided at outset of task)

1A Number of stimulus classes

1 One stimulus class (a word, picture, etc.)
2 Two stimulus classes (as in many types of MC items, PA learning, etc.)

Description of the ith stimulus class:

1B Completeness

1 Complete
2 Degraded (with visual or auditory "noise")

1C Interpretability

1 Unambiguous (immediately interpretable)
2 Ambiguous (codable several ways)
3 Anomalous (not immediately codable)

Memory to be addressed in interpretation:

5A Term (see list 5A)

5B Contents (see list 5B)

5C Relevance of Individual Differences (in this memory store)

OVERT RESPONSE TO BE MADE AT END OF TASK

2A Number and Type

1 Select response from presented alternatives
2 Produce one correct answer from operations to be performed
3 Produce as many responses as possible (all different)
4 Produce a specified number of responses (all different)

2B Response Mode

1 Indicate choice of alternative (in some conventional way)
2 Produce a single symbol (letter, numerical quantity)
3 Write word
4 Write phrase or sentence
5 Write paragraph or more
6 Make spoken response
7 Make line or simple drawing

TABLE 1 - (2)

2C Criterion of response acceptability

1 Identity
2 Similarity (or non-similarity) with respect to one or more features
3 Semantic opposition
4 Containment
5 Correct result of serial operation
6 Instance (subordinate of stimulus class)
7 Superordinate
8 Correct answer to verbal question ("fill in wh-")
9 Comparative judgment
10 Arbitrary association established in task
11 Semantic and/or grammatical acceptability ("makes sense")
12 Connectedness of lines or paths

TASK STRUCTURE

3A 1 Unitary (each item completed on a single occasion)
2 There is a temporal structure such that stimuli are presented on one occasion, responses are made on another occasion (as in memory and learning tasks)
[This coding would have to be extended greatly to include many types of experimental cognitive tasks]

OPERATIONS AND STRATEGIES

4A Number of operations and strategies coded for the task

Description of the ith operation:

4B Type or description

1 Identify, recognize, interpret stimulus
2 Educe identities or similarities between two or more stimuli
3 Retrieve name, description, or instance from memory
4 Store item in memory
5 Retrieve associations, or general information, from memory
6 Retrieve or construct hypotheses
7 Examine different portions of memory
8 Perform serial operations with data from memory
9 Record intermediate result
10 Visual inspection strategy (examine different parts of visual stimulus)
11 Reinterpretation of possibly ambiguous item
12 Imaging, imagining, or other way of forming abstract representation of a stimulus
13 Mentally rotate spatial configuration
14 Comprehend and analyze language stimulus
15 Judge stimulus with respect to a specified characteristic
16 Ignore irrelevant stimuli
17 Use a special mnemonic aid (specify)
18 Rehearse associations
19 Develop a special search strategy (visual)
20 Chunk or group stimuli or data from memory

TABLE 1 - (3)

[Description of the ith operation or strategy, cont'd]

4C Is the operation specified in the task instructions?

1 Yes, explicitly
2 Implied but not explicitly stated
3 Not specified or implied in instructions

4D How dependent is acceptable performance on this operation or strategy?

1 Crucially dependent
2 Helpful, but not crucial
3 Of dubious effect (may be positive or negative)
4 Probably a hindrance, counterproductive

Memory involved in this operation:

5A Term (see list 5A)

5B Contents (see list 5B)

5C Relevance of Individual Differences (in this memory store) (see list 5C)

Temporal aspects of the operation or strategy:
(if 6A = 0 ["irrelevant"], 6B pertains to the probability that the S will adopt a strategy)

6A Duration (range of average duration)

0 Irrelevant or inapplicable
1 Very short (e.g., < 200 msec.)
2 Middle range (e.g., < 1 sec.)
3 Long (e.g., 1 - 5 sec.)
4 Longer (e.g., > 5 sec.)

6B Individual differences in duration (or probability of strategy)

1 Probably inconsequential
2 Possibly relevant
3 Probable wide individual differences (in likely test populations)

6C Criterion for termination of operation

0 Irrelevant
1 Upon arrival at recognizably correct solution (self-terminating)
2 Not self-terminating in sense of (1). (That is, the solution may be a guess, or S may be satisfied with what is actually an incorrect solution.)

TABLE 1 - (4)

MEMORY STORE INVOLVED

5A Term

1 Sensory buffer
2 Short term memory (STM) (a matter of seconds)
3 Intermediate term memory (ITM) (a matter of minutes)
4 Long term or permanent memory

5B Contents

0.5 Non-specific
1.0 Visual (general, non-specific)
1.1 Points, positions of points
1.2 Lines (one-dimensional)
1.3 Lines & curves (2-dimensional)
1.4 Geometric patterns and shapes
1.5 Pictorial (objects, etc.)
1.51 Subcategory (e.g. tools)
1.6 Real 2-dimensional items
1.7 Maps, charts, grids
1.8 Representations of 3-dimensional geometric shapes
1.85 Pictures of 3-dimensional objects or situations
1.86 Faces
1.9 Real objects in 3 dimensions
2.0 Auditory (not further specified here)
3.0 Graphemic, general
3.1 Letters
3.2 Words (apart from their semantic information)
3.5 Alphabetic order information
4.0 Linguistic, general (of native language)
4.01 - Subcategories (e.g. terminology and expressions in a special field)
4.1 Lexical
4.11 -- Subcategories
4.2 Syntactic
4.21 Lexicogrammatical (e.g. grammatical classifications of words)
4.3 Grammatical rules and features, general
4.4 Semantic (meanings of words, syntactic features, etc.)
4.5 Non-verbal semantics (e.g. meanings of pictorial symbols)
5.0 Numerical, mathematical, general
5.1 Digit symbols with meanings
5.2 Elementary number operations and symbols
5.3 Algorithms for dealing with quantitative relations
6.0 Logic, general
6.1 Various abstract patterns (alternation, sequence, etc.)
6.2 Attributes in which stimuli could vary
7.0 Movements, kinesthetic "concepts"
8.0 "Real world" experiences and learnings, situations, facts, information
8.1 -- Subcategories (e.g. mechanical and electrical information)
9.0 Arbitrary, new codings and associations established in the task situatio

TABLE 1 - (5)

MEMORY STORE INVOLVED (Cont'd)

5C Relevance of individual differences in this store

1 Most Ss will have required store
2 Doubtful that most Ss will have required store
3 Wide individual differences in this memory store are likely

Individual Differences in
Cognitive Processes and Memory Stores Associated with 24 FA Factors*

FACTOR	PRINCIPAL MEMORY INVOLVED	COGNITIVE PROCESSES				RESPONSE RENDERING
		OPERATIONS			STRATEGIES	
		Addressing Sensory Buffers	Addressing ITM or LTM	Manipulations in executive and STM		
SS Spatial Scanning	STM (visual)	Visual search for connectedness of lines and paths (T,C)			Search from goal rather than start (P)	
Le Length Estimation	STM (visual)			Compare distances (T,C)		
PS Perceptual Speed	STM (visual)	Visual search for specified items (T)				
CF Flexibility of Closure	STM (visual)			Image figure-in-ground (T, C)		
SO Spatial Orientation	STM (visual)			Mentally rotate spatial configuration (T, C)		
Vz Visualization	STM (visual)			(1) Mentally rotate spatial configuration (T, C) (2) Perform serial operations (T)		
XF Figural Adaptive Flexibility	STM (visual) [LTM, general logic]		Search hypotheses in LTM (T, C)	(1) Image figure-in-ground (T, C) (2) Perform serial operations (T)		

Table 2 (cont'd)
Individual Differences in
Cognitive Processes and Memory Stores Associated with 24 FA Factors*

FACTOR	PRINCIPAL MEMORY INVOLVED	COGNITIVE PROCESSES				RESPONSE RENDERING
		OPERATIONS			STRATEGIES	
		Addressing Sensory Buffers	Addressing ITM or LTM	Manipulations in executive and STM		
MS Memory Span	STM (non-specific)			(1) Store in STM (T, C) (2) Retrieve from STM (T, C)	Chunk or group stimulus items (P)	
MA Associative Memory	ITM (non-specific)		(1) Store in ITM (T, C) (2) Retrieve from ITM (T, C)		(1) Find mediators in LTM (P, C, T) (2) Rehearse associations (P)	
CS Speed of Closure	LTM (visual-representational)		Search for match of cue (T, C?)		(1)Search hypotheses in LTM (P, C) (2)Search different portions of LTM (P) (3)Restructure perception (P)	+Writing Speed?
FW Word Fluency	LTM (lexicographemic)		Search for instances (T, C)		(1)Search different portions of LTM (P) (2) Use alphabet as mnemonic (P)	+Writing Speed
FE Expressional Fluency	LTM (lexicogrammatical)		Search for instances (T, C)		(1)Search different portions of LTM (P) (2) Use grammatical mnemonics (P)	++Writing Speed

Individual Differences in
Cognitive Processes and Memory Stores Associated with 24 FA Factors*

FACTOR	PRINCIPAL MEMORY INVOLVED	COGNITIVE PROCESSES				RESPONSE RENDERING
		OPERATIONS			STRATEGIES	
		Addressing Sensory Buffers	Addressing ITM or LTM	Manipulations in executive and STM		
FA Associational Fluency	LTM (Lexico-semantic)		Search for instances (T, C)		Search different portions of LTM (P)	+Writing Speed
V Verbal Comprehension	LTM (Lexico-semantic)		Retrieve word meanings (C)			
N Number Facility	LTM (numbers & numerical operations)		Retrieve number associations and algorithms (C)	Perform serial operations with algorithms (T, C)	(1) Chunk intermediate results (P) (2) Record intermediate results (P)	
I Induction	LTM (abstract logical)		Search hypotheses (C, T)		Serial operations to construct new hypotheses (P,T)	
RL Syllogistic Reasoning	LTM (lexico-semantic, abstract logical)		Retrieve meanings & algorithms (C, T)	Perform serial operations (T, C)	Attention to stimulus materials (P)	
RG General Reasoning	LTM (abstract logical, algorithms for quantitative relations		Retrieve algorithms (C, T)	Perform serial operations (T, C)		

Table 2 (cont'd)
Individual Differences in
Cognitive Processes and Memory Stores Associated with 24 FA Factors*

FACTOR	PRINCIPAL MEMORY INVOLVED	COGNITIVE PROCESSES				RESPONSE RENDERING
		OPERATIONS			STRATEGIES	
		Addressing Sensory Buffers	Addressing ITM or LTM	Manipulations in executive and STM		
FI Ideational Fluency	LTM (experiential, general)		Search for associations (C, T)		Search different portions of LTM (P)	++Writing Speed
O Originality	LTM (experiential, general)		Search for "unusual" instances (C, T)		Search different portions of LTM (P)	+Writing Speed?
SR Semantic Redefinition	LTM (experiential, uses of objects		Search for associations (C, T)		Search different portions of LTM (P)	+Writing Speed?
XS Semantic Spontaneous Flexibility	LTM (experiential)		Search for associations (C, T)		Search different portions of LTM (P)	+Writing Speed
SP Sensitivity to Problems	LTM (experiential, abstract logical)		Retrieve associations (C, T)	Perform serial operations (T, C)	Search different portions of LTM (P)	++Writing Speed
Mk Mechanical Knowledge	LTM (mech. knowledge)		Retrieve associations (C, T)			

*Individual differences in: (C) contents or capacity of memory store involved; (T) temporal parameters of the process; (P) probability of a strategy.

TABLE 3

Intercorrelation of Tests in the Wechsler Intelligence Scale for Children

Age 7½ — 100 Boys and 100 Girls

	Information	Comprehension	Arithmetic	Similarities	Vocabulary	Digit Span	Picture Completion	Picture Arrangement	Block Design	Object Assembly	Coding A	Mazes	Verbal Score	Performance Score	Full Scale Score
Comprehension	.37														
Arithmetic	.51	.31													
Similarities	.49	.36	.40												
Vocabulary	.55	.51	.46	.45											
Digit Span	.34	.29	.40	.33	.43										
Picture Completion	.24	.39	.29	.27	.36	.33									
Picture Arrangement	.36	.39	.38	.38	.39	.44	.32								
Block Design	.33	.32	.27	.29	.33	.24	.28	.37							
Object Assembly	.27	.25	.29	.29	.30	.22	.28	.48	.53						
Coding A	.26	.22	.32	.15	.22	.27	.12	.24	.26	.30					
Mazes	.24	.23	.20	.25	.22	.16	.20	.36	.49	.48	.19				
Verbal Score*	.64	.49	.55	.55	.66	.48	.42	.51	.42	.38	.31	.31			
Performance Score**	.44	.46	.46	.41	.47	.45	.34	.51	.53	.59	.32	.51	.60		
Full Scale Score***	.59	.54	.57	.53	.63	.52	.43	.58	.52	.52	.35	.46	—	—	
Mean	10.0	10.0	10.1	9.9	10.1	9.8	10.0	10.1	10.1	9.9	10.1	10.0	50.0	50.3	100.3
SD	2.9	2.8	2.7	2.8	2.6	2.7	2.8	2.9	2.8	3.0	3.1	3.0	10.3	9.8	18.0

Correlation of tests with Verbal, Performance and Full Scale Scores and of Verbal Scale Score and Performance Scale Score with Full Scale Score *before* correction for contamination

	Information	Comprehension	Arithmetic	Similarities	Vocabulary	Digit Span	Picture Completion	Picture Arrangement	Block Design	Object Assembly	Coding A	Mazes	Verbal Score	Performance Score
Verbal Score*	.79	.69	.72	.73	.79	—	—	—	—	—	—	—	—	—
Performance Score**	—	—	—	—	—	—	.58	.72	.72	.77	.58	—	—	—
Full Scale Score***	.69	.64	.66	.64	.71	—	.56	.68	.63	.64	.50	—	.90	.89

*Verbal Score—Sum of 5 tests, Digit Span omitted.

**Performance Score—Sum of 5 tests, Mazes omitted.

***Full Scale Score—Sum of 10 tests, Digit Span and Mazes omitted.

TABLE 4

Intercorrelation of Tests in the Wechsler Intelligence Scale for Children
Age 10½ — 100 Boys and 100 Girls

	Information	Comprehension	Arithmetic	Similarities	Vocabulary	Digit Span	Picture Completion	Picture Arrangement	Block Design	Object Assembly	Coding B	Mazes	Verbal Score	Performance Score	Full Scale Score
Comprehension	.65														
Arithmetic	.69	.48													
Similarities	.67	.55	.63												
Vocabulary	.75	.75	.62	.64											
Digit Span	.38	.41	.45	.39	.48										
Picture Completion	.41	.37	.32	.34	.47	.10									
Picture Arrangement	.51	.48	.48	.41	.56	.33	.35								
Block Design	.48	.44	.48	.38	.54	.34	.46	.51							
Object Assembly	.28	.35	.33	.25	.41	.35	.38	.30	.59						
Coding B	.37	.32	.38	.29	.41	.30	.20	.36	.27	.23					
Mazes	.41	.34	.35	.26	.44	.34	.39	.35	.53	.43	.24				
Verbal Score*	.82	.70	.70	.72	.82	.50	.45	.58	.55	.38	.42	.43			
Performance Score**	.59	.56	.57	.48	.68	.40	.48	.53	.66	.52	.35	.55	.68		
Full Scale Score***	.77	.69	.69	.65	.83	.50	.51	.62	.64	.47	.43	.53	—	—	
Mean	9.9	10.1	10.2	10.0	10.1	10.0	10.0	9.9	10.1	10.0	10.0	10.1	50.2	50.0	100.2
SD	2.9	3.1	3.1	3.0	3.1	2.9	3.0	3.1	3.0	2.9	3.1	2.9	12.8	10.5	21.4

Correlation of tests with Verbal, Performance and Full Scale Scores and of Verbal Scale Score and Performance Scale Score with Full Scale Score *before* correction for contamination

	Information	Comprehension	Arithmetic	Similarities	Vocabulary	Digit Span	Picture Completion	Picture Arrangement	Block Design	Object Assembly	Coding B	Mazes	Verbal Score	Performance Score
Verbal Score*	.88	.81	.81	.82	.89	—	—	—	—	—	—	—	—	—
Performance Score**	—	—	—	—	—	—	.68	.72	.80	.70	.59	—	—	—
Full Scale Score***	.82	.76	.76	.72	.87	—	.61	.70	.72	.58	.54	—	.93	.90

*Verbal Score—Sum of 5 tests, Digit Span omitted. **Performance Score—Sum of 5 tests, Mazes omitted.

***Full Scale Score—Sum of 10 tests, Digit Span and Mazes omitted.

TABLE 5

Intercorrelation of Tests in the Wechsler Intelligence Scale for Children

Age 13½ — 100 Boys and 100 Girls

	Information	Comprehension	Arithmetic	Similarities	Vocabulary	Digit Span	Picture Completion	Picture Arrangement	Block Design	Object Assembly	Coding B	Mazes	Verbal Score	Performance Score	Full Scale Score
Comprehension	.61														
Arithmetic	.59	.46													
Similarities	.67	.61	.50												
Vocabulary	.74	.60	.46	.66											
Digit Span	.39	.28	.40	.34	.38										
Picture Completion	.35	.25	.26	.36	.31	.23									
Picture Arrangement	.35	.31	.25	.44	.41	.18	.35								
Block Design	.48	.33	.35	.45	.42	.29	.51	.42							
Object Assembly	.29	.13	.20	.31	.33	.13	.55	.42	.63						
Coding B	.38	.32	.34	.33	.37	.24	.23	.35	.35	.38					
Mazes	.39	.21	.36	.35	.32	.25	.26	.29	.28	.33	.27				
Verbal Score*	.80	.68	.59	.74	.75	.44	.38	.43	.50	.31	.42	.40			
Performance Score**	.51	.37	.38	.52	.51	.29	.55	.51	.65	.68	.42	.39	.56		
Full Scale Score***	.73	.58	.55	.71	.70	.42	.51	.53	.64	.52	.48	.44	—	—	
Mean	9.9	10.2	10.0	10.0	10.0	10.0	10.1	10.0	9.8	10.0	9.9	10.1	50.1	49.7	99.8
SD	3.0	3.2	2.8	2.9	3.2	2.8	2.9	3.1	3.1	3.0	3.1	2.9	12.4	11.1	20.7

Correlation of tests with Verbal, Performance and Full Scale Scores and of Verbal Scale Score and Performance Scale Score with Full Scale Score *before* correction for contamination

	Information	Comprehension	Arithmetic	Similarities	Vocabulary	Digit Span	Picture Completion	Picture Arrangement	Block Design	Object Assembly	Coding B	Mazes	Verbal Score	Performance Score
Verbal Score*	.88	.81	.73	.84	.85	—	—	—	—	—	—	—	—	—
Performance Score**	—	—	—	—	—	—	.72	.70	.80	.81	.63	—	—	—
Full Scale Score***	.80	.68	.64	.78	.78	—	.61	.63	.72	.62	.59	—	.89	.87

*Verbal Score—Sum of 5 tests, Digit Span omitted. **Performance Score—Sum of 5 tests, Mazes omitted.

***Full Scale Score—Sum of 10 tests, Digit Span and Mazes omitted.

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Fig. 1. Practice Coding task.

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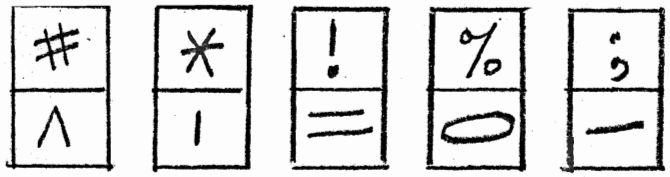

Fig. 1 (2)

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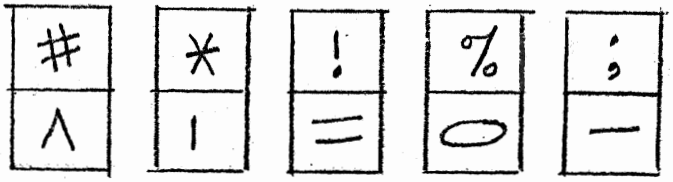

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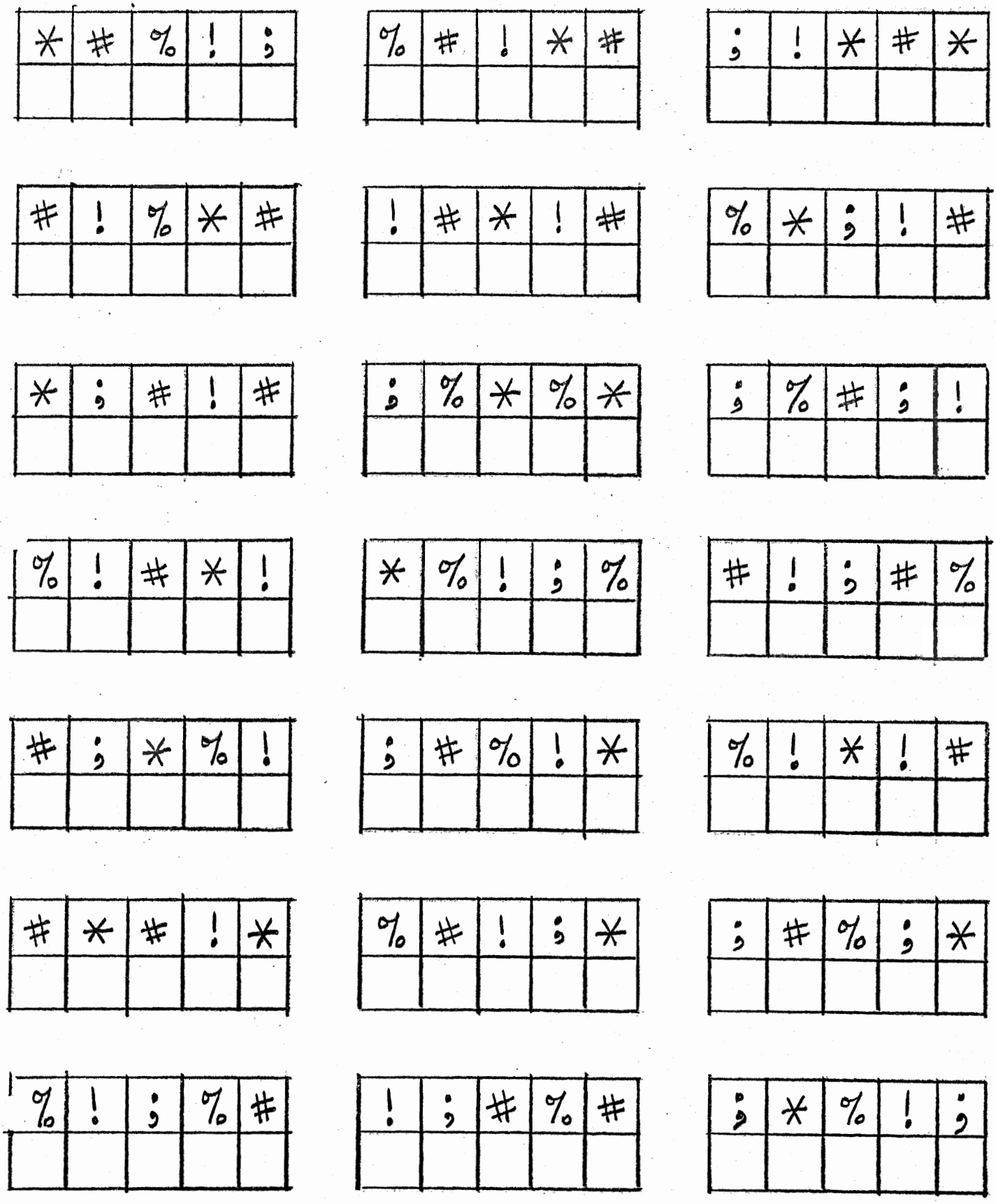

Fig. 1 (4)

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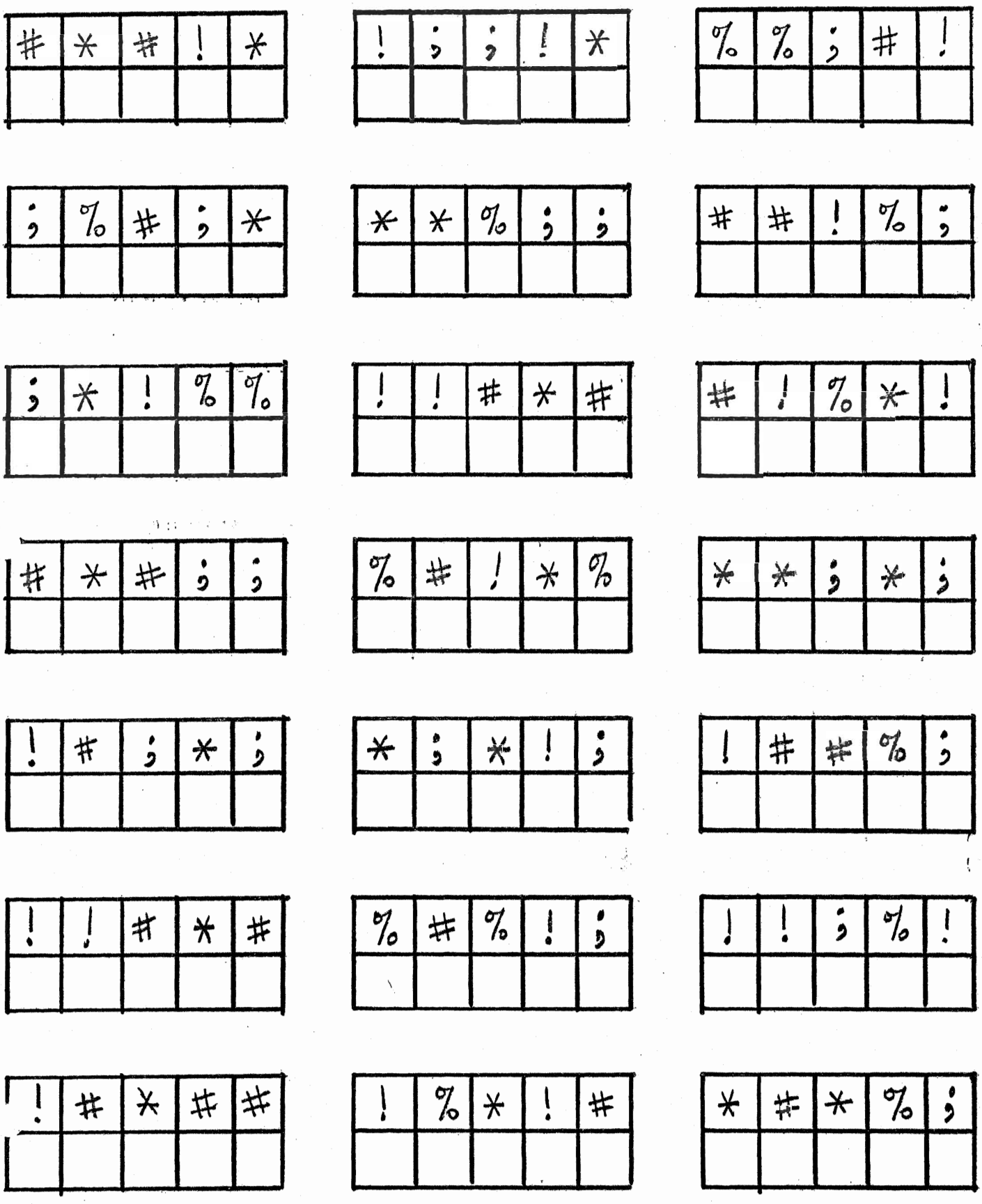
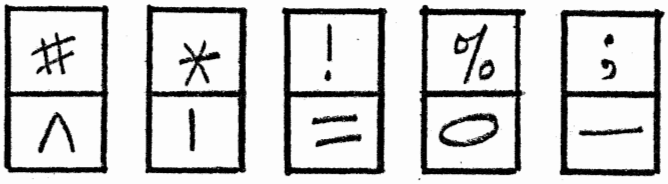
Fig. 1 (5)





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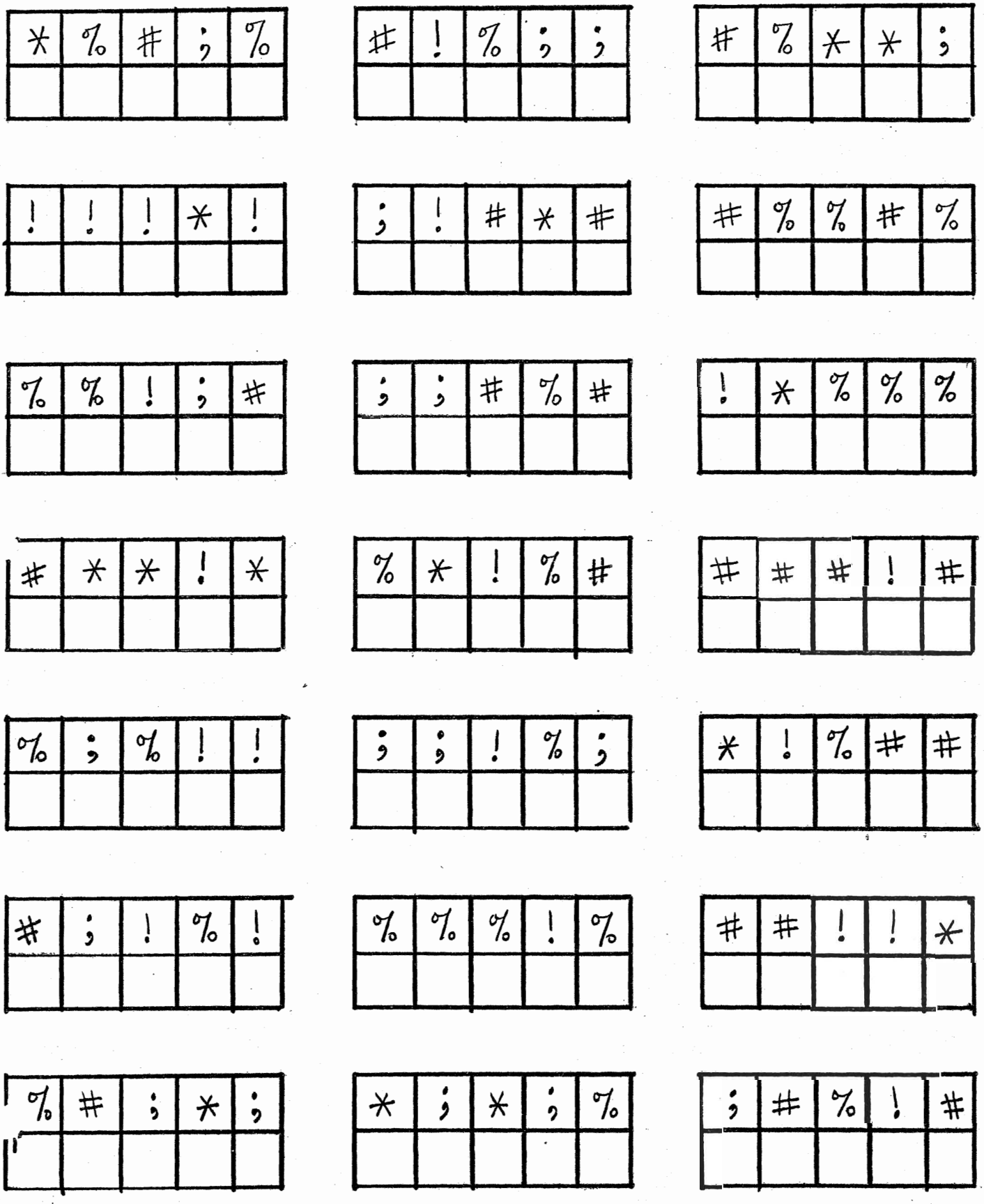

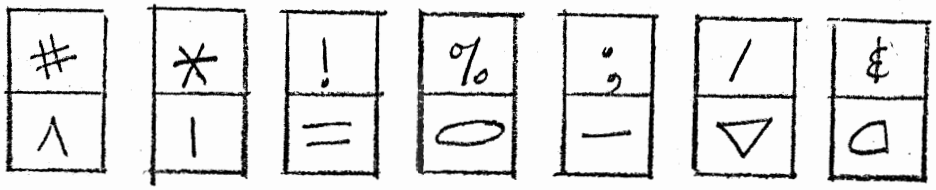

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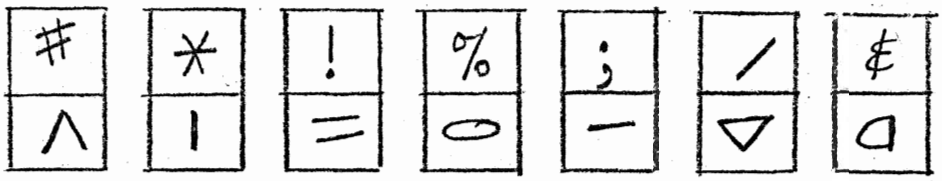

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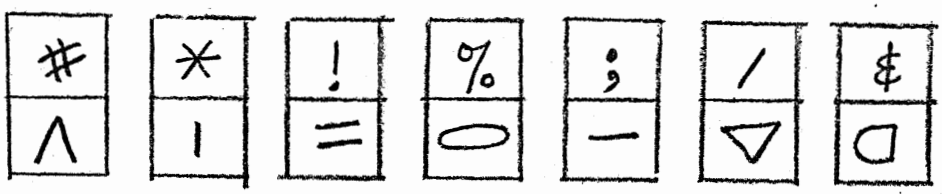

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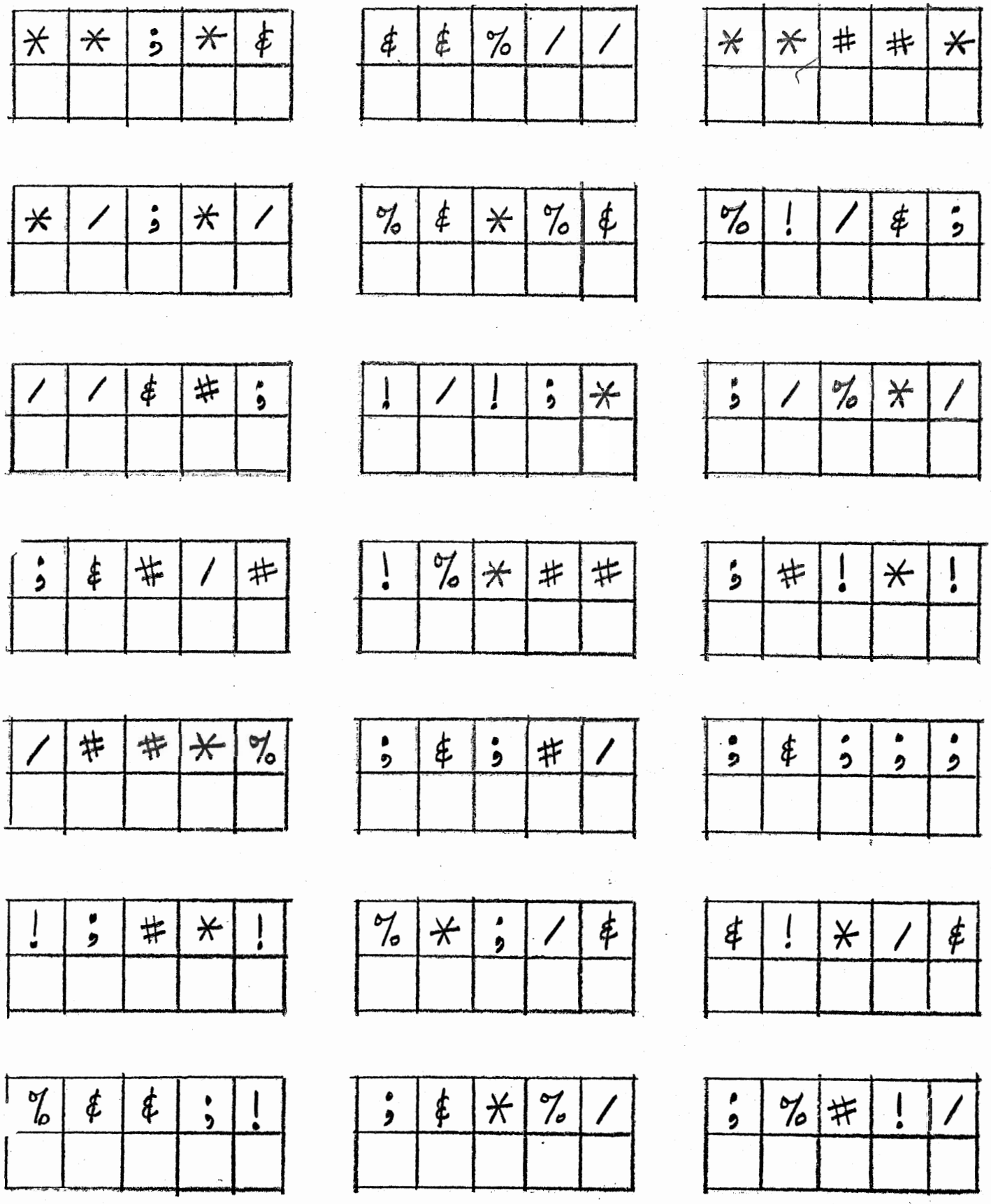

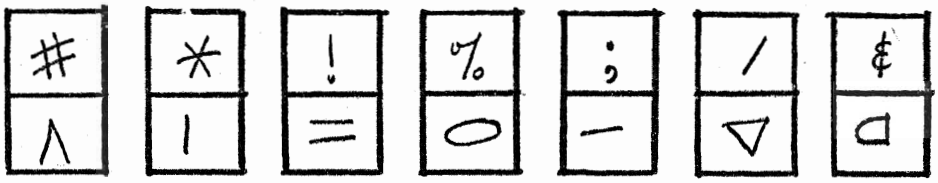

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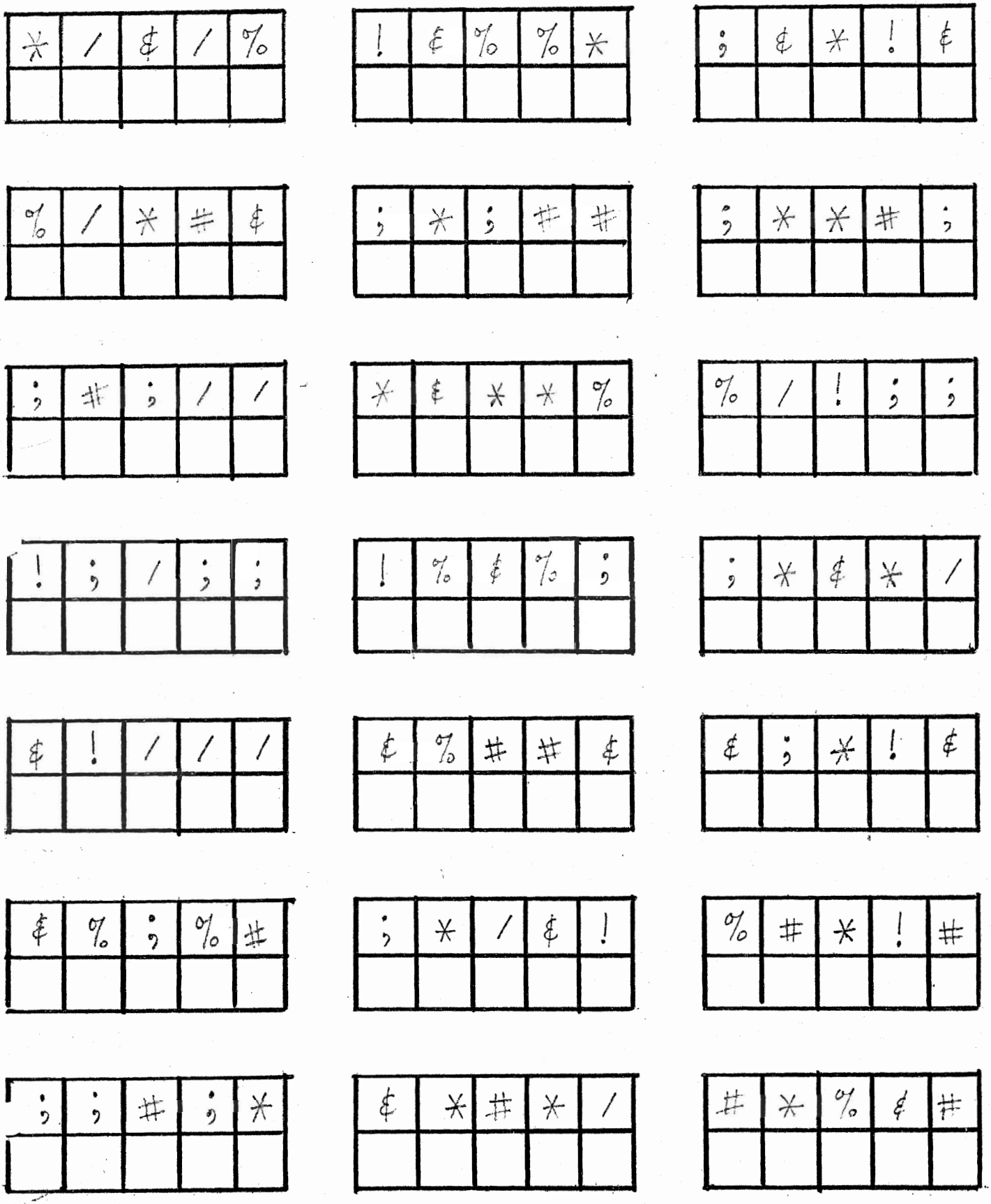

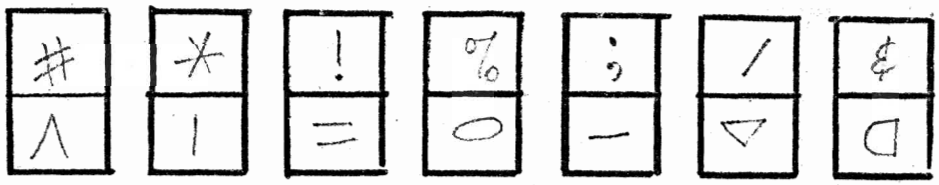

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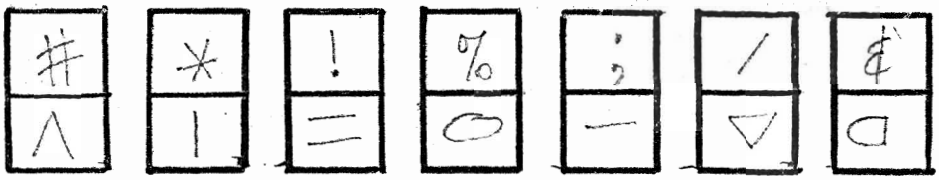

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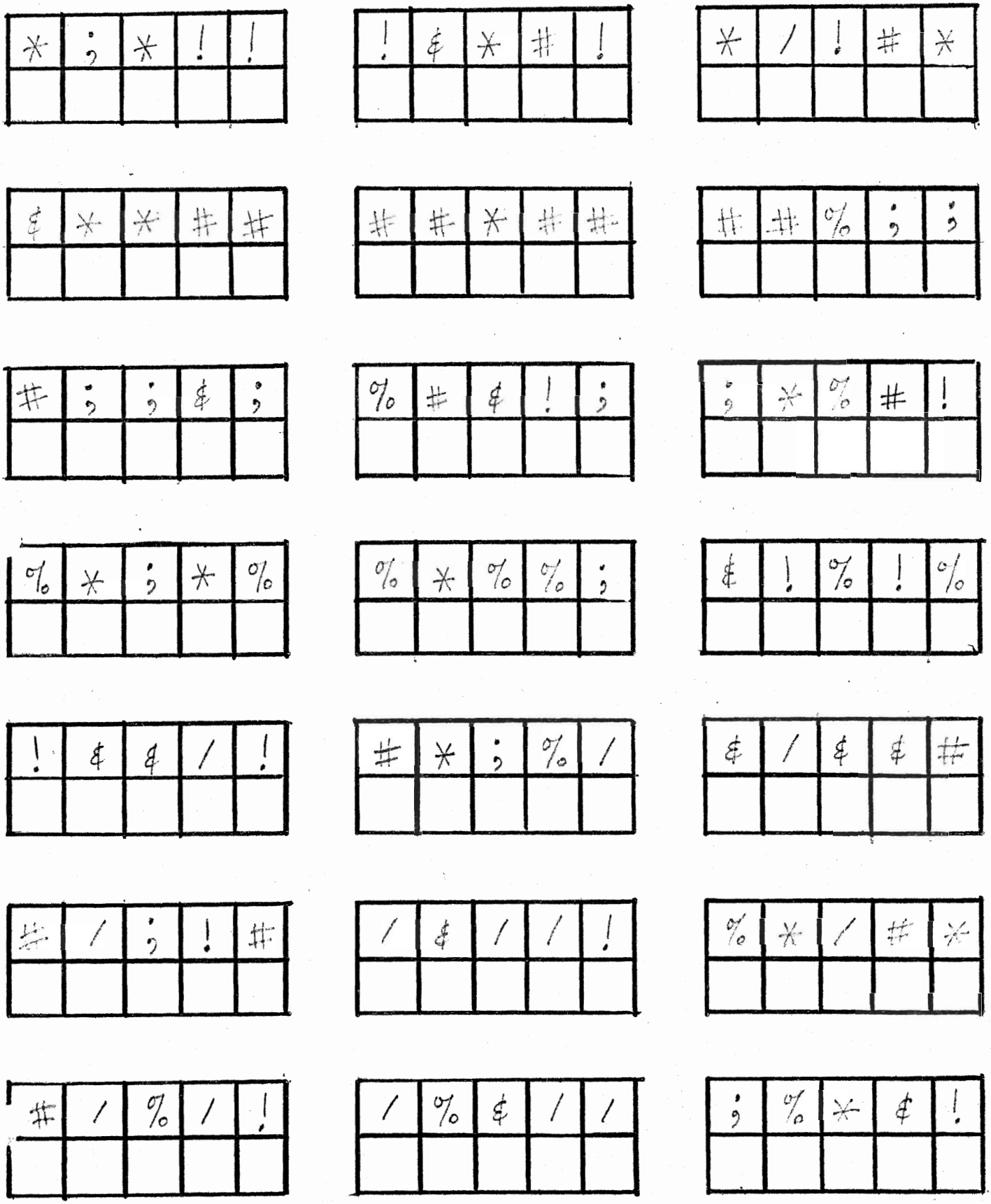

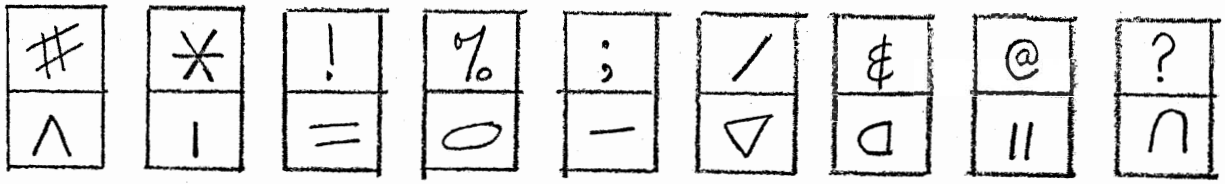

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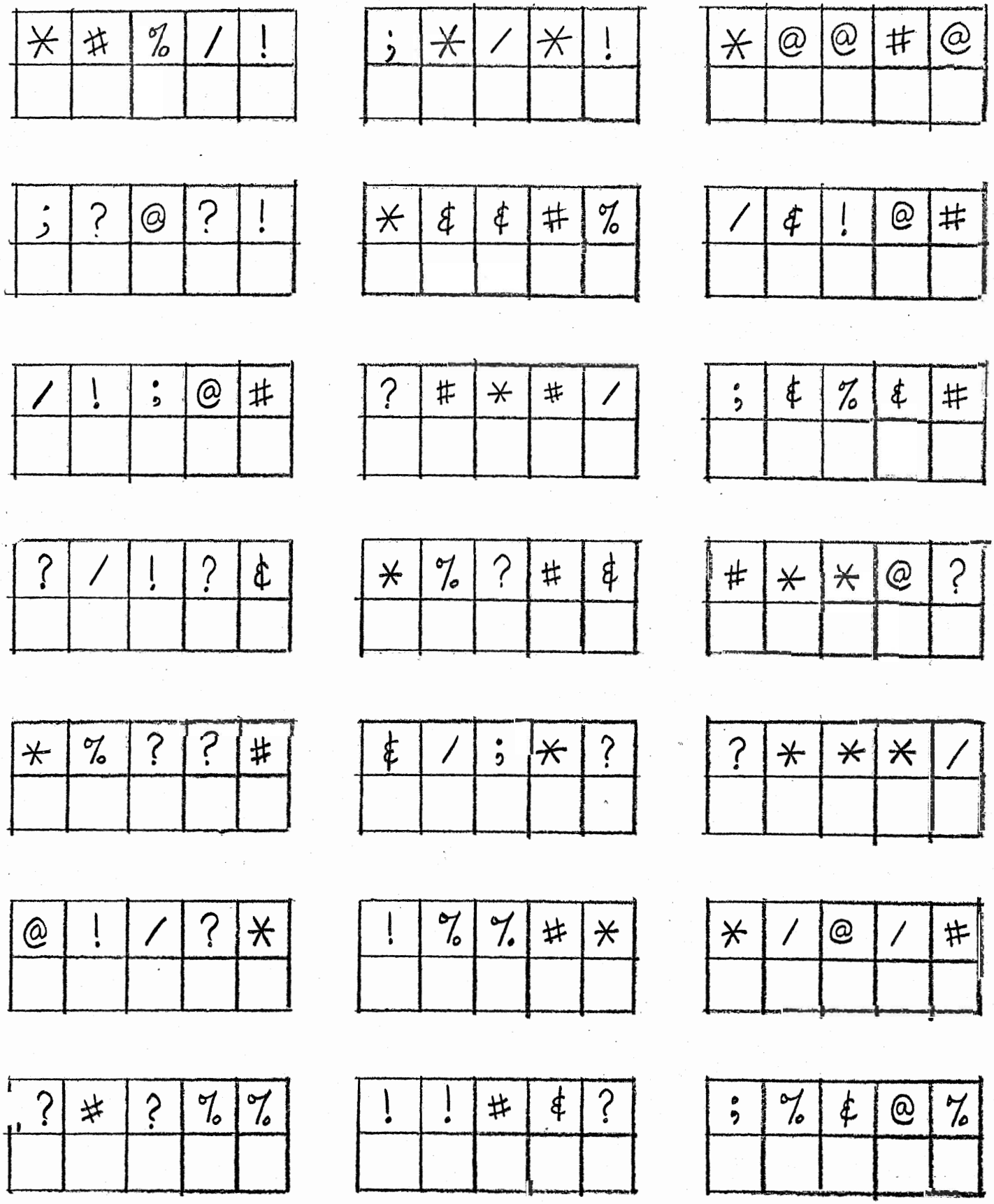

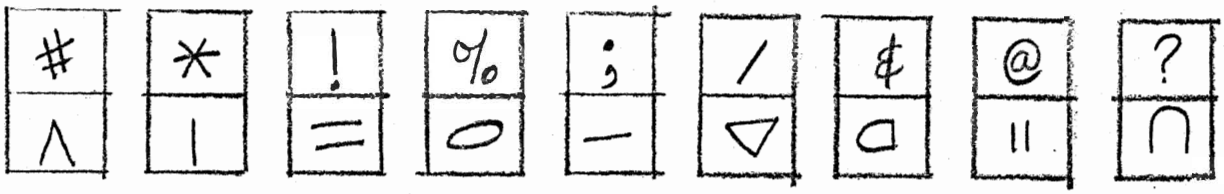

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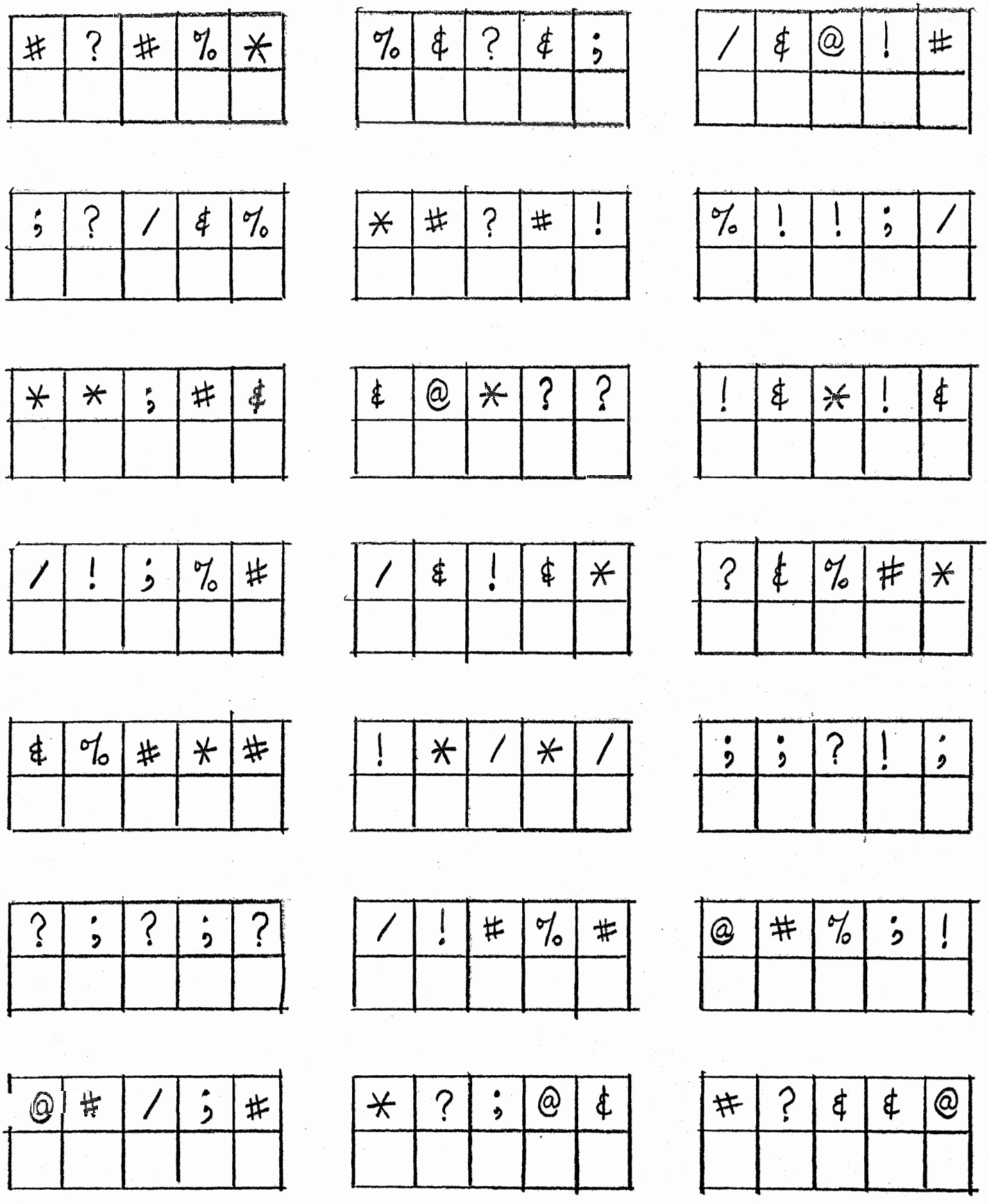

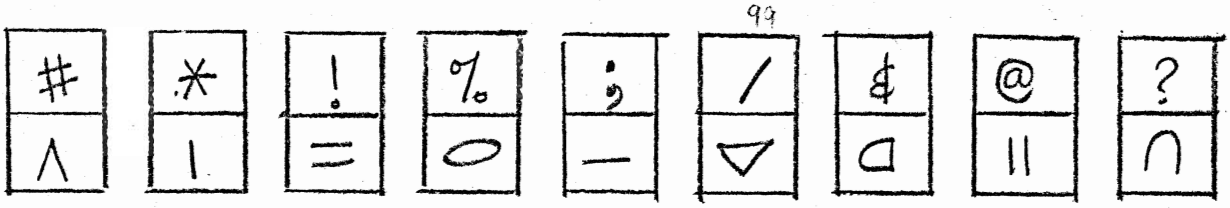

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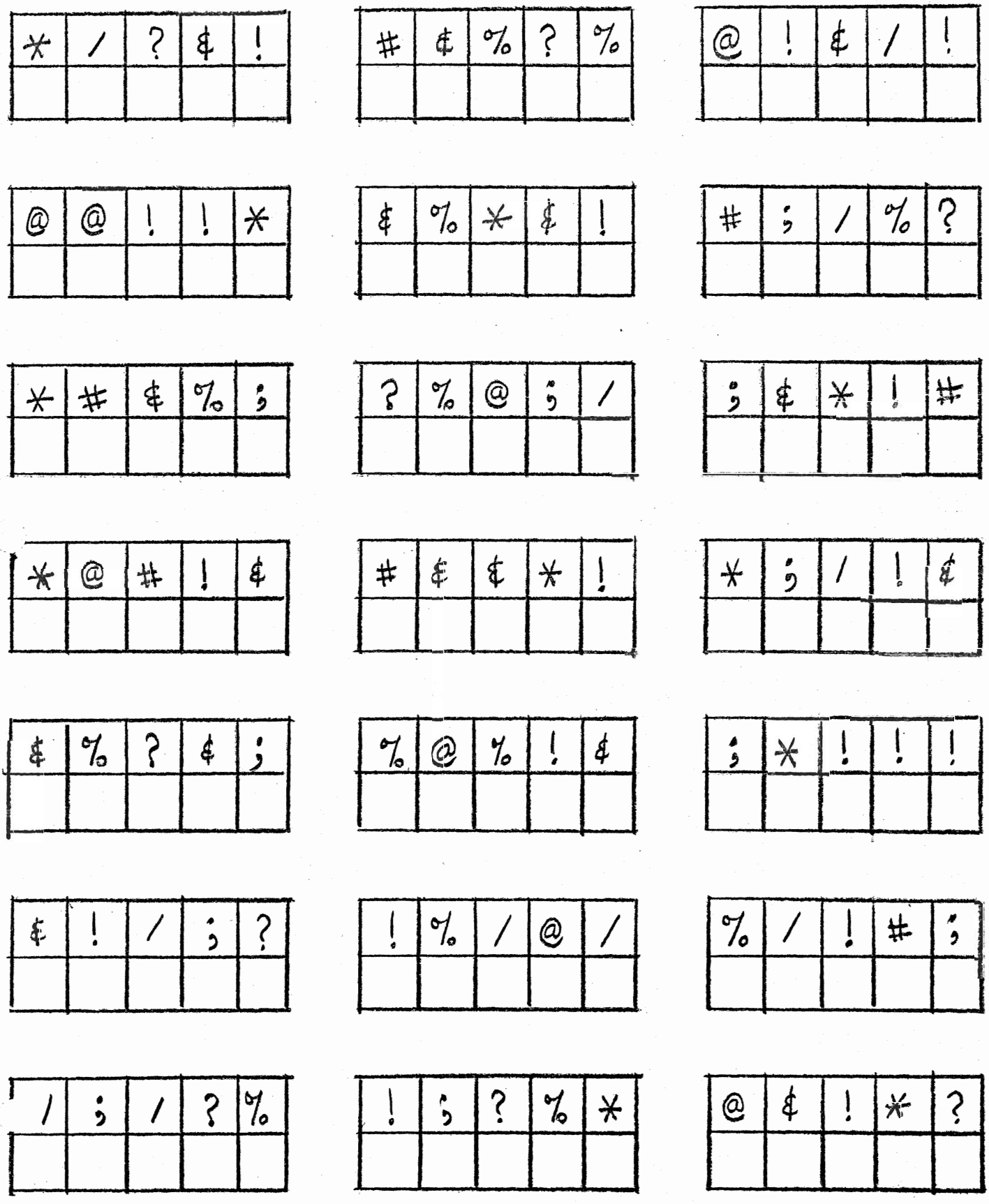

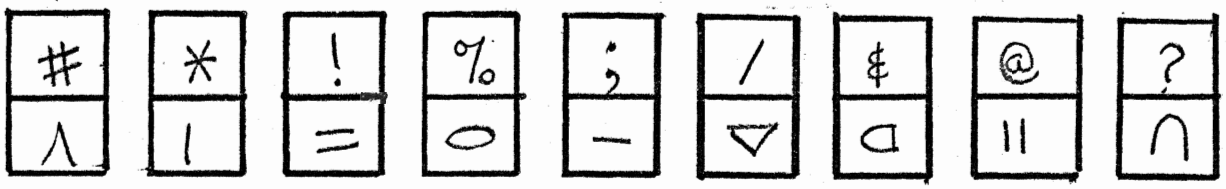

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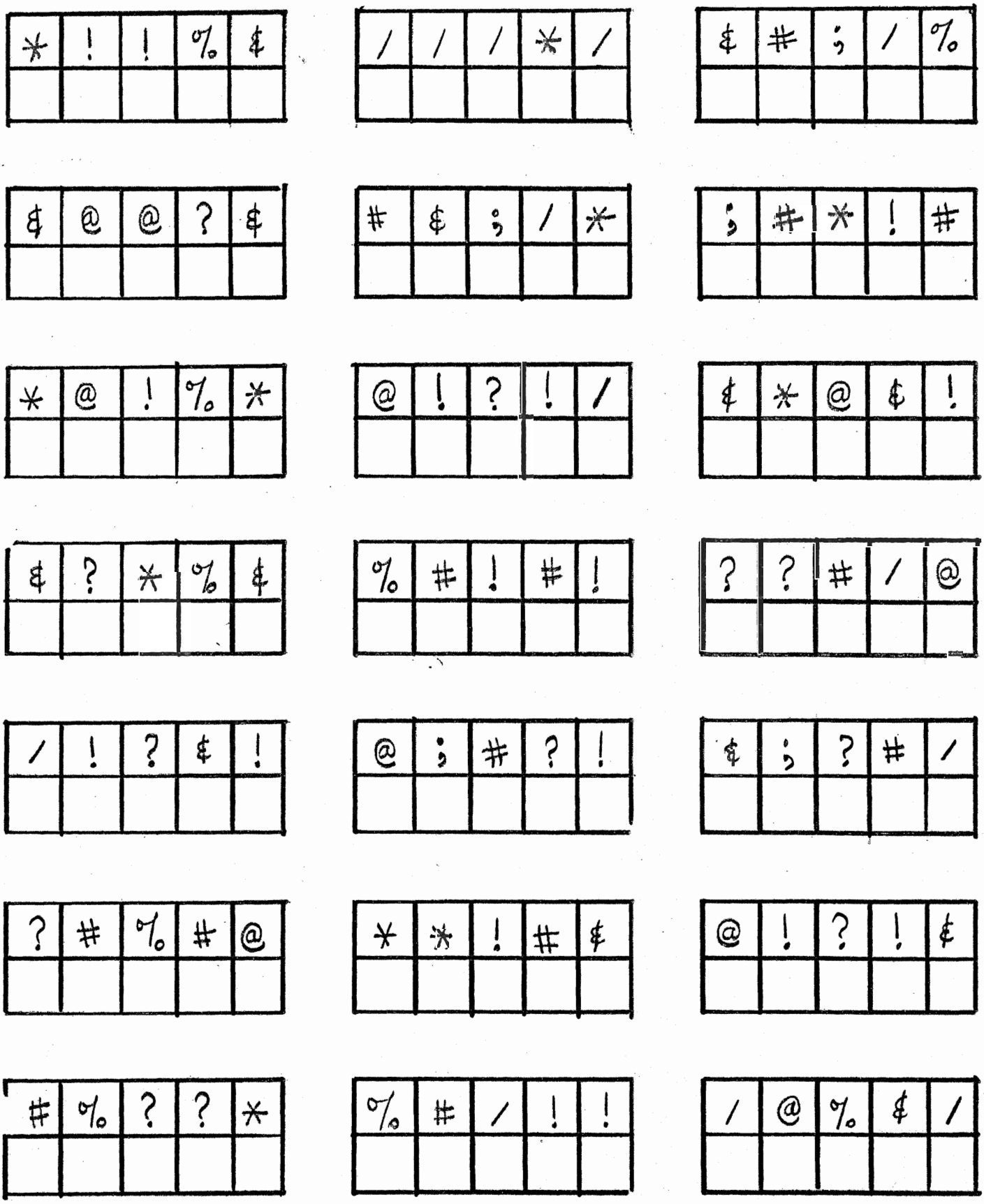

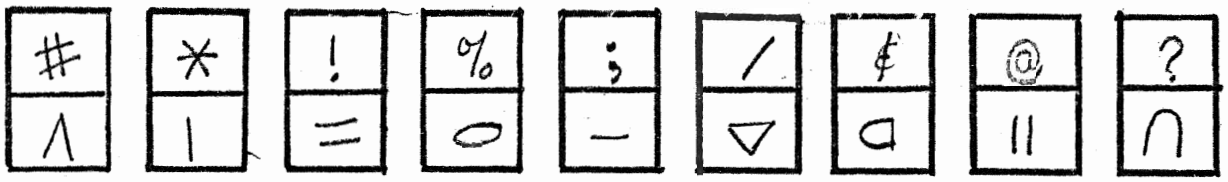

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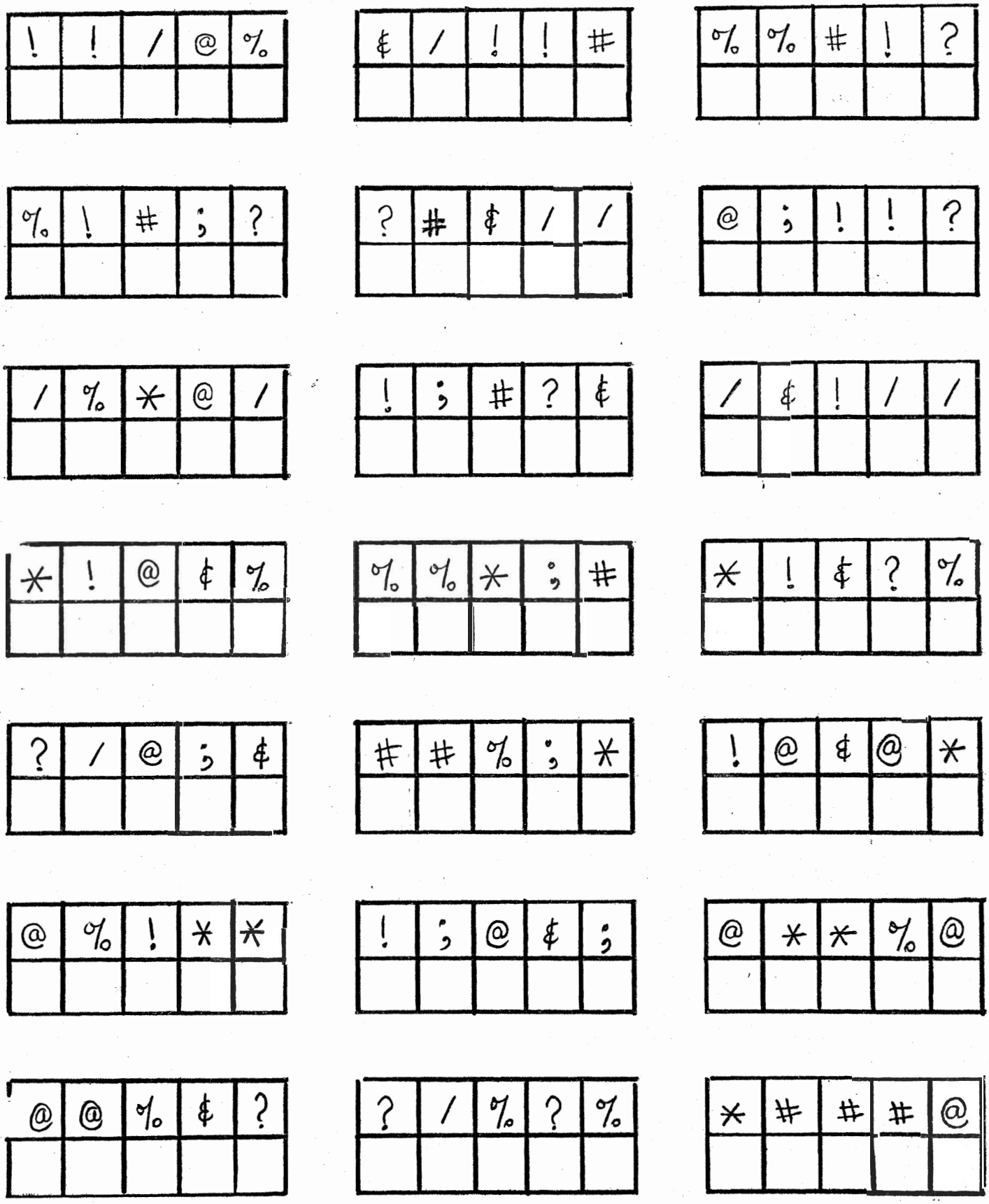

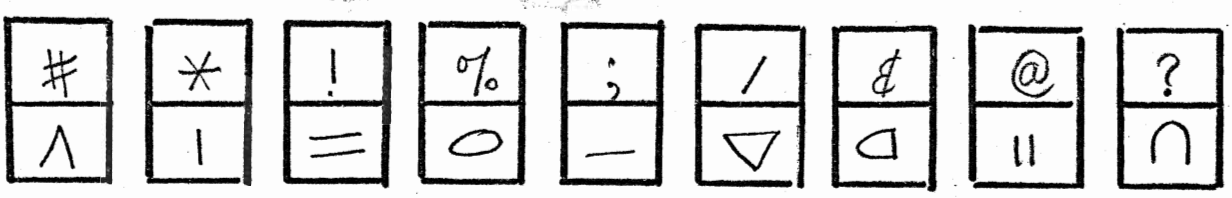

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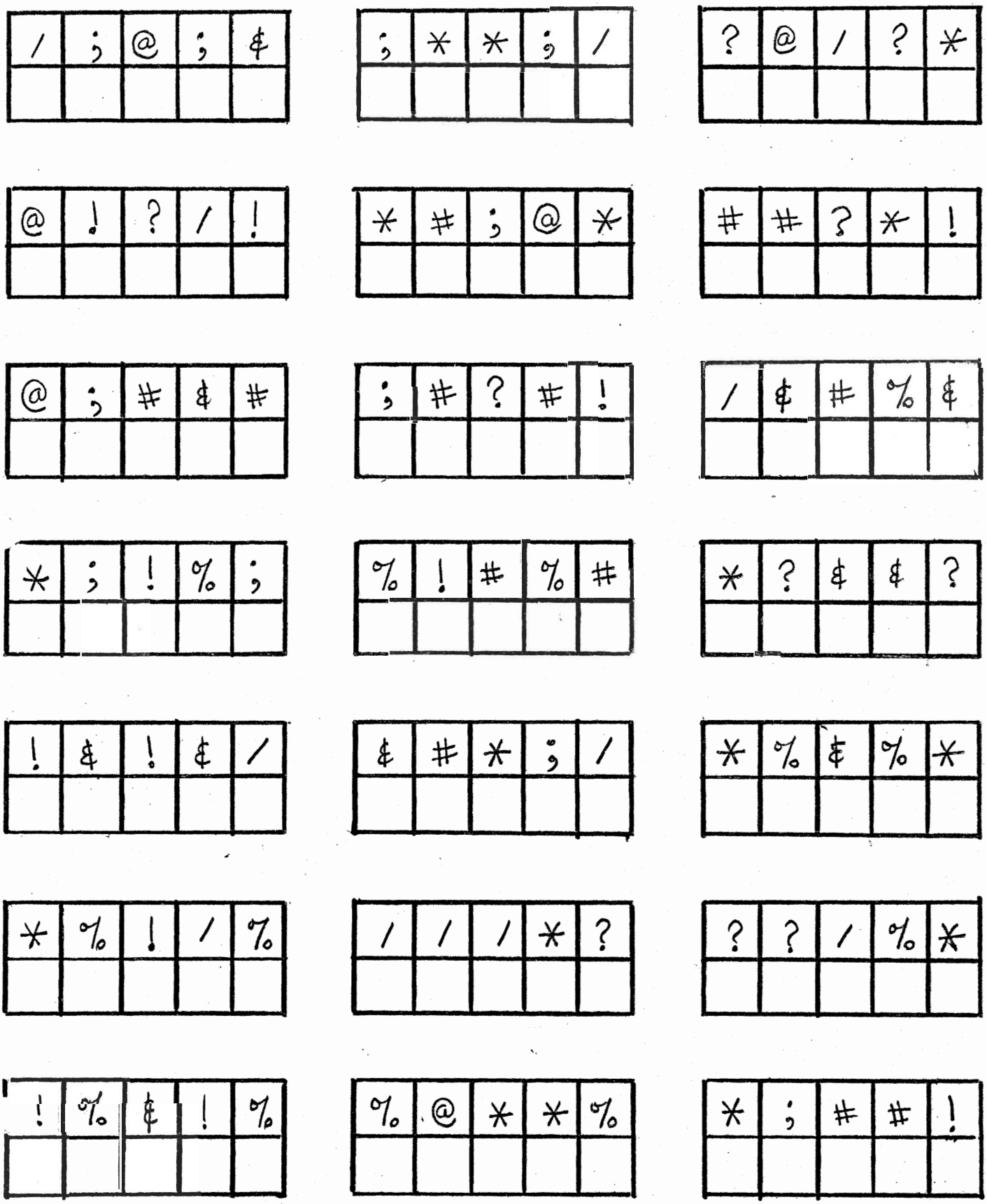


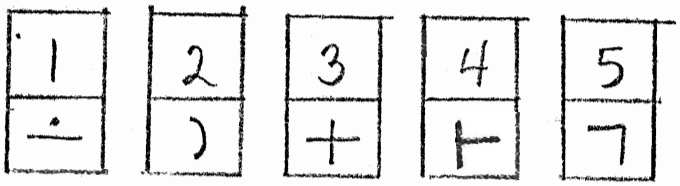
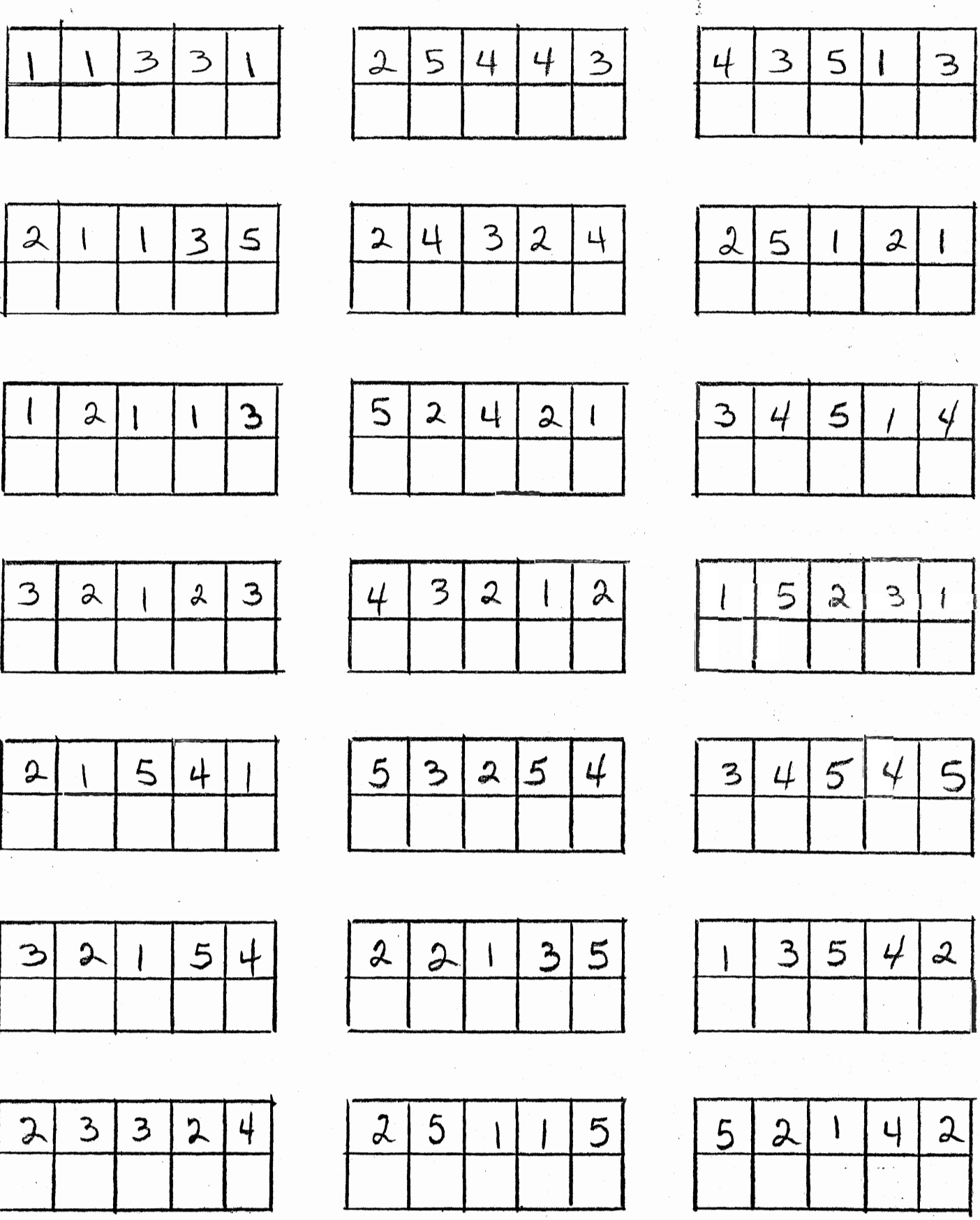


Fig. 2. Actual Coding Tasks.



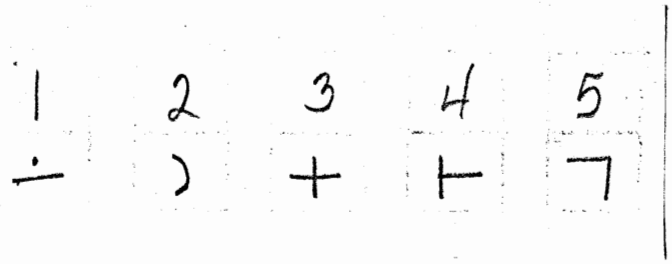


Fig. 2 (2)

4	5	5	4	1

1	3	1	2	2

4	5	4	1	1

3	4	2	4	1

3	1	2	1	2

4	2	5	5	2

5	4	3	5	1

1	3	4	2	1

4	3	2	3	2

4	5	1	4	2

5	4	2	5	2

5	2	4	3	4

2	1	3	3	1

3	2	5	1	1

4	5	5	2	1

5	3	5	3	4

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3	2	1	3	4

2	4	4	1	4

1	2	1	3	2

2	2	5	4	1

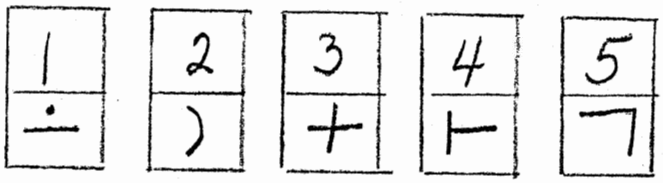
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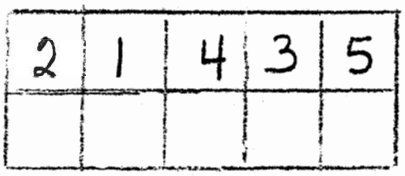
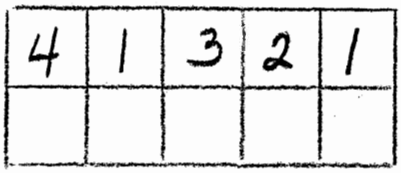
Fig. 2 (3)


2 1 4 3 5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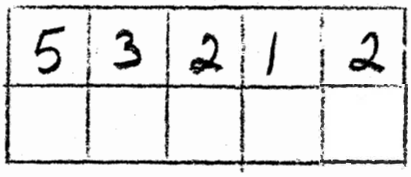
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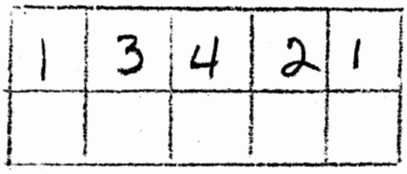
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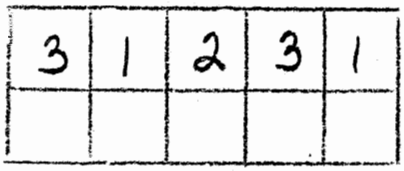
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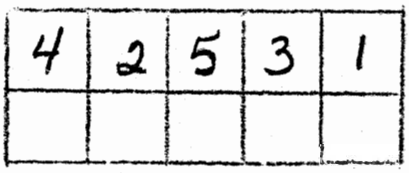
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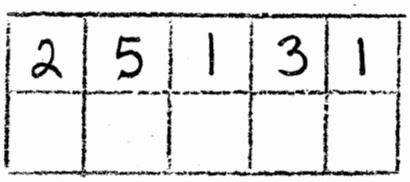
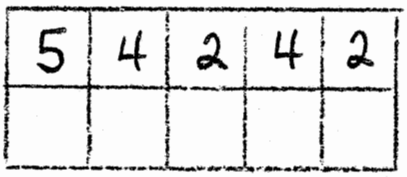

2 5 1 3 1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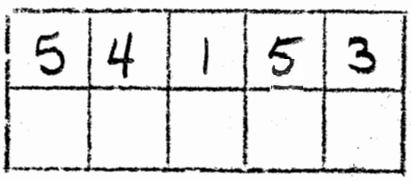
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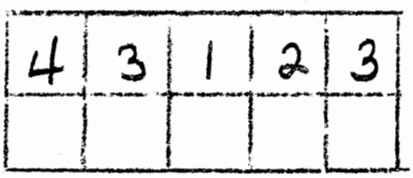
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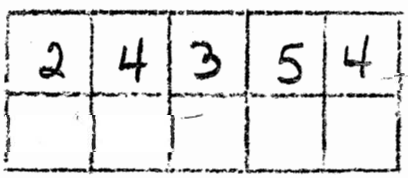
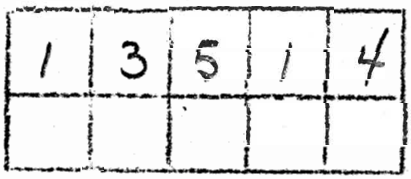
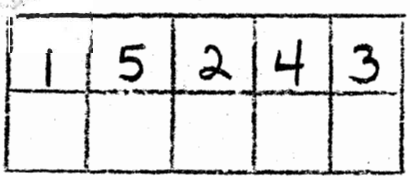
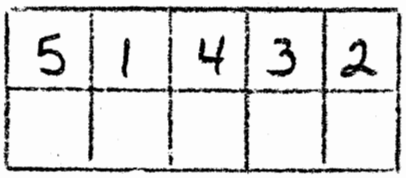

2 4 3 5 4


1 3 5 1 4


1 5 2 4 3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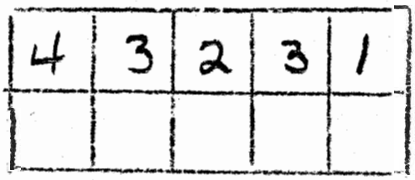
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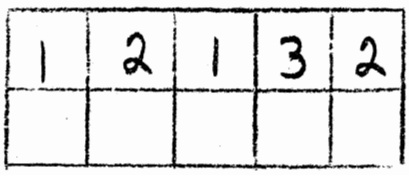
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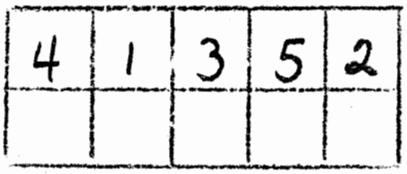
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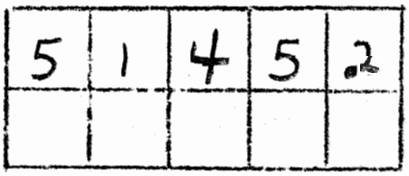
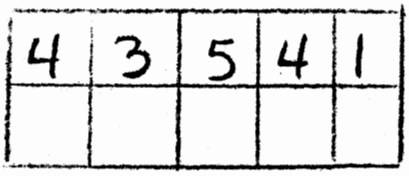

5 1 4 5 2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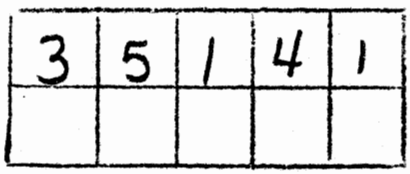
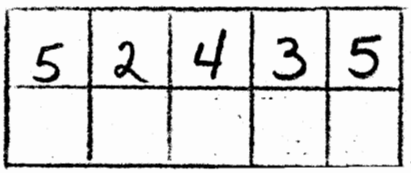

3 5 1 4 1


5 2 4 3 5

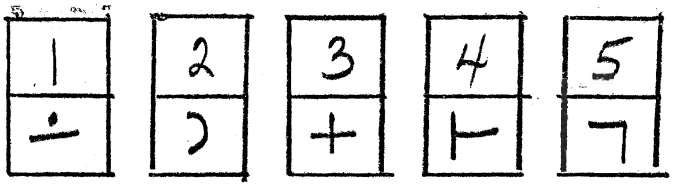


Fig. 2 (4)

1	1	5	1	3

5	1	2	2	5

3	5	1	3	2

2	1	1	3	3

3	1	2	2	1

1	4	3	3	2

5	4	3	3	3

2	1	4	1	5

1	4	4	5	4

1	1	4	5	4

5	5	2	4	2

1	4	3	2	4

1	3	5	4	2

2	2	4	1	2

5	2	2	2	2

5	2	4	2	2

1	1	2	2	5

2	4	2	4	4

3	5	1	5	3

3	5	2	5	4

2	5	1	1	3

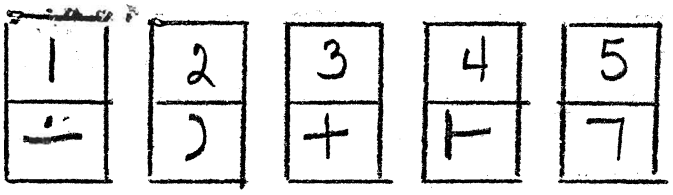


Fig. 2 (5)

2	3	1	1	2

4	5	5	1	5

5	5	5	3	5

1	2	3	4	2

5	3	2	4	5

3	5	2	4	5

4	1	3	1	2

2	4	3	3	2

3	5	3	3	1

3	1	3	2	3

1	2	1	4	1

5	2	5	3	1

3	5	4	3	4

2	2	4	5	2

2	4	2	3	5

4	5	1	5	3

5	5	1	5	1

5	4	2	3	3

5	2	4	4	1

1	3	4	5	2

5	2	3	4	1

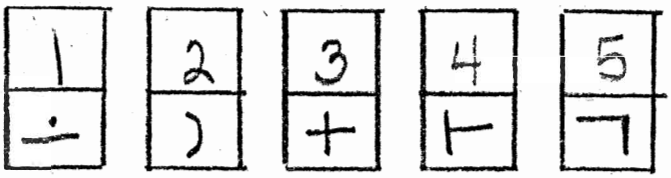


Fig. 2 (6)

2	5	1	3	4

4	1	2	4	1

4	5	4	5	2

3	5	2	3	3

1	4	4	1	3

5	3	5	1	3

4	3	4	5	3

4	5	1	4	5

4	3	5	5	5

4	3	4	3	1

2	5	5	2	3

3	2	3	2	4

4	2	3	3	5

3	3	2	4	5

3	5	2	4	1

3	1	1	4	3

3	2	5	5	5

2	4	1	1	3

3	4	2	2	2

5	3	4	3	3

4	5	3	3	5

1	2	3	4	5	6	7
÷	)	+	⊢	¬	∨	(

Fig. 2 (7)

2	1	4	6	3

5	2	1	3	4

2	1	3	1	2

3	1	4	2	6

3	1	2	5	1

3	1	5	4	2

7	4	2	6	1

2	5	4	7	6

1	5	4	6	4

3	1	2	7	6

2	5	4	7	3

6	5	4	1	6

3	7	5	1	4

1	5	7	6	7

2	4	3	5	6

7	1	4	3	6

2	7	3	1	5

2	3	4	6	4

1	5	3	7	2

1	5	7	6	7

1	2	7	6	3

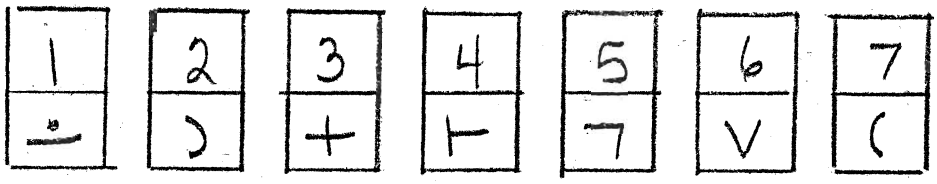


Fig. 2 (8)

1	1	5	1	6

3	5	1	2	2

5	3	7	5	1

3	6	7	2	2

1	1	3	3	3

6	1	6	2	6

6	2	1	1	4

6	3	3	7	6

2	5	6	4	3

3	7	6	3	2

7	6	6	1	4

7	6	1	5	1

6	4	4	5	7

6	4	7	1	1

4	5	4	7	7

5	5	2	4	2

6	1	6	4	3

2	6	4	1	3

5	4	3	2	2

2	6	4	1	2

7	6	5	2	2

1	2	3	4	5	6	7
÷	)	+	⊢	⊣	∨	(

Fig. 2 (9)

2	2	5	2	7

7	7	4	6	6

2	2	1	1	2

2	6	5	2	6

4	7	2	4	7

4	3	6	7	5

6	6	7	1	5

3	6	3	5	2

5	6	4	2	6

5	7	1	6	1

3	4	2	1	1

5	1	3	2	3

6	1	1	2	4

5	7	5	1	6

5	7	5	5	5

3	5	1	2	3

4	2	5	6	7

7	3	2	6	7

4	7	7	5	3

5	7	2	4	6

5	4	1	3	6

1	2	3	4	5	6	7
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Fig. 2 (10)

1	2	7	2	7

4	3	3	7	6

2	3	5	7	3

3	6	1	3	1

3	2	3	1	6

2	6	7	1	6

4	1	7	7	6

6	5	2	5	7

3	7	1	7	3

7	7	5	4	3

4	2	2	7	4

5	2	7	2	4

2	3	5	6	4

6	5	6	6	1

7	5	3	7	5

5	1	5	1	5

4	7	6	6	2

6	3	3	5	2

4	4	7	7	1

1	3	7	7	4

7	7	5	6	2

7-5

1	2	3	4	5	6	7
÷	)	+	⊢	7	V	(

Fig. 2 (11)

5	2	3	4	1

1	7	6	2	5

7	7	1	6	3

4	4	1	6	2

6	6	4	1	4

6	5	4	5	2

3	5	7	2	3

6	3	1	4	6

7	4	1	3	5

3	5	1	7	3

4	3	4	5	3

4	5	1	7	4

5	4	3	5	5

5	4	6	6	3

4	6	7	3	1

2	5	5	7	2

3	3	7	7	2

3	6	2	6	6

7	6	4	4	2

3	6	3	5	6

3	6	3	2	6

T-6

1	2	3	4	5	6	7
÷	)	+	⊢	¬	∨	(

Fig. 2 (12)

4	5	3	7	5

3	3	2	6	

4	5	2	4	7

1	3	1	1	4

3	3	2	9	5

9	5	5	2	6

4	1	1	3	3

4	2	2	7	2

5	3	4	6	3

3	4	7	5	3

3	5	4	5	5

6	1	6	4	4

4	5	4	7	7

6	7	2	3	3

2	7	7	4	5

7	2	2	4	5

3	6	1	6	5

7	7	1	2	4

1	2	5	4	1

2	6	4	5	5

5	2	1	7	2

1	2	3	4	5	6	7	8	9
÷	)	+	⊢	⅂	V	(	·	⊣

Fig. 2 (13)

2	1	4	6	3

5	2	6	2	3

2	8	8	1	8

5	9	8	9	3

2	7	7	1	4

6	7	3	8	1

6	3	5	1	8

9	1	2	1	6

5	7	4	7	1

9	6	3	9	7

2	4	9	1	7

1	2	2	8	9

2	4	9	9	1

7	6	5	2	9

9	2	2	2	6

8	3	6	9	2

3	4	4	1	2

2	6	8	6	1

9	1	9	4	4

3	3	1	7	9

5	4	7	8	4

1	2	3	4	5	6	7	8	9
÷	)	+	⊢	¬	∨	(	·	⊣

Fig. 2 (14)

1	9	1	4	2

4	7	9	7	5

6	7	8	3	1

5	9	6	7	4

2	1	9	1	3

4	3	3	5	6

2	2	5	1	7

7	8	2	9	9

3	7	2	3	7

6	3	5	4	1

6	7	3	7	2

9	7	4	1	2

7	4	1	2	1

3	2	6	2	6

5	5	9	3	5

9	5	9	5	9

6	3	1	4	1

8	1	4	5	3

8	1	6	5	1

2	9	5	8	7

1	9	7	7	8

1	2	3	4	5	6	7	8	9
-	)	+	⊢	⅂	V	(	÷	⊣

Fig. 2 (15)

2	6	9	7	3

1	7	4	9	4

8	3	7	6	3

8	8	3	3	2

7	4	2	7	3

1	5	6	4	9

2	1	7	4	5

9	4	8	5	6

5	7	2	3	1

2	8	1	3	7

1	7	7	2	3

2	5	6	3	7

7	4	9	7	5

4	8	4	3	7

5	2	3	3	3

7	3	6	5	9

3	4	6	8	6

4	6	3	1	5

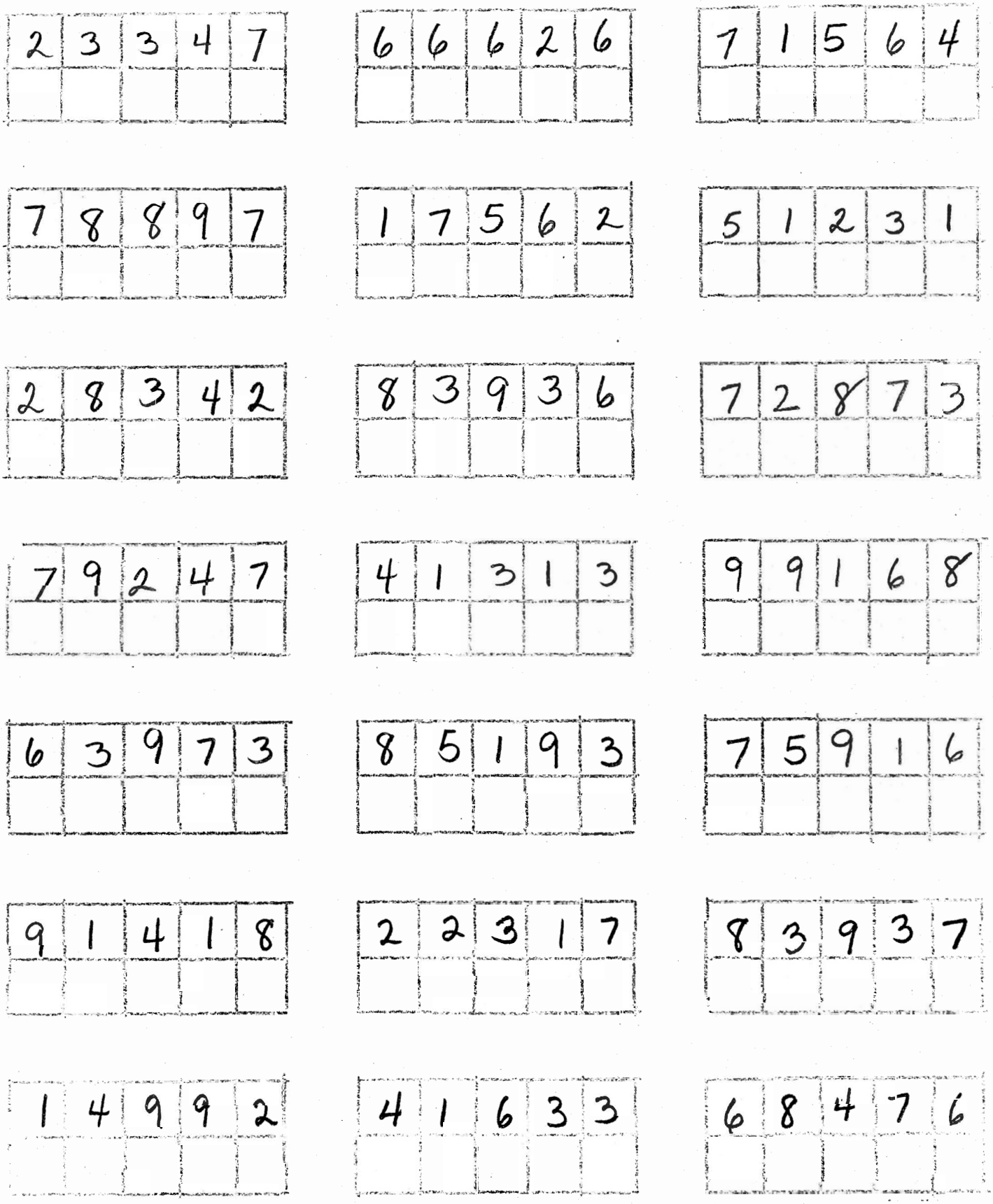
6	5	6	9	4

3	5	9	4	2

8	7	3	2	9

1	2	3	4	5	6	7	8	9
÷	)	+	⊢	⅂	V	(	÷	⊣

Fig. 2 (16)



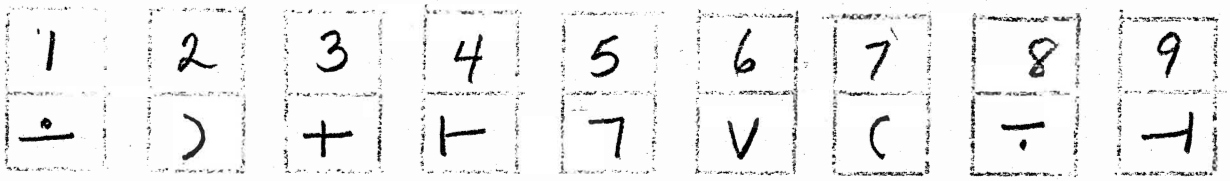
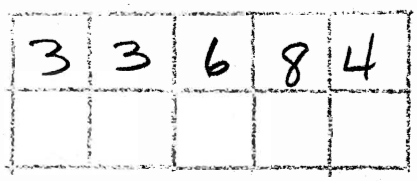
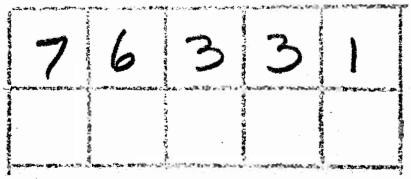
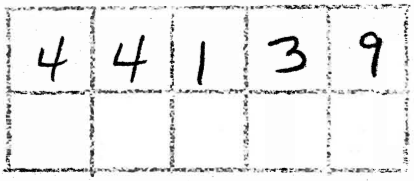
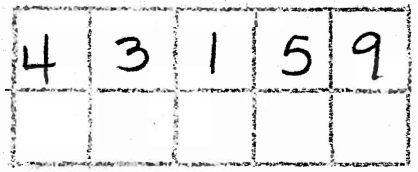

1 2 3 4 5 6 7 8 9
÷) + ⊢ 7 V (÷ ⊣

Fig. 2 (17)


3 3 6 8 4


7 6 3 3 1


4 4 1 3 9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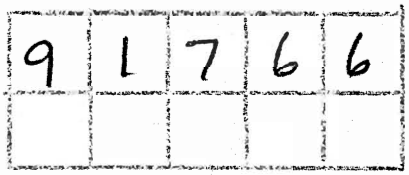
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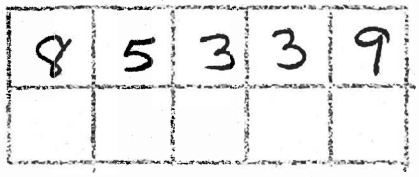
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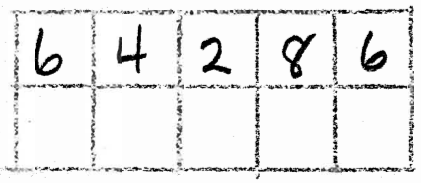
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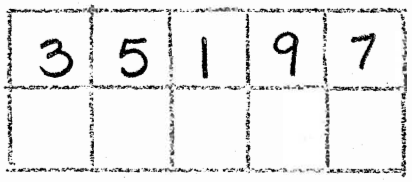
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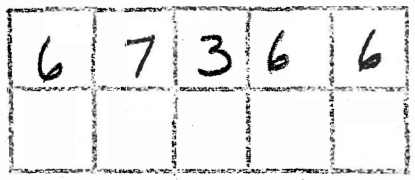
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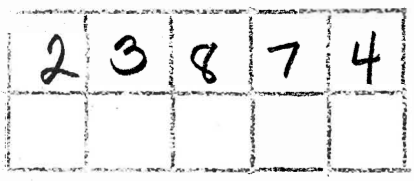
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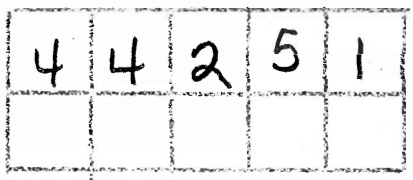
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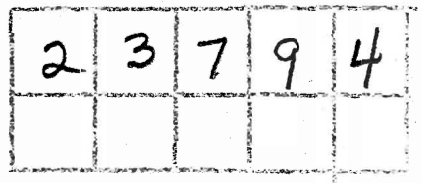
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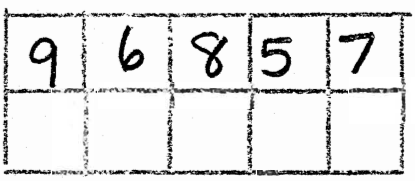
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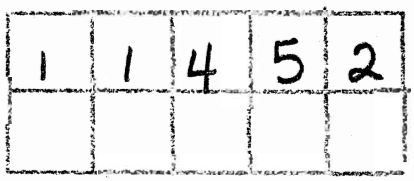
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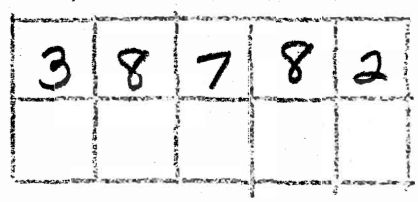
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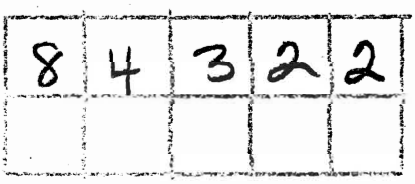
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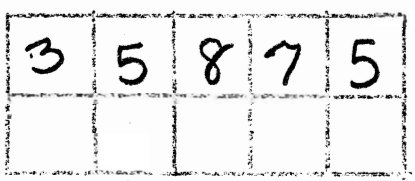
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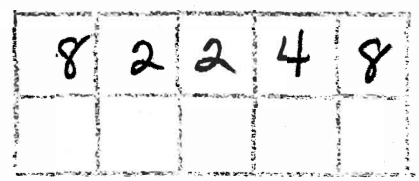
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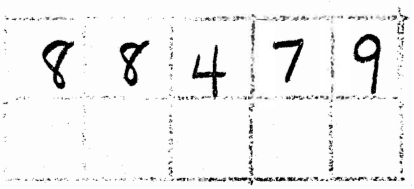
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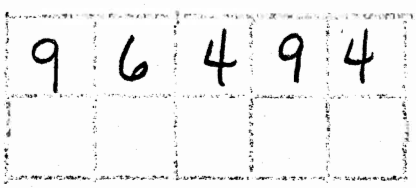
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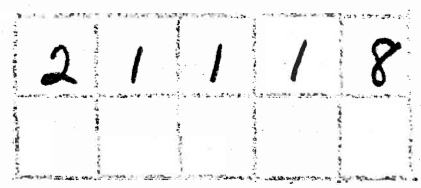
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Fig. 2 (18)

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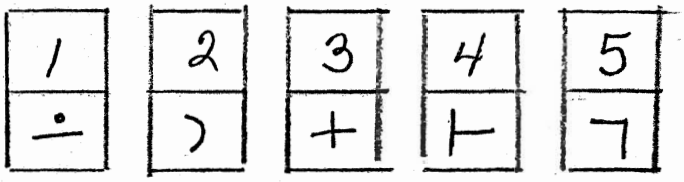
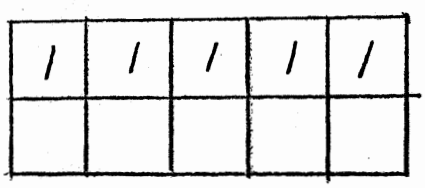
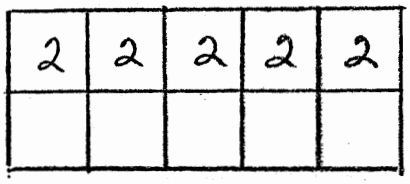
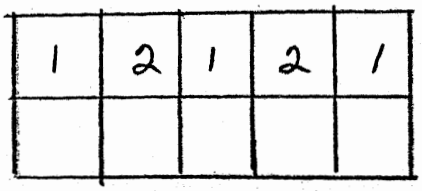
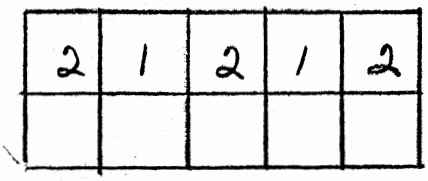


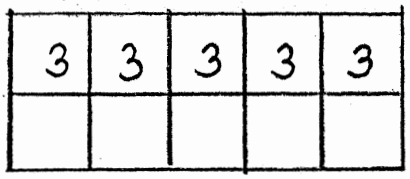
Fig. 3. Rehearsal Strategy Task.

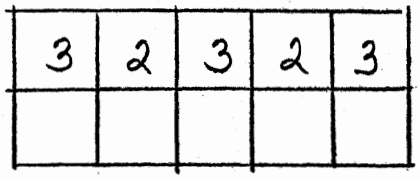


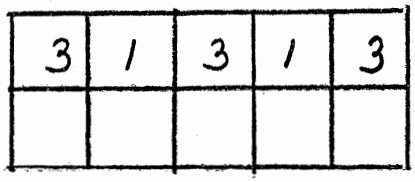


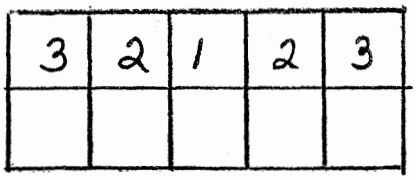


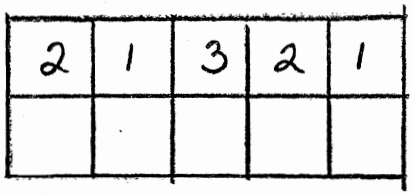


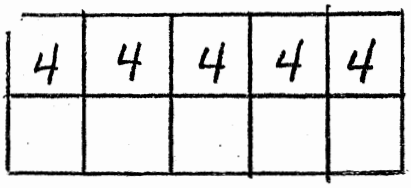


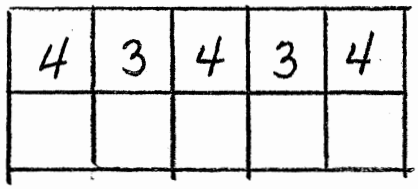


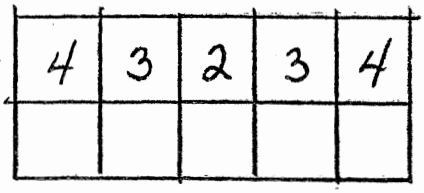


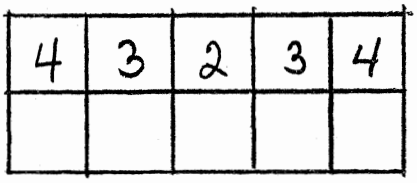


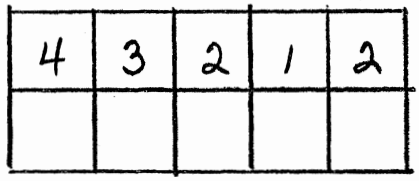


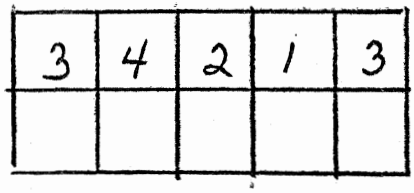


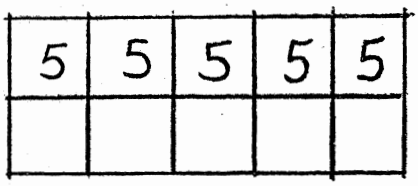


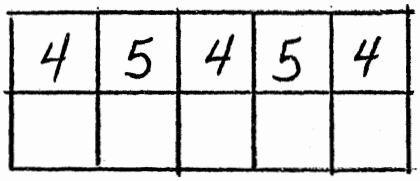


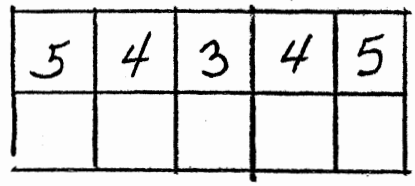


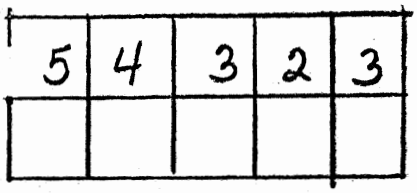


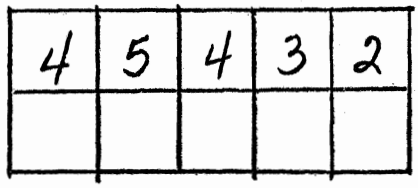


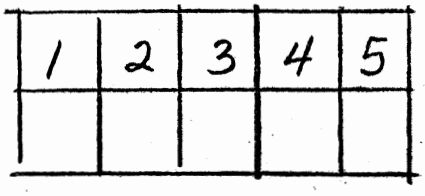












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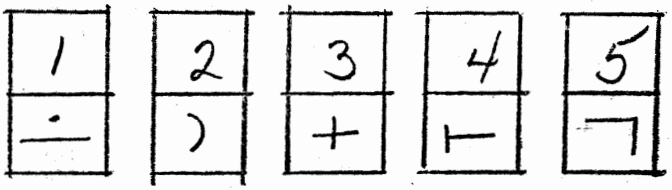
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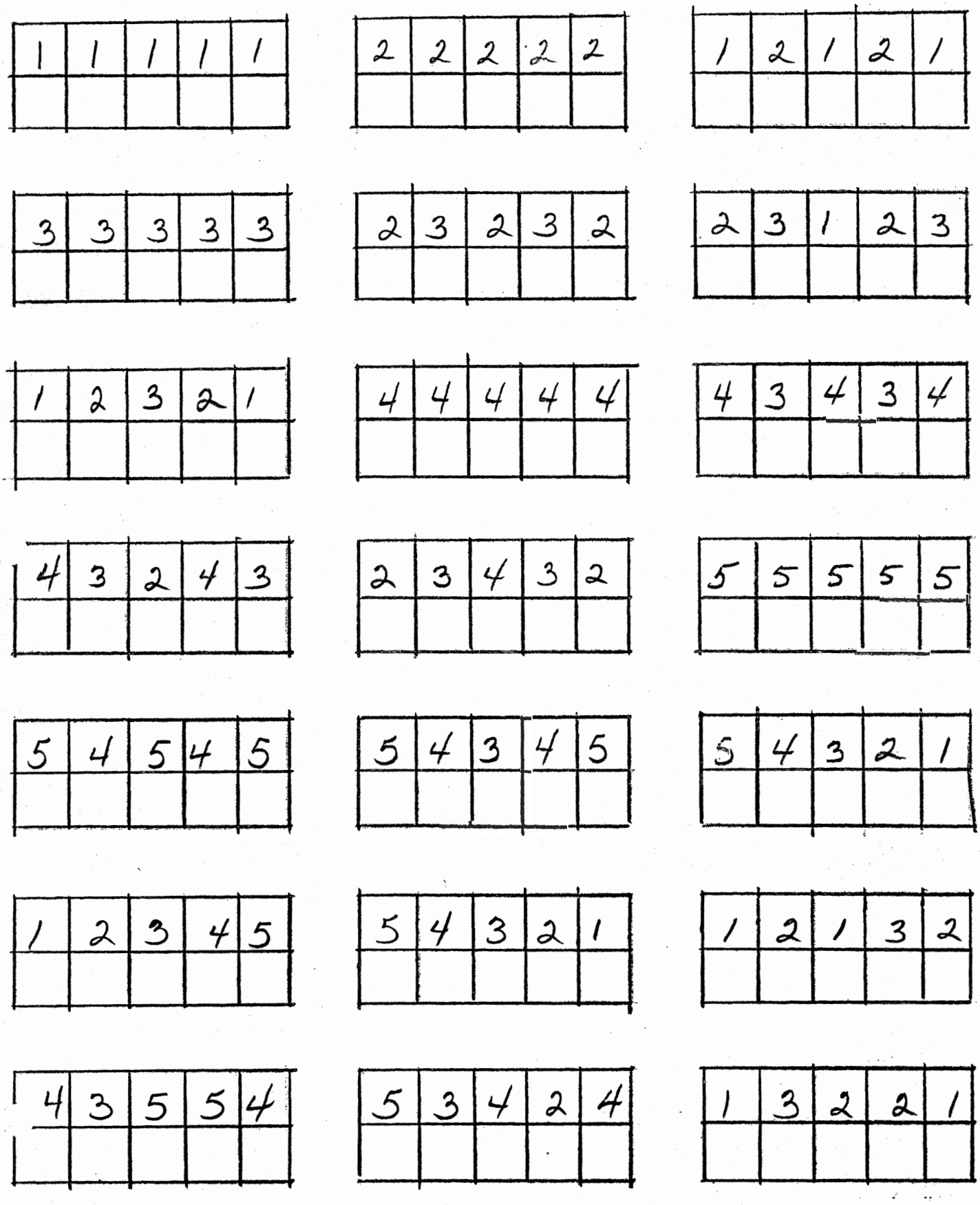
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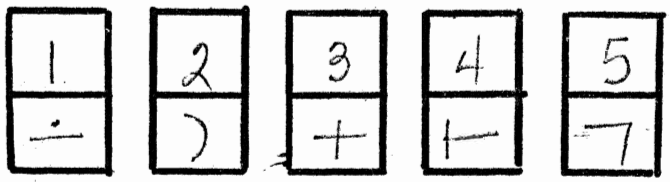
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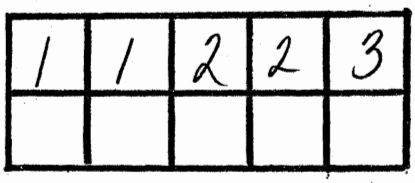
Fig. 3 (3)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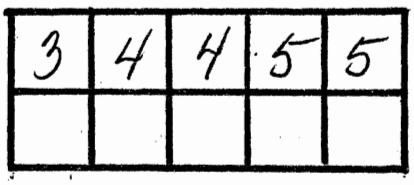
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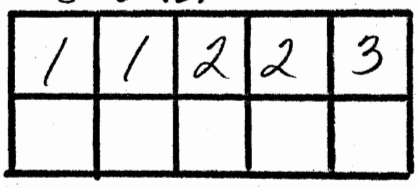
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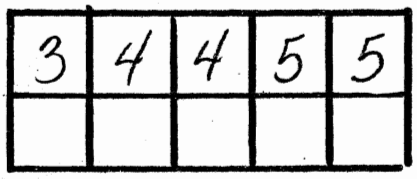
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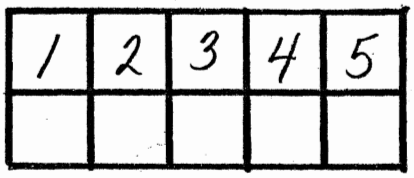
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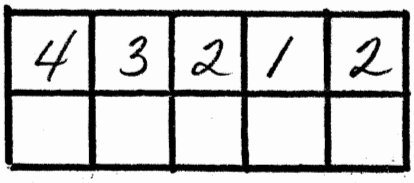
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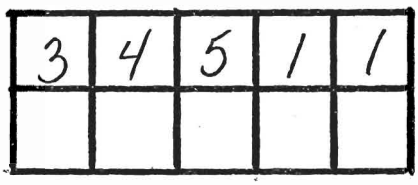
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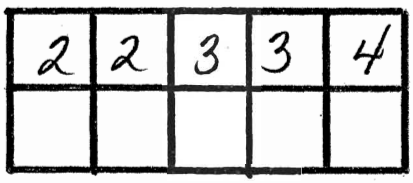
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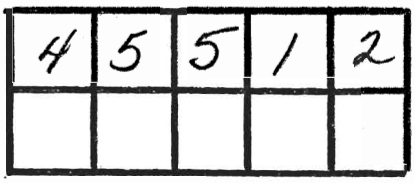
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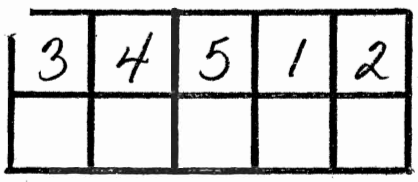
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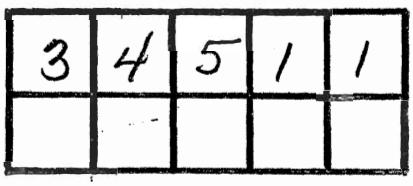
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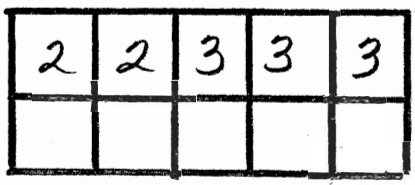
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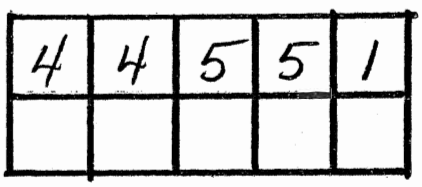
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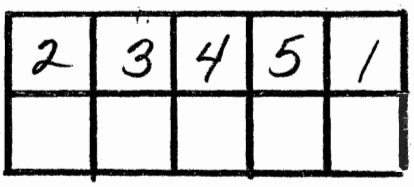
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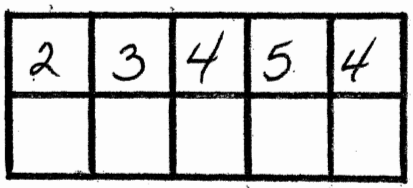
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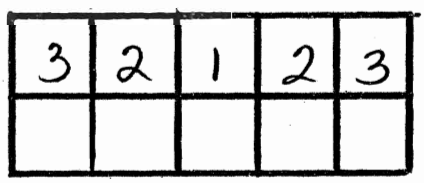
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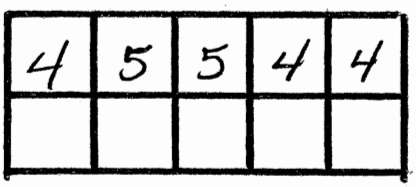
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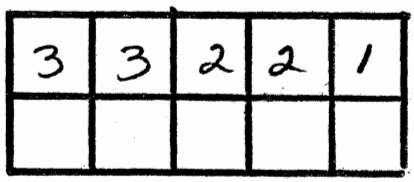
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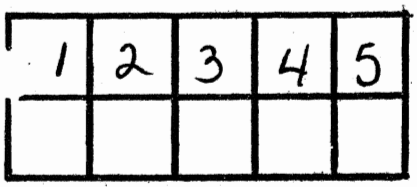
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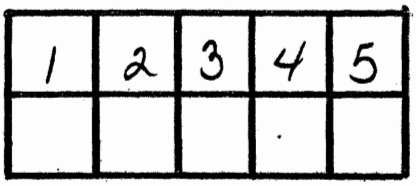
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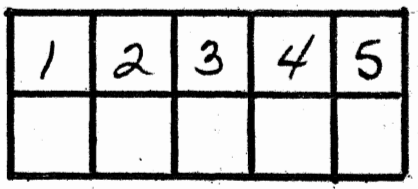
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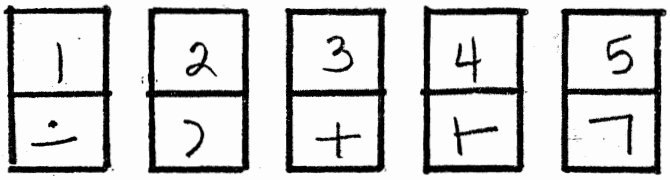
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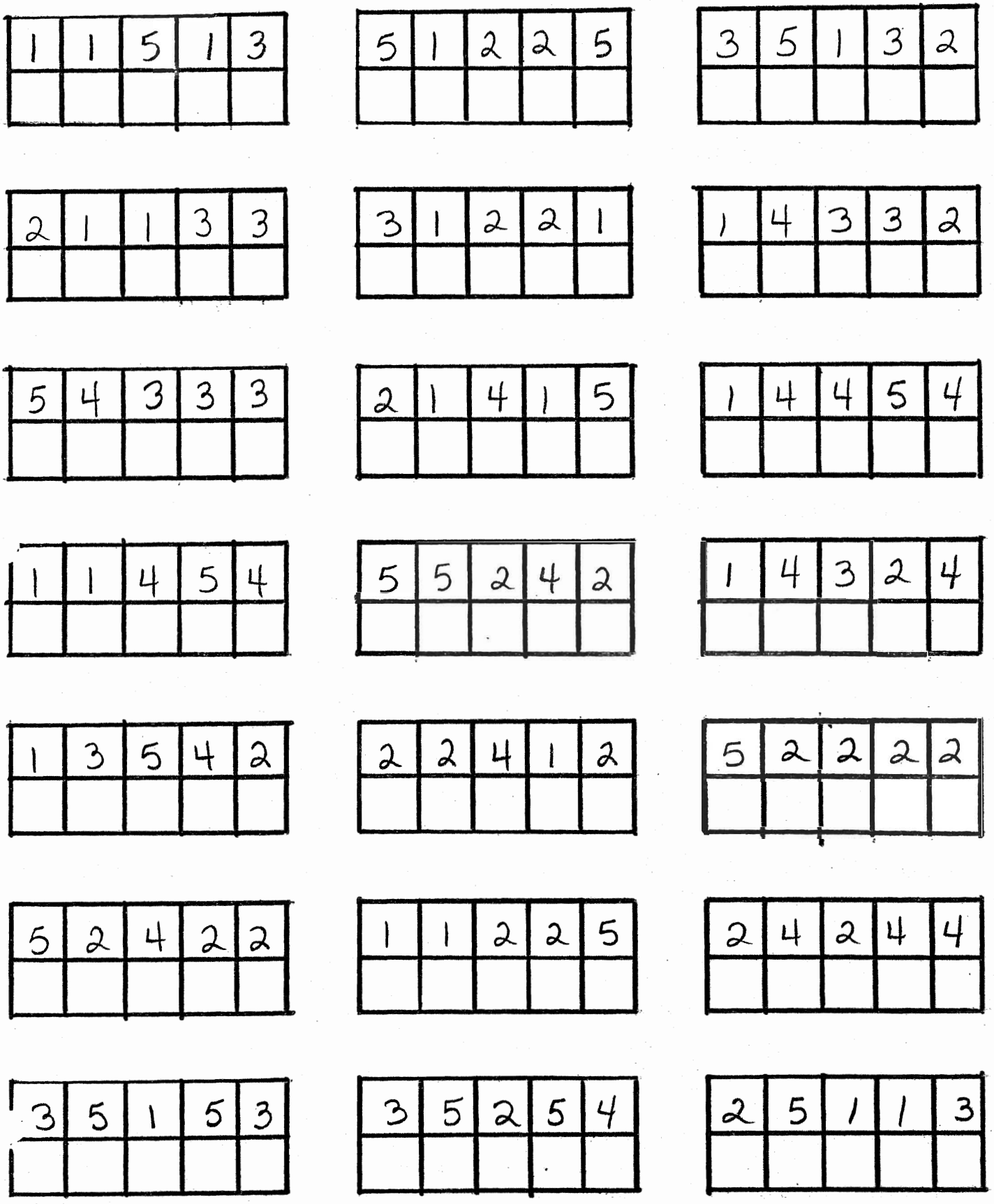
Fig. 3 (4)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5 1 2 2 5
3 5 1 3 2
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1 4 3 3 2
5 4 3 3 3
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1 1 4 5 4
5 5 2 4 2
1 4 3 2 4
1 3 5 4 2
2 2 4 1 2
5 2 2 2 2
5 2 4 2 2
1 1 2 2 5
2 4 2 4 4
3 5 1 5 3
3 5 2 5 4
2 5 1 1 3

1	2	3	4	5
÷	)	+	⊢	⊓

Fig. 3 (5)

2	3	1	1	2

4	5	5	1	5

5	5	5	3	5

1	2	3	4	2

5	3	2	4	5

3	5	2	4	5

4	1	3	1	2

2	4	3	3	2

3	5	3	3	1

3	1	3	2	3

1	2	1	4	1

5	2	5	3	1

3	5	4	3	4

2	2	4	5	2

2	4	2	3	5

4	5	1	5	3

5	5	1	5	1

5	4	2	3	3

5	2	4	4	1

1	3	4	5	2

5	2	3	4	1

5-6
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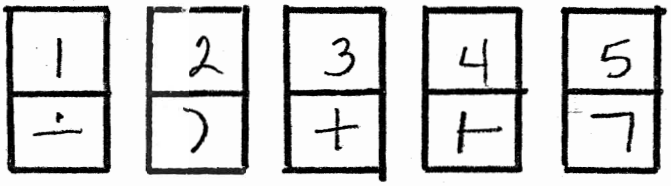
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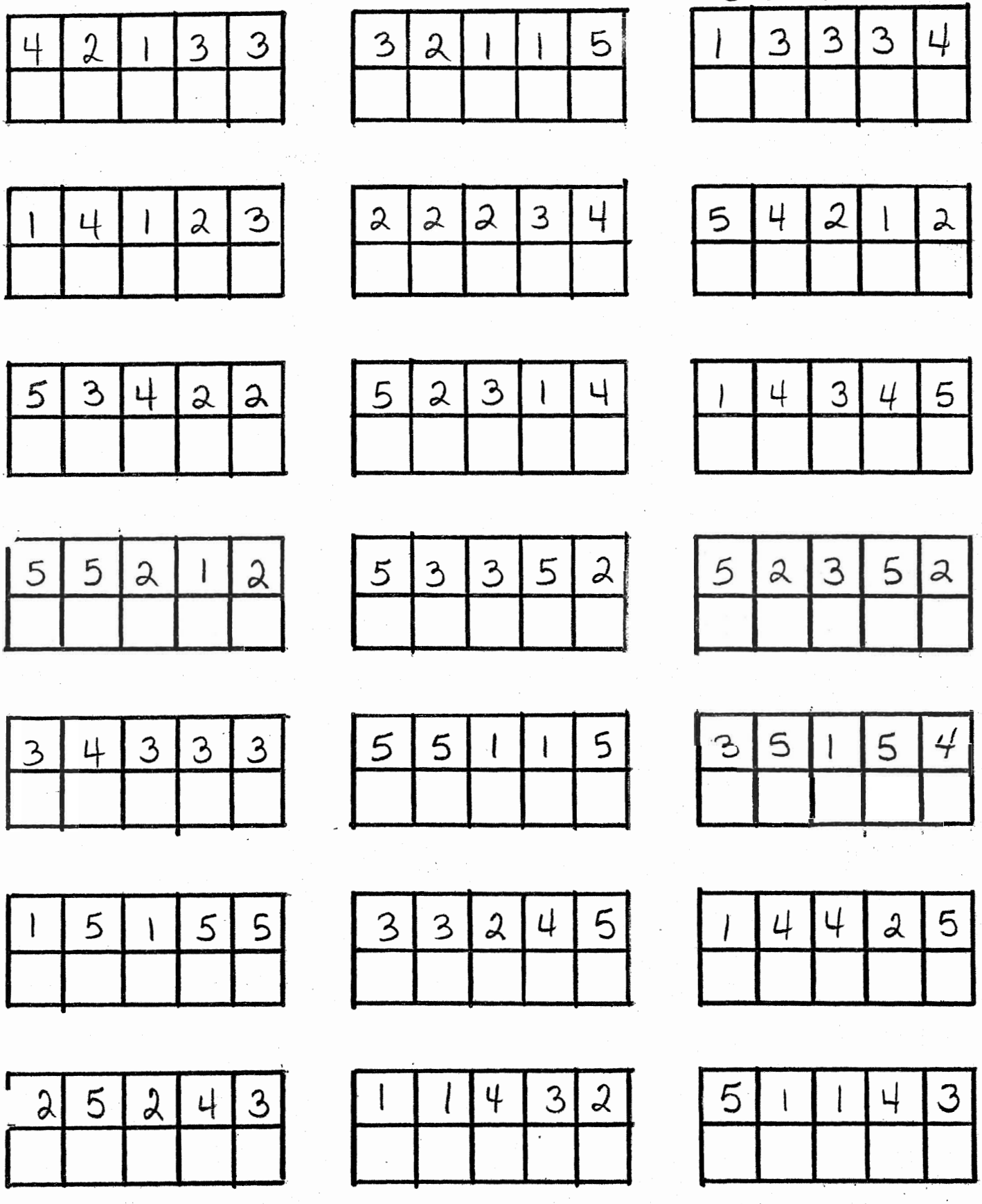
Fig. 3 (6)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5 4 2 1 2
5 3 4 2 2
5 2 3 1 4
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5 5 2 1 2
5 3 3 5 2
5 2 3 5 2
3 4 3 3 3
5 5 1 1 5
3 5 1 5 4
1 5 1 5 5
3 3 2 4 5
1 4 4 2 5
2 5 2 4 3
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7-1
S

1	2	3	4	5	6	7
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Fig. 3 (7)

1	1	1	1	1

2	2	2	2	2

1	2	1	2	1

2	1	2	1	2

3	3	3	3	3

3	2	3	2	3

3	1	3	1	3

3	2	1	2	3

2	1	3	2	1

4	4	4	4	4

4	3	4	3	4

4	3	2	3	4

4	3	2	3	4

4	3	2	1	2

3	4	2	1	3

5	5	5	5	5

4	5	4	5	4

5	4	3	4	5

5	4	3	2	3

4	5	4	3	2

1	2	3	4	5

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Fig. 3 (8)

6	6	6	6	6

6	5	6	5	6

6	5	4	5	6

6	5	4	3	4

5	6	5	4	3

2	3	4	5	6

7	7	7	7	7

7	6	7	6	7

7	6	5	6	7

7	6	5	4	5

6	7	6	5	4

3	4	5	6	7

6	5	4	3	2

3	4	5	6	7

6	5	4	3	2

1	2	3	4	5

6	7	6	7	6

5	6	4	5	3

4	2	3	1	6

7	4	3	1	2

5	6	2	7	3

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Fig. 3 (9)

1	1	1	2	2

2	3	3	3	4

4	4	5	5	5

6	6	6	7	7

7	1	1	2	2

3	3	4	4	5

5	6	6	7	7

1	2	3	4	5

6	7	1	2	3

4	5	6	7	1

1	1	2	2	3

3	4	4	5	5

6	6	7	7	1

2	3	4	5	6

7	6	5	4	3

2	1	2	3	4

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6	7	7	7	7

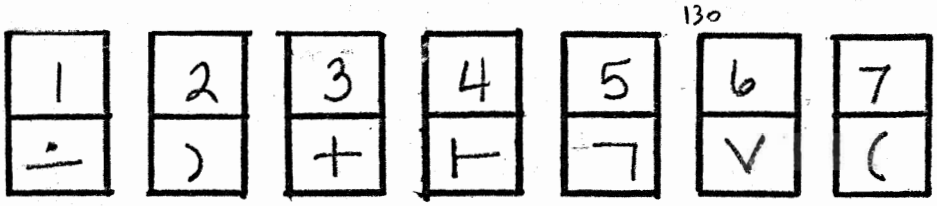
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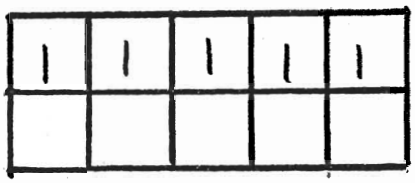
Fig. 3 (10)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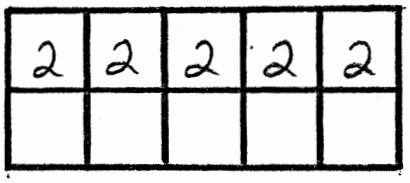
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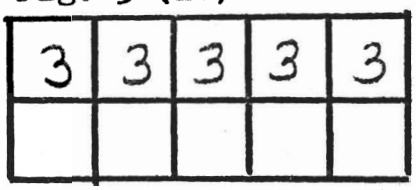
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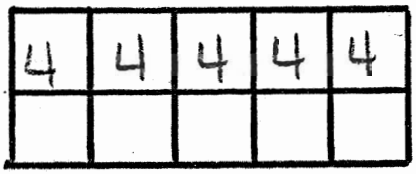
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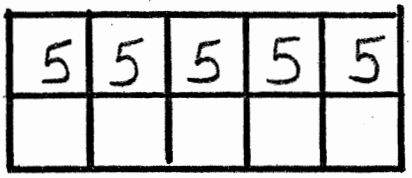
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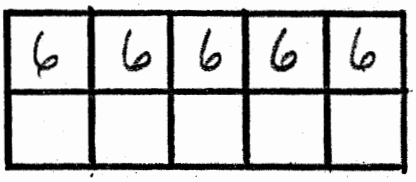
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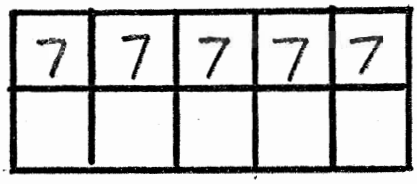
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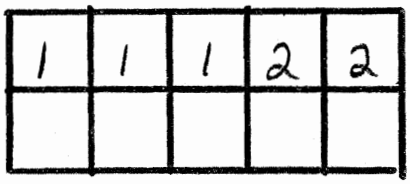
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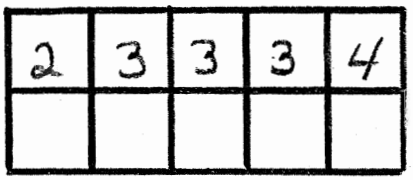
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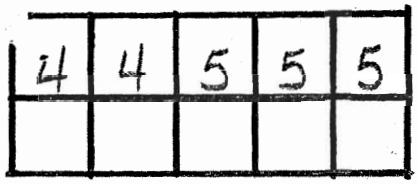
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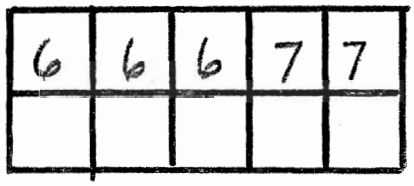
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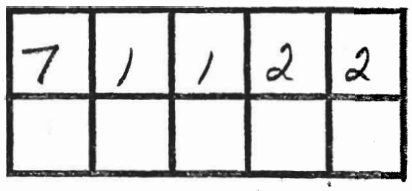
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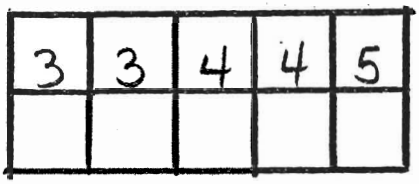
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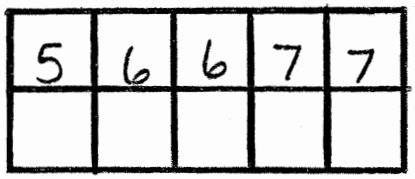
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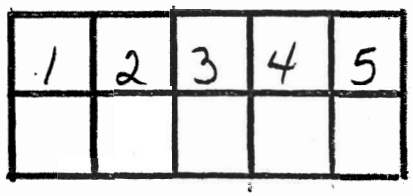
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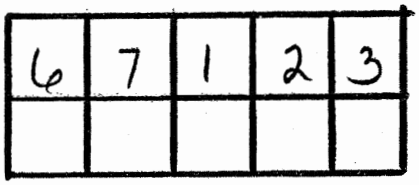
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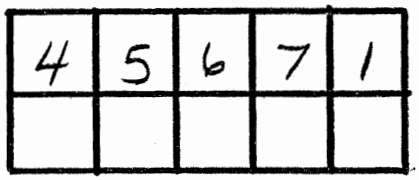
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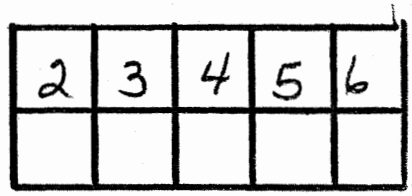
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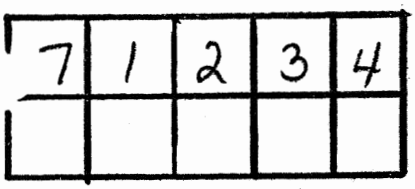
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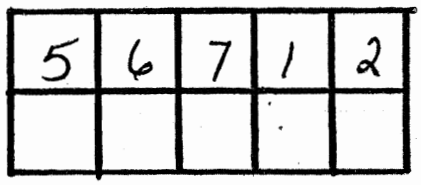
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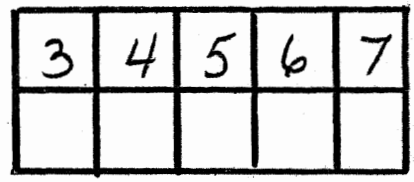
3 4 5 6 7

1	2	3	4	5	6	7
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Fig. 3 (11)

1	2	7	2	7

4	3	3	7	6

2	3	5	7	3

3	6	1	3	1

3	2	3	1	6

2	6	7	1	6

4	1	7	7	6

6	5	2	5	7

3	7	1	7	3

7	7	5	4	3

4	2	2	7	4

5	2	7	2	4

2	3	5	6	4

6	5	6	6	1

7	5	3	7	5

5	1	5	1	5

4	7	6	6	2

6	3	3	5	2

4	4	7	7	1

1	3	7	7	4

7	7	5	6	2

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Fig. 3 (12)

5	2	3	4	1

1	7	6	2	5

7	7	1	6	3

4	4	1	6	2

6	6	4	1	4

6	5	4	5	2

3	5	7	2	3

6	3	1	4	6

7	4	1	3	5

3	5	1	7	3

4	3	4	5	3

4	5	1	7	4

5	4	3	5	5

5	4	6	6	3

4	6	7	3	1

2	5	5	7	2

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7	6	4	4	2

3	6	3	5	6

3	6	3	2	6

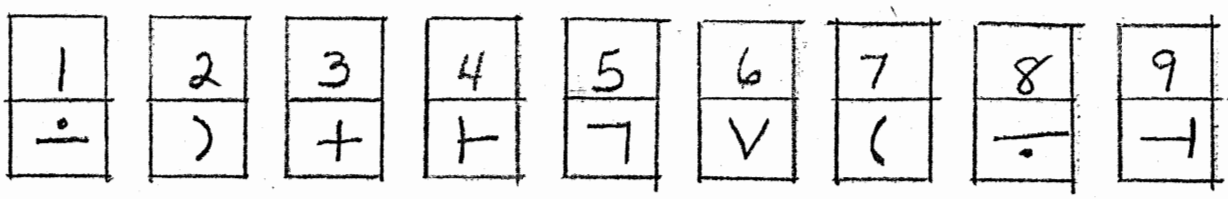
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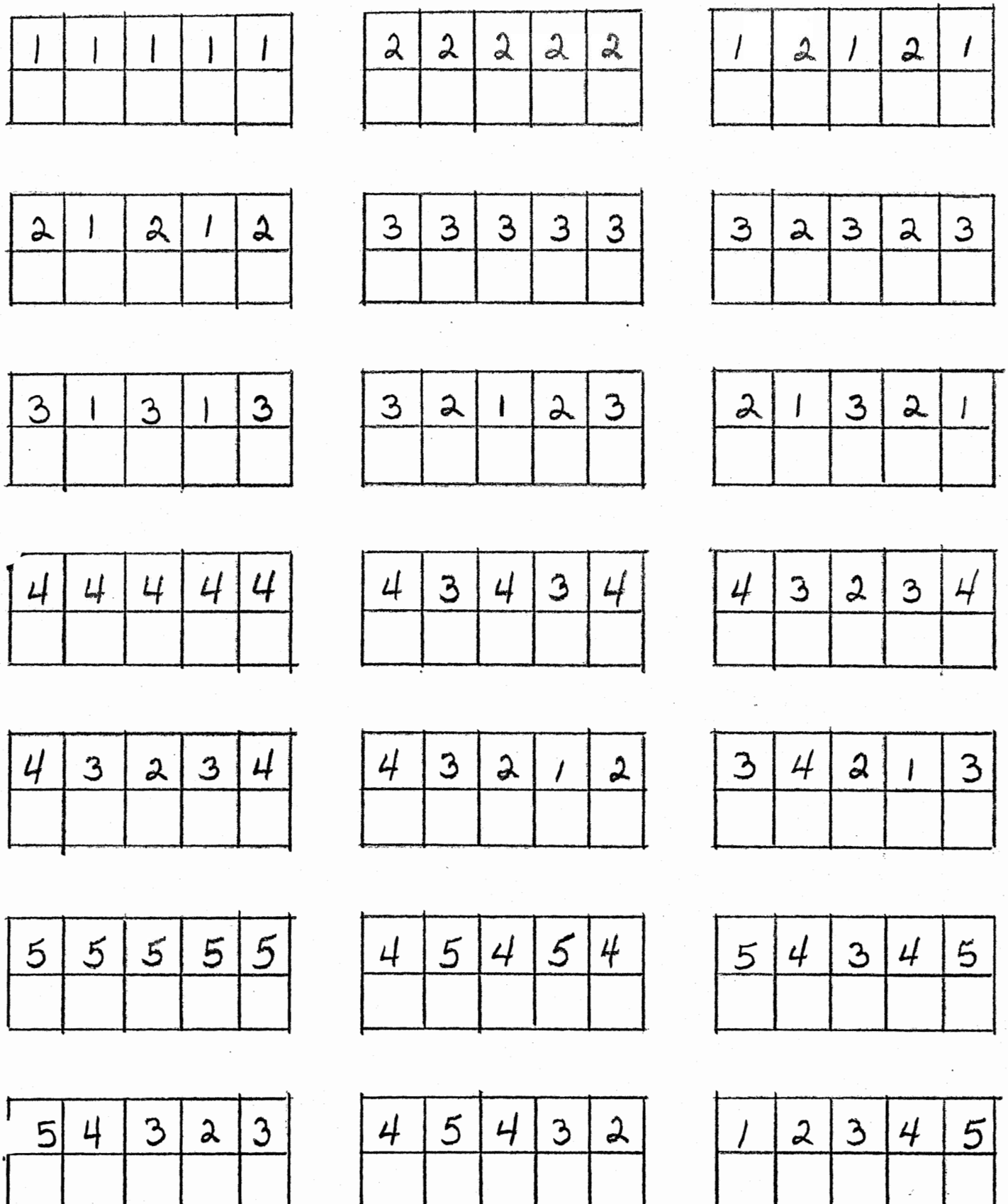
Fig. 3 (13)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2 1 2 1 2
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3 2 3 2 3
3 1 3 1 3
3 2 1 2 3
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4 4 4 4 4
4 3 4 3 4
4 3 2 3 4
4 3 2 3 4
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3 4 2 1 3
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4 5 4 3 2
1 2 3 4 5

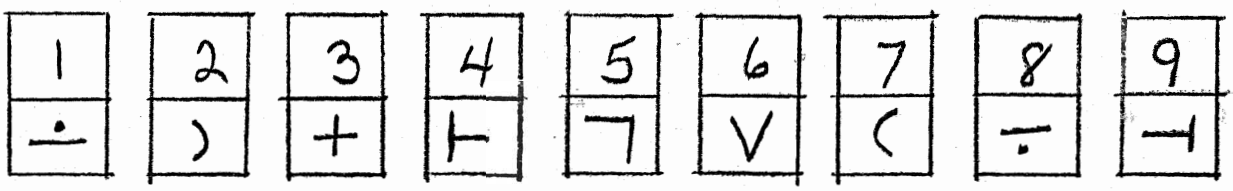
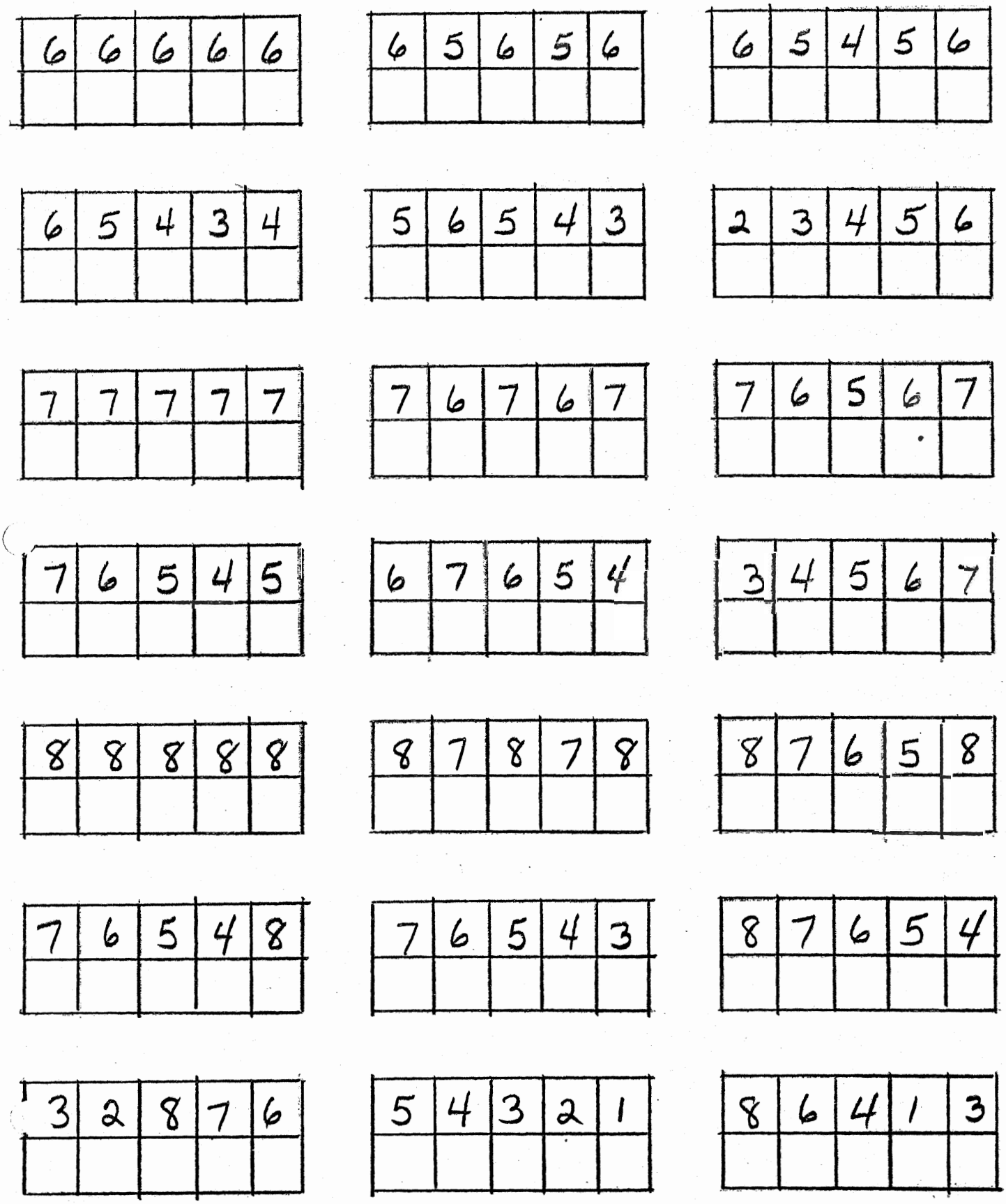

1 2 3 4 5 6 7 8 9

Fig. 3 (14)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7 6 7 6 7
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7 6 5 4 5
6 7 6 5 4
3 4 5 6 7
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7 6 5 4 8
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8 6 4 1 3

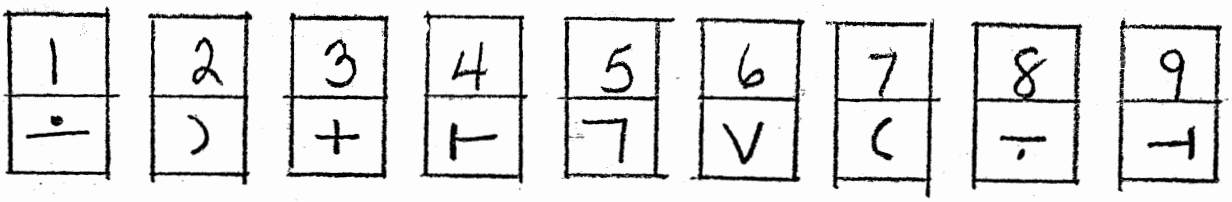

Fig. 3 (15)

9	9	9	9	9

8	9	8	9	8

9	8	7	9	8

7	6	7	8	9

8	7	6	5	6

7	8	9	8	7

6	5	4	5	6

7	8	9	8	7

6	5	4	3	4

5	6	7	8	9

8	7	6	5	4

3	2	3	4	5

6	7	8	9	8

7	6	5	4	3

2	1	2	3	4

5	6	7	8	9

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9	9	8	5	8

4	3	8	3	4

9	2	5	8	1

6	7	2	7	6

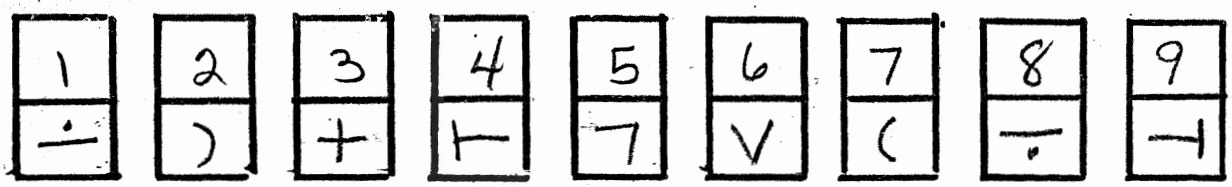
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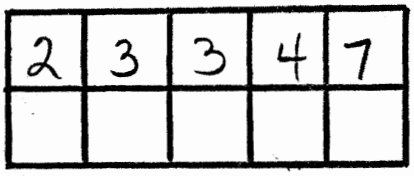
Fig. 3 (16)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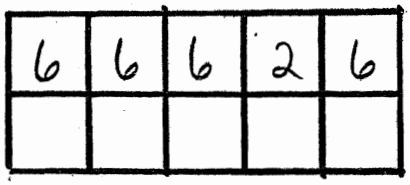
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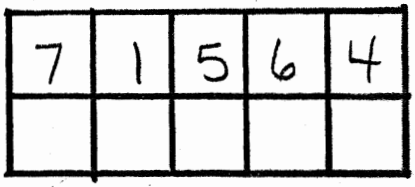
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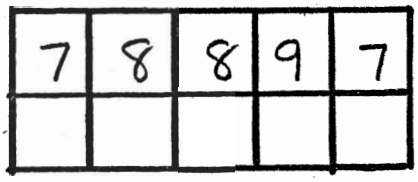
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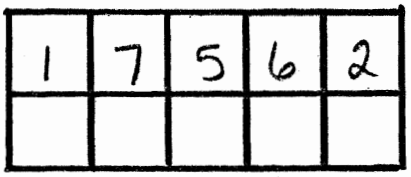
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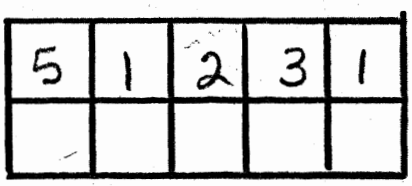
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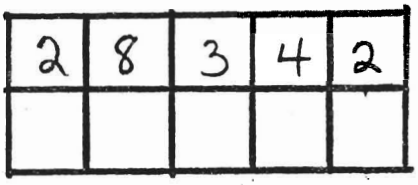
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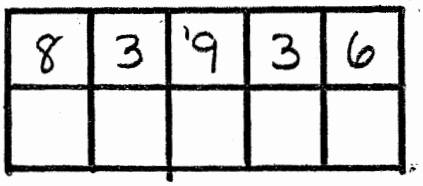
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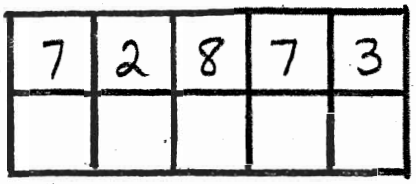
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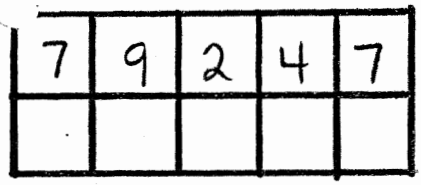
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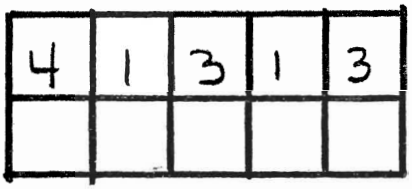
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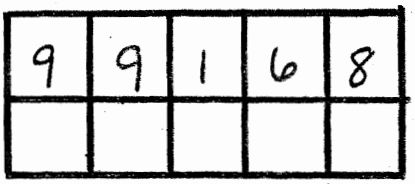
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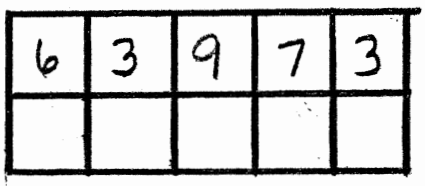
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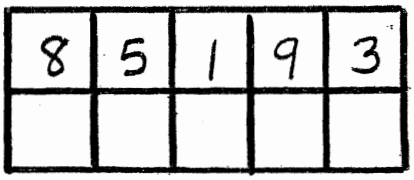
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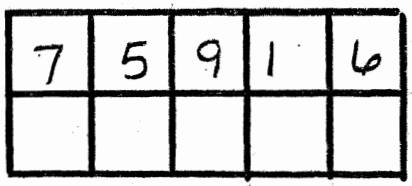
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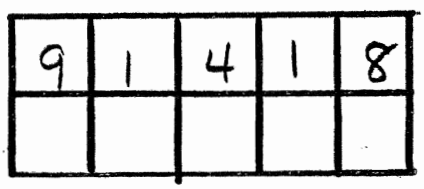
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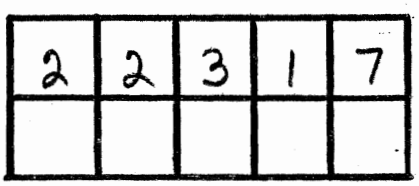
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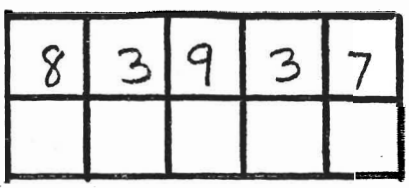
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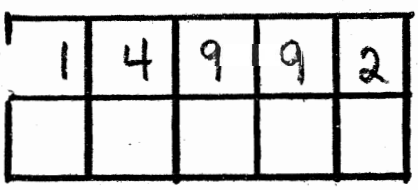
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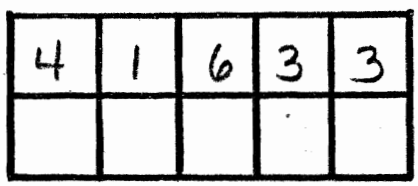
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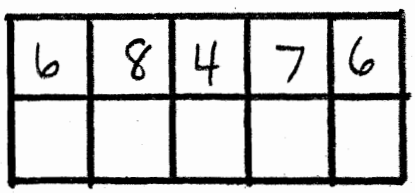
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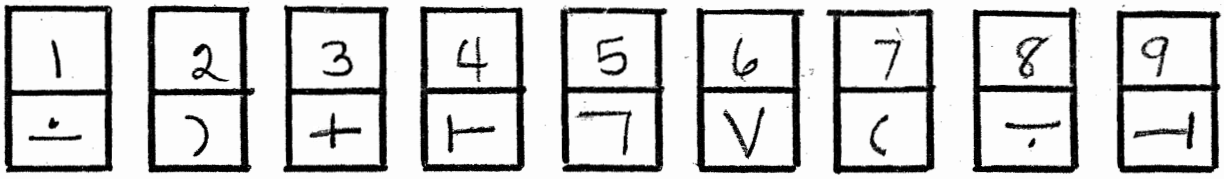
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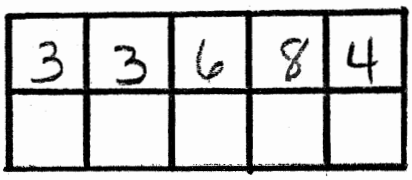
Fig. 3 (17)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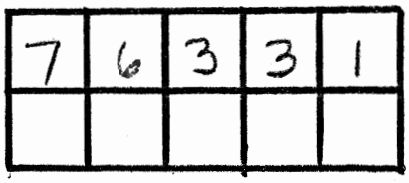
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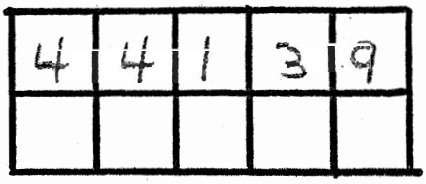
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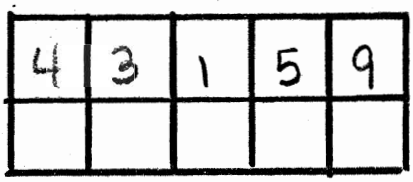
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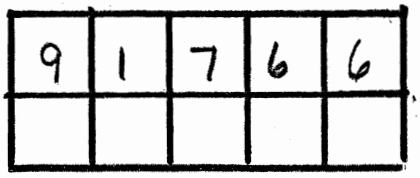
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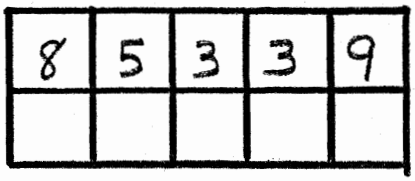
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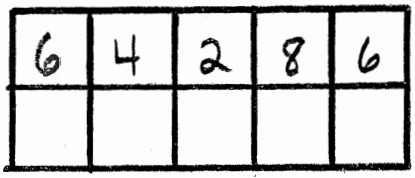
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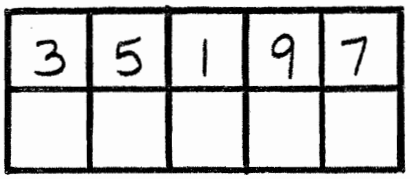
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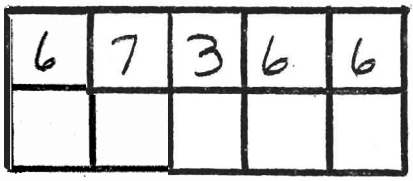
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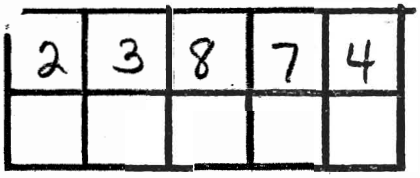
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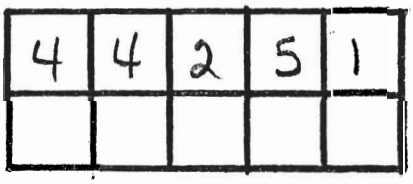
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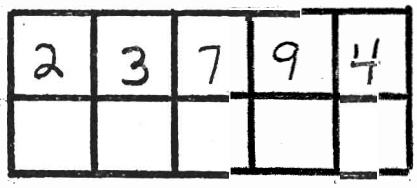
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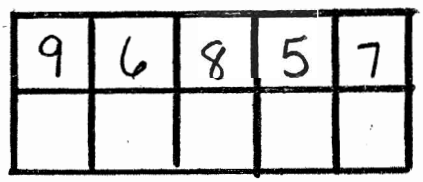
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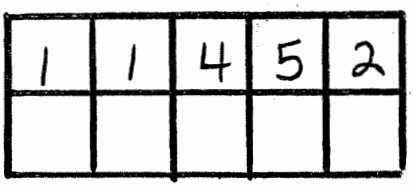
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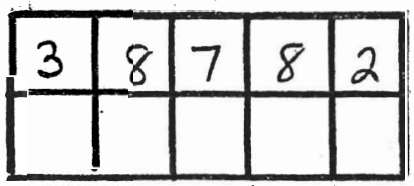
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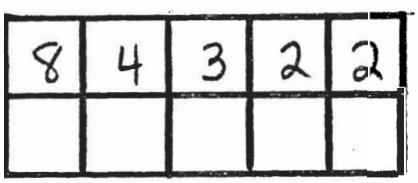
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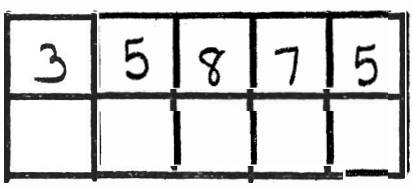
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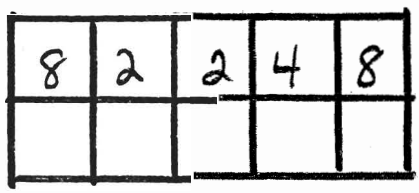
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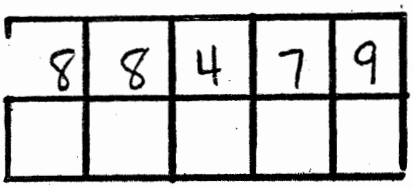
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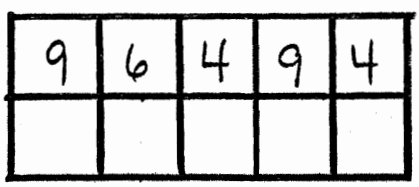
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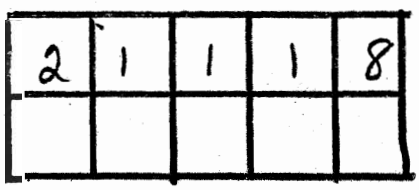
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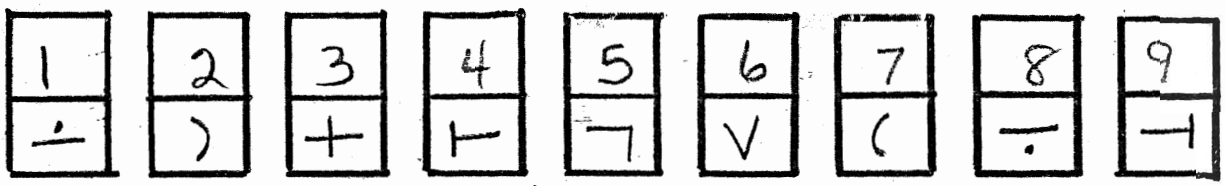
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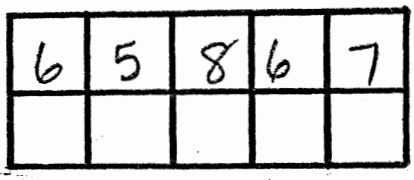
Fig. 3 (18)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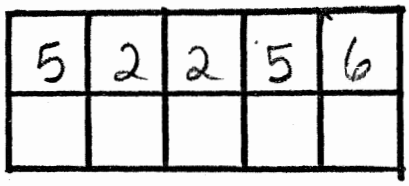
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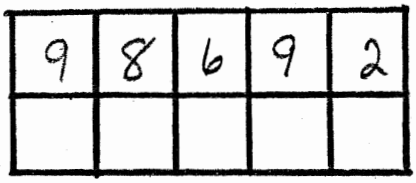
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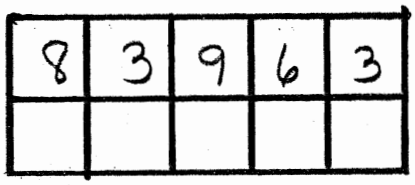
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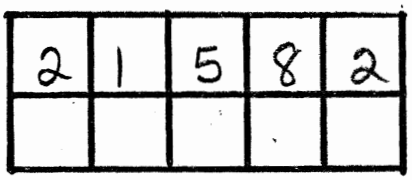
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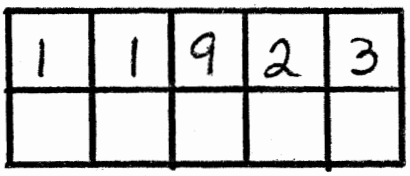
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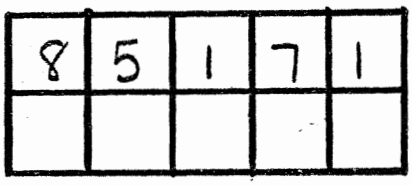
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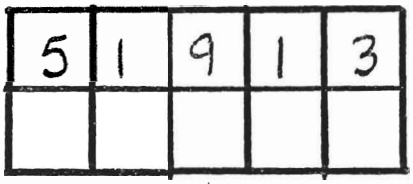
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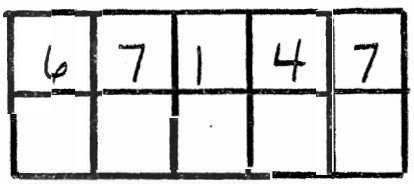
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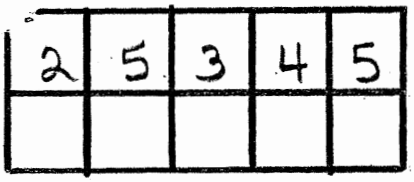
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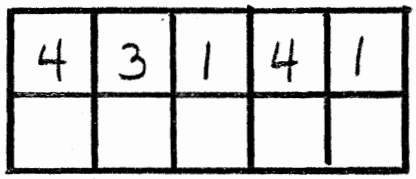
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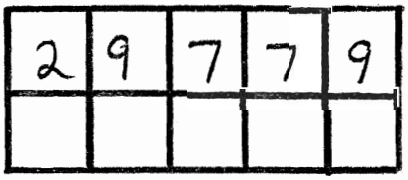
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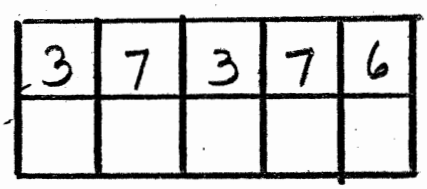
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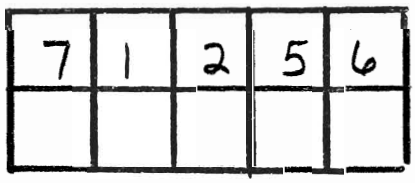
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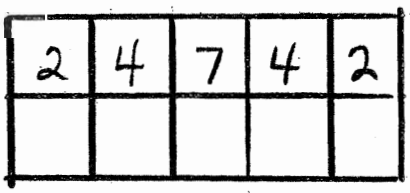
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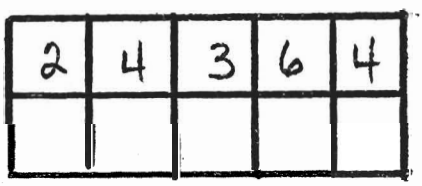
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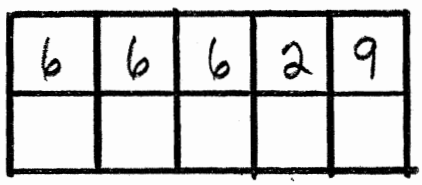
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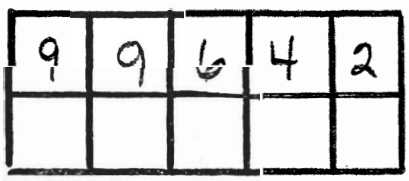
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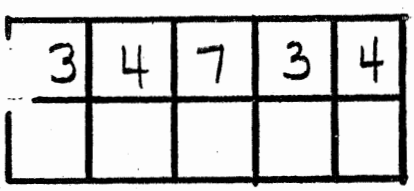
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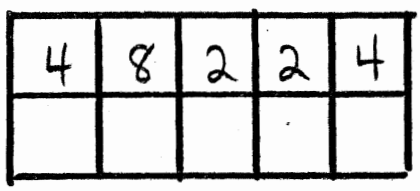
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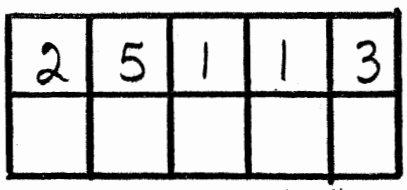
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