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LEARNING TO COUNT

A Summary of Laboratory Findings

BECAUSE of its importance in various life activities, (12) society demands of individuals at least a knowledge of the fundamental operations relating to numbers. Since the mechanics of number are prescribed, and its laws and processes are carried on within one's self, it is difficult to ascertain just how the learning proceeds. In the child, the evidence is almost wholly objective (8, 9, 15); adults, by introspection, are able to make subjective analyses of the mental activities through which they pass, consequently investigations with these individuals have led to interpretations which, otherwise, could not have been made.

The concept of number lies beyond imagination (4), and involves learning by abstraction, thereby concentrating upon a single characteristic to the exclusion of others. For example, in counting, only the "how many" idea may be present without consideration of size, shape, or color of the various objects. These may not even be alike in kind, but for one's purpose the units are the same. The instruments of abstraction, in counting, are symbols, or names, which stand for the things themselves. These names, or symbols, are serial.

The first, as well as the simplest and most fundamental phase of numbers, is counting, through which the apprehension of number is slowly developed. All the fundamental processes grow out of it—addition, subtraction, multiplication, and division (11). The first stage is the rhythmical movement or motor response to an inner series without reference to external stimuli (1, 2, 8, 10, 16, 17). From the very early period of infancy, experiences are being registered in the consciousness through the different senses—impressions from sounds of various kinds, the succession of day and night, the movements of the child, himself, respiration, the pulsing of the heart—from which the series-idea is gradually built up. Hall (6) calls this the series skeleton. After a time the responses express themselves in nods of the head, in beating on the table or chair with a spoon, in passing from object to object, or from person to person, putting each one in turn, and in various other activities, through all of which, the rhythmic, inner series is apparent. One series passes; another takes its place. At first the child delights only in the rhythmical order which he secures through concrete experiences of ear, eye, and touch.

Presently, by imitation, (8) he begins to acquire the number names, with no knowledge, however, of their meaning, or order. Phillips says they are surely learned abstractly (15). Articulation is one of the motor responses which accompany these number series. Oftentimes, movements of the head, hands, or feet are observed as well. If one muscular movement is suppressed, another muscle responds. Even with adults, it is practically impossible to count without motorization of some kind, but in such cases it is usually a verbal or incipient articulatory response.

The thing that first engages the attention of the child is not the application, but the series. Only a few names are learned to begin with, but these he repeats over and over. Repetition delights him, even though it be monotonous. The rhythm seems his one interest. Even in the very small child, the idea of more or less seems to be developed through contact with concrete ob-

jects and is expressed in his behavior. If he be playing with two objects that are exactly alike and one be taken from him, he vigorously protests. When the object is returned, he shows satisfaction and resumes his playing. A little later in his development, before the well-defined number consciousness is present, if he has a number of like objects, he senses the fact when any of them are removed, giving proof of the gradual building up, within him, of the number sense (4).

But the child just acquiring the number names, does not associate them with more or less. He applies them indiscriminately and mechanically (6). One may observe him going from one object to another, repeating 1, 3, 4, 6, 9, or other numbers in some such order. He is likely to call one object several names, or several objects the same name (4). Although it is the rhythm of the counting that apparently catches his fancy, through repetition, he is fixing the number names in his memory, so that by the time he has learned the order in which they come, his reaction has become spontaneous and unrestrained. He finds satisfaction in the mere abstract following of the names. Indeed, it is play to him, and he needs no other motive than the fun he gets out of it (6). Even yet, he is probably unable to make orderly application of the names, running them far ahead of the objects when he attempts to apply them. Often he uses 0 for 1, in which case, even in counting a short series, he is always one number short of the true count. He may be able to repeat the names in order and to apply them to the objects, but, instead of attaching the real meaning to them, for him, they represent the names of the individual objects and, if the order of the objects be changed, he still calls each of them by the number name by which he first designated it.

In the early stages most children express motorization by counting on their fingers, or by touching the articles in question, in addition to articulating the names. In this way they get the idea of position or the ordinal use of number, frequently before the cardinal use, because they think of the number as representing the position of the object rather than as one of a group or series. This habit of counting may linger long and in some cases is never entirely dropped (4, 15).

As time progresses the child sees these same names applied to objects other than those to which he has given them, or else to the same objects in a different order, and thus begins to understand that 1 means a single thing, regardless of the characteristics of the object; that 2 is one more than 1; and that 3 is one more than 2. In fact, he begins to see that names can be applied wherever there are objects.

Most children have the number idea fairly well established when they enter school. Children who have attended kindergarten usually have it more clearly defined than those who have not (5). Studies of children entering school in Berlin show that 74% or more, have an idea of the number 2 and Hartman's study (5) in the Annaberg schools, extending over a period of five years, shows that 69% of boys and 62% of girls entering school, were able to count from 1 to 10. But Hall (5) found among 200 first-grade children in Boston, 8% did not know 3; 17% did not know 4; and 28.5% did not know 5. The rational conclusion is that ability to count does not mean, always, ability to apply.

The years from 6 to 10 represent the period of spontaneous counting. While the time varies with different individuals, it precedes the period of recognition of a quantity as a collection of units. In these early years (13) the child should have much experience in counting and in seeing collections of things, numbering from 50 to 100. It is at this stage that (2) he begins to make rational application of the number names to external objects, thereby relating

the inner to the outer series (10). This is a very difficult step. Although he has been following the abstract series, pure number is still concrete for him (6, 15), and he is likely to personify or dramatize each one. 4 may become a big, fat duck; 7, a tall, lean man; 9, a lazy man, and so on. This dramatization, or individualization possibly grows out of the association of number with a single individual, or object, instead of as a part of a series.

There comes, too, a growing dislike for odd numbers (6, 15) with a tendency sometimes to skip them altogether, while a favoritism exists for even numbers. The writer remembers in her own experience ,this same reaction to odd numbers. One cannot be sure of the reason—possibly it is partly due to the difficulty experienced in pronouncing some of the names. There is an inclination to ignore the difficult names and carry the series on just the same. First-grade children find it very hard to keep the number and the object together.

Slowly another idea begins to dawn upon the child. He finds, in reality, there are only a few number names—ten, to be exact —and when these are exhausted, he must begin all over again, using various modifications to indicate the different cycles. Thus, 10 introduces the "teen" cycle, and 20, the twenty cycle. He realizes that all he needs to do is to fix in mind, by practice, these several modifications, add to each in turn the 1 of the units series, and they automatically run off to the end of each cycle.

Some children use number forms, zigzag, or curved figures as aids to memory and association in counting. Each number occupies so definite a place on the figure in their minds that they can draw the forms (6). There comes to mind one person who sees the numbers following each other in straight succession to 57 when the perspective fades entirely. The explanation for this probably lies in the method employed in learning the numbers, which were so arranged on a roll that only one number appeared at each turn of the knob which unrolled it. Imagination projects itself upon memory and association.

A few children seem to have no counting ability—due, very likely, to a lack of rhythmic sense. Rhythmic arrangement of the counters, as, ⁘ ⁘ ⁘ etc., assist materially, sometimes. It aids, also, in the next stage wherein grouping is used to facilitate counting. But experiments show that if the dots are arranged in a different grouping, children find it necessary to learn the new form before they can make the association without counting the dots (8). Here visual experience plays an important part. In fact, it occupies so large a place in children's thoughts, that it is very hard for them to make abstractions from these experiences into words (5). Finally, however, they become able to think, not only of the name in connection with some definite object, but to detach it from that object and, in their minds, to apply it to other objects unlike the first-named. The concrete character of the object no longer is of any consequence; it is simply a unit counter (4).

This is the pairing, or the one-to-one (4) matching of the series. Before the child is thus able to rationalize his counting, it is necessary that he practice the series of names until they become automatic, so that, when they are started, they will run off of themselves, while he gives his attention to the pairing of the two series (1).

As the stages progress ,the process becomes more complicated. The child does not merely tally when he counts. He gives names to each position in the series; when 2 is counted, he must remember that 1 is behind it, or that he is holding together two distinct 1's; when 5 is counted, that there are four numbers behind it; and so on (7, 15). Here he is putting units together in direct relation to each other. Abstraction presents a difficulty, because he must ignore

all characteristics except the one-to-one relation. If any interference (1) occur in the natural succession of either series, or in the harmonizing of the two, it slows up the process. In counting visual objects, the involuntary wink may cause interference and produce error; distance may create strain in the vision with consequent hindrance to the counting. Group, area, order, complexity in group composition, complexity of individual members of the group, environment, etc., produce modification in the process, but factors outside the group, such as noises, seem to offer no interference (8).

In studies (10) which have been made, it has been found that the relating of the inner and the outer series is more easily accomplished when the outer succession is sounds. Although the child does his thinking in visual terms (5), he can count sounds much more rapidly than he can visual objects, because he is accustomed to hearing and counting at the same time, therefore his ability to use the sound mechanism is more pronounced. Visual counting, as has been stated above, is complicated by form and other related factors, but, ordinarily, there is no interference in counting sounds because of the associations already formed. The number names (1, 10) being automatic, he can give his entire attention to the pairing of the series. Therefore he counts as rapidly as he can articulate. This is greatly facilitated by the rhythmical character of the series. Rate and accuracy are dependent upon the readiness of the associative connections (3).

A demonstration, in class, by means of an instrument used for experimentation showed clearly that beyond a certain rate, immediate readiness does not exist; that it varies with different individuals; that light flashes occurring simultaneously with the beats of the sound hammer seem to speed up the rate with which the flashes come, complicating the counting process with both visual and auditory impressions. This suggests that a diversity of impressions occurring at the same time, do not make for absolute concentration of attention in consequence of which, the process is retarded. One member of the class had a tendency to count from the number image left in the mind from counting the previous series. She also tapped with the fingers in counting the light flashes, giving evidence of the association of motor impulses with the act of counting.

Since some children lack the ability to formulate the rhythmical inner series, they are limited in their ability to count sounds (10). For most people the inner rhythm is that of articulation, and the resulting adjustment is complex. Experiments show that it is very hard to count beyond 10 without breaking, due, most likely, to the tendency to accent some of the names with the consequent grouping of the numbers. The increasing difficulty of pronunciation and the rhythmical sense must share the responsibility for the accenting. The child counts rhythmical units much more rapidly than he does those that carry no rhythm, but practice will bring about improvement even in the latter. The fact that one counts aloud as rapidly as he does silently is an interesting symptom of the necessity for motor expression. Lip movement and contraction of the vocal organs are also indicative of this necessity. The child seems to feel a greater sense of accuracy with voluntary movement and any inhibition of movement or articulatory response, invariably slows up the process, sometimes 20% or 30% (10).

Eventually, the mental activity becomes more mature and more rationalized, as well as more complex, as the relations of the various numbers are learned. The child has learned to count, not only in a straightforward manner taking the numbers serially, but also by groups, 2's, 3's, 4's, 5's, and knows the relation of one number to another (1). In Arnett's study, it is shown

that while there is a decrease in the counting time with larger groups, the decrease is not proportionate to the numbers. For example, counting by 5's is only twice as fast as by 1's—not five times as fast. The associative process takes longer for 5, 6, 7, etc., than for 1, 2, 3. It is the general opinion of those who have made a study of the matter, that the eye-span and the ear-span can take in only small groups at a time, in most cases not more than 3 (8, 6, 15). The child's ability to take in larger groups comes from very rapid counting, or else from the association of number with form (8).

At this stage, the child understands that he can put all of the objects in one group or that he can take the same objects and put them into two or more groups, and that the number in the one group corresponds to the number in the two or more groups taken together (1). He begins, too, to grasp the idea that every series counted forms a group. The process of abstraction is becoming more nearly complete. In the child's mind the numbers have become detached from particular objects. He arranges them and rearranges them in his mind without giving thought to objects. Counting beyond 4 or 5 requires special effort of attention—a more complex mental process, and a longer reaction time than in counting that far (17).

There are three types of counting (17)—progressive, perceptive, and inferential. Progressive counting brings to mind each number in succession and is, therefore, counting by 1's—a long process; perceptive counting is the apprehension of the largest number possible without taking extra time or making extra movements, this being in most cases as far as 3; counting by inference involves longer groupings. Not a wide use is made of the last-named. Some of the larger groupings are more easily apprehended than others. The child will naturally seek these rather than the more difficult ones.

Grouping of objects gives the child experiences which enable him to make the transition to the mature processes where he recognizes the more complex relations of numbers to each other. Thus, 12 means to him not only the serial number, but 3x4, 2x6, 9+3, and various other relations (1,9). This represents the final stage in counting.

In summarizing the discussion, it becomes clearly evident that counting is not the simple mental process we are prone to think it. It is made up of a complexity of reactions which increase from the early stages to the later ones. Perception, memory, association, imagination, and abstraction all play their part. Motorization is so vital that the process cannot be carried on without it. It is subject to difficulties that the child does not easily overcome. Habits, such as counting on the fingers, verbal articulation, etc., often persist into maturity. Four stages mark its course: (2)

1. Motor response to the inner rhythmical series, with no reference to outer successions.
2. The mechanical application of number names to objects without attention to their meaning.
3. The rational application of the names, in which an understanding of the meaning is apparent.
4. The further rationalizing of the application, in which groupings are made and the relations of numbers, one to another, are understood.

Counting, in fact, is the fundamental base upon which the whole of number rests, and the series-idea is the sub-base underlying the entire structure. In order that the child may secure a firm foothold in his climb to the top, it is necessary that the mental processes, involved in this particu-

lar phase, be so closely related through continual practice and association that an absolutely stable foundation is the result.

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Service is the rent we pay for the room we occupy.

A COMPARATIVE STUDY OF FOUR STANDARD CHILDREN'S MAGAZINES

IN MAKING a comparative study of the contents of the standard children's magazines — *St. Nicholas, Youth's Companion, Child Life* and *John Martin's Book*—from the point of view of how they satisfy the present day child's demands in a magazine, an attempt has been made here to check them up against the magazines shown by surveys to be most read by children, against what surveys have shown to be the reading interests of children, against the effect of the physical make-up of a book on children, and against the established standards of the format of books.

We are all inclined to think back to our youth and to remember the joy with which we received and read *St. Nicholas* and the *Youth's Companion,* and how we could hardly wait for each number to arrive. We feel that they should delight the child of today, also. But when we pick them up now and go over them, do they still seem quite as good to us or do we feel that perhaps they have gone down a little since the old days? Has our point of view changed a little, or is it that we have grown too old to appreciate them? Since good juvenile literature is usually liked by adults also, this last should not be true. And what is the opinion of the child of today as shown by his choice of magazines to read?

There have been several surveys made to show which magazines are most read by children. On 1925 a survey was made by Huber and Chappelear in five different cities in the eastern part of the United States. A questionnaire used in two public schools situated in an industrial neighborhood in Jersey City, in which 659 children, the majority of foreign parents, answered, disclosed as the first three choices from 88 popular magazines, *True Story Magazine, Saturday Evening Post,* and *Boy's Life. St.*