On the Analysis of the Memory Function in Orthography

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ON THE ANALYSIS OF THE MEMORY FUNCTION IN ORTHOGRAPHY

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1.

I NATURE AND AIM OF THE PROBLEM.

In reviewing the many experiments on memory which have been conducted in psychological laboratories we are struck with one general characteristic. The experimentors have chosen some one or few phases and factors in the field of memory for investigation. They have then produced in the laboratory by artificial means an artificial process of memory in which this one factor or set of factors was emphasized and all others ruled out as nearly as possible. The experiments by Bryan and Harter on the learning of the telegraph language ("Studies in the Physiology and Psychology of the Telegraphic Language"—Psych. Rev. 1897, pp. 27, 1899, pp. 345) and by Swift on learning to manipulate the typewriter ("The Acquisition of Skill in Typewriting"—Psych. Bull. 1904, pp. 295-305) stand out as the only ones in literature so far which have been carried on with the purpose of analyzing a complex memory process as it is found in every day life.

In our present problem we have undertaken, not a determination of some factor or factors which we can say with assurance form a part of the process of memory of the average man under the average conditions, but we have endeavored to make a detailed analysis of a complex memory process under the conditions in which this process is actually found in daily life. For this complex process we have chosen that of spelling. It is a process which every man who reads goes through and it is possible not only to cause the subject to repeat in the laboratory the entire procedure
which he has always used on these occasions but also to produce
the same conditions which he would meet in the school room or in
his study if he intended to learn how to spell a word.

In carrying out our problem we have had three very definite
aims in view. First, the detailed analysis of the factors that
enter the process of learning. Our most effective means of getting
at this has been direct observation and interpretation of our ob-
jective results in the light of this direct observation. When this
analysis was completed we had a full knowledge of the elements and
factors which constitute the procedure of the subject when he
learned to spell any word. But in order to determine the function
of these factors we set out to discover the relative value of each
in the total learning process. We controlled the conditions in
such a manner that the subject was forced to rely first on one and
then on another factor, and again using the direct observations
of the subject as an aid to the interpretation of the objective
results we learned the relative importance of these factors. The
next step was to determine if by controlling these factors we
could so change the process as to cause the subject to use a bet-
ter method of memorizing, a method which would give him more
satisfactory results than the one which he had hit upon of his own
accord. If this natural spontaneous method should be one which
had grown up by the gradual elimination of the factors which did
not aid and a growing predominance of those which aided most, then
it would be advantageous for him to know it and be confirmed in
his use of it. But if it should prove to have been chosen accident-
ally, to have been strengthened merely by use and habit and to
prove clumsy, expending more energy than was justified by the re-
results, then a better method should be discovered and provided for him.

II CORRELATED LITERATURE.

A. Visual and auditory Presentation of Words and nonsense Syllables compared.

The ground has been covered satisfactorily with regard to this point and the results have been of such uniformity as to justify certain general conclusions. McDougall ("Recognition and Recall," Journal of Philosophy, Psychology, and Scientific Methods, 1904, Vol. I, pp. 229-233), Whitehead ("A Study of Visual and Aural Memory Processes," Psychological Review 1896, Vol. 3, pp. 258-267) and Calkins ("A Study of Immediate and Delayed Recall of the Concrete and the Verbal," Psychological Review) have used adult subjects in their experiments and in all cases in which the syllables were presented successively, visually and auditorily at the same rate, the visual presentation gave the more satisfactory results. All these observers used nonsense syllables and no effort was made to compare nonsense with meaningful material. Hawkins used both school children and adults as subjects ("Experiments on Memory Types," Psych. Rev., Vol. 4, pp. 285-294). He presented visual and auditory words successively at the same rate to his subjects and he discovered that the auditory presentation was better for children while the visual presentation gave the most satisfactory results in the case of the adults. Kirkpatrick ("An Experimental Study of Memory," Psy. Rev., 1894, Vol. I, pp. 602-609) has used both school children and adults but has not made any direct comparison between the two. He used groups of ten words presented successively and his number recalled per group is 6.85 for auditory, and
for visual presentation. It is possible that the advantage of
the visual for the adults counteracted the advantage of the audi-
tory for the children. The most careful work along this line has
been done by Pohmann (Experimentelle Beiträge zur Lehre von
Gedächtnis). His subjects were school children from nine to four-
teen and he used both words and nonsense syllable as material. He
agrees with Hawkins in saying that the auditory presentation is
more satisfactory for children when familiar words are used, but,
on the other hand, the visual is better for unfamiliar material.
Both experimentors lay this in part to the predominence of audi-
tory imagery in the world of the child who can talk but to whom
writing means nothing, whereas the adult uses visual symbols much
more than auditory; and in part, to the present school methods.
Pohlmann also notes that in auditory presentation it is possible
to substitute visual imagery for the material; the heard word or
syllable may be at once visualized and the visual images instead
of the sounds fixed in memory. But it is easier to visualize a
familiar word than it is to visualize the letter for the unfamil-
liar sound of a syllable, the latter being a relatively slow and
uncertain process. Hence, the advantage of the visual presenta-
tion when unfamiliar material is used. This last point is a strong
factor in the presentation of a word the spelling of which must be
learned. It must of necessity be an unfamiliar word and it will
take less time to revisualize an unfamiliar word when it has been
seen than to construct it visually when it has been heard. Another
potent factor in this problem of presenting a word to be spelled
is the fact that the essential thing to be done is to get the let-
ters of a word rightly grouped as will be seen in the results be-
low. Any auditory presentation must be successive and the subject must do the grouping for himself whereas in a visual presentation it is done for him. This grouping is not of such supreme importance nor aid in the case of learning lists of words and syllables.

B. Influence of accompanying Motor Processes.

In learning words or syllables, the average person has a tendency to make use of vocalization and perhaps also of incipient writing movements.

The influence of vocalization as an aid to memory has been widely recognized although there is doubt whether it is to be considered merely an aid or a necessary element. Smith ('On Muscular Memory', American Journal of Psychology, 1896, p. 458) has experimented on five trained laboratory subjects. She has used pictures of the deaf mute alphabet in series of five and ten and presented them simultaneously. Part of them were simply shown to the subject for twenty seconds. During the presentation of the other half the subject was allowed to form the letters at the same time. The results were always in favor of the latter series. In another series of experiments, using nonsense syllables as material, Miss Smith has allowed her subjects to vocalize for half the groups and has eliminated the vocalization in the other half by making them count mechanically. Again the results are strongly in favor of the vocalization. In all cases, however, the motor process seems to be a material aid rather than a necessary element. Secor ("A Study in Mental Imagery", Am. Jour. of Psy., Vol. 11, pp. 225-236) puts great dependence on direct observation in determining the influ-
ence of motor processes especially the articulation and believes he can determine larynx movements as readily in this way as by any instrument. He also believes it is possible to read without any articulation or audition. The experiments of Curtis ("Automatic Movement of the Larynx," Am. Jour. of Psy., Vol. 11, pp. 237-239) seem to give results contrary to this since he was able to record larynx movements when the subject was endeavoring to suppress them and was totally unconscious that they had taken place. This would seem to indicate that the process of vocalization was an integral part of the process of mental activity.

C. Pedagogical Discussions on Methods in Orthography.

In the process known as "learning to spell" there are very many factors which may enter to a greater or less degree. Suppose a person to be presented with a long and difficult, unfamiliar word which he must learn how to spell. There are several ways in which he may go about it. He may have the printed or written word placed before him and merely look at it for a certain length of time until he has such a clear mental picture of it that he can read off the spelling from this visual image. Or, at the same time that he is looking at the word he may pronounce it and spell it to himself or aloud; or write it out, or both. On the other hand he may not actually see the word at all but may have some one spell it out loud to him. He may only listen while this is done or he may follow the spelling himself by vocalizing each letter as it is heard and he may also write it out as he hears it. There is yet another way in which he may proceed. He may recognize in the word
certain roots and prefixes and suffixes and by applying certain rules which he knows he may reduce the word to such a scheme that he can at any time construct it correctly according to these rules. In all of these cases he may make use of an immediate recall of the word after it has been presented to him or he may not. The application of rule presupposes a wide knowledge of the language and its science to be of much avail. Hence it is the least commonly used and of little practical value to the beginner. Of the other factors we find the auditory imagery the most rare. Pure auditory imagery seldom occurs and when it does it appears only as an aid and not as a primary element of the process. Writing movements are always found to be of great help probably because in attempting to write out the word the subject discovers exactly what he does not know and must attend to, rather than from any value attached to the movement itself. Of the visual and vocal it is difficult to determine the relative prominence and value. We find visual imagery constantly recurring and it seems impossible to satisfactorily rule out all vocalization. Where one fails the other is intensified in support of the memory and they seem to depend largely on each other. The predominance of one or the other seems to be largely a matter of individual type. Of all these factors that of immediate recall seems to be the most universally important. It has come to be so strong a habit with the average man that it might almost be termed instinctive, to immediately go over anything in his mind after he has perceived it if he wishes to remember it. Further discussion of the importance of this factor will be given below. Lay ("Führer durch den Rechtschreib-Unterricht" - Wiesladen '99) has reviewed the methods of spelling used by various teachers at different times and the theories dif-
ferent men have formulated with regard to them. The history of language itself has changed the prominence of the visual, vocal, and auditory processes and their relation. Before we had the written language there was greater prominence of the auditory. With the entrance of the custom of writing and particularly with the invention of printing the visual has gained greatly in prominence. Methods of teaching therefore have been different in these different stages. We find the Greeks and Romans learning to read and write simultaneously and so did the Germans until the invention of printing. Later the spelling method of reading was used and we find still great stress laid on the vocal. This was the period when emphasis was put on the practice in accurate vocalizing. The first theory assumes that there is a closer relation between the heard and spoken word than between the seen and spoken word. (Oliver Friedrich: "Lesebuch über die in jeder Sprache amwendbare Kunst, recht Sprechen Lesen und Schreiben zulehren."- 1804) (Grassman; "Anleitung für Volks schullehrer zum ersten Unterricht un Lesen Rechtschreiben," Berlin, 1816). This is true not only because we always talk more than we write but especially true for children because in general children have a stronger motor tendency than adults. The second theory admits that the first language learned is the spoken, but assumes that the visual is in general more prominent than the auditory and notes too that words are not phonetic. Hence the theory that learning to spell should proceed through the auditory and vocal to the visual. (Bokmann; "Der orthographische Unterricht in seiner einfachsten Gestalt- 3 Auflage, Berlin, 1865) Another theory combines the auditory and visual laying stress on the auditory as the method for
phonetic words and on the visual as the method for unphonetic words. A third entirely different mode of procedure lays stress on neither auditory or visual, but points out that learning correct spelling is a matter of acquiring a knowledge of derivation and roots of words. This employs the method of rules and derivations. In orthography one must teach the history of the language. One must arrange the words in family groups and teach rules of spelling. Lay himself puts the burden of the emphasis on motor processes. He considers the vocalization and writing of the utmost importance. He thinks that the motor process is a very efficient and powerful means of recall, and in order to get the best results he would have the subject vocalize and copy the words he wishes to learn to spell.

The great objection to each and all these theories is that they do not fit individual types. Any one of them might be the best method possible for one person while it might be the worst method possible for another person. No method, however general or well founded on theory it may be, can be universally accepted as long as it lays stress on any one type of mental imagery.

**D - EXPERIMENTS IN ORTHOGRAPHY.**

Lay ("Führer durch den Rechtschreib-Unterricht, already referred to) used as subjects pupils of the "Volkschule" one to six years of age and "seminar" pupils about sixteen years of age. As material he used groups of five nonsense words and the number of repetitions for a group was the same in all cases. These words were presented in different ways with the object of determining
the relative influence of the auditory, visual, vocal, and writing processes. In the auditory presentation the words only, not the letters, were read to the pupils. His results given in terms of the average number of errors per pupil per group of words were as follows-

<table>
<thead>
<tr>
<th>Condition</th>
<th>Errors per Group of Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heard, without vocalizing</td>
<td>3.04</td>
</tr>
<tr>
<td>Heard, pronouncing words in a whisper</td>
<td>2.69</td>
</tr>
<tr>
<td>Heard, pronouncing words aloud</td>
<td>2.25</td>
</tr>
<tr>
<td>Seen, without vocalizing</td>
<td>1.22</td>
</tr>
<tr>
<td>Seen, pronouncing words in a whisper</td>
<td>1.02</td>
</tr>
<tr>
<td>Seen, pronouncing words aloud</td>
<td>0.95</td>
</tr>
<tr>
<td>Seen, pronouncing letters aloud</td>
<td>1.02</td>
</tr>
<tr>
<td>Seen, copied without direction as to vocalization</td>
<td>0.54</td>
</tr>
</tbody>
</table>

From a series of experiments tried later he concludes that the advantage in copying does not lie in the longer time it takes to present the group of words.

After a discussion of such observations as those of Srticker, Dodge, Charchot and others, and also a discussion of verbal ideas, the motor speech ideas of children and the types and factors in orthography he arrives at the conclusions quoted above, concerning the relative influence of the motor processes.

Itschner's experiment ("Lay's Rechtschreibe-Reform", Jahrbuch d. Verein f. wis. Päd., Vol. 32, 1900) differs from Lay's in that he kept the presentation time constant and varied the number of the repetitions. He also used nonsense words and children in the fourth and sixth grades as subjects. His results are as follows-

<table>
<thead>
<tr>
<th>Condition</th>
<th>Errors per Group of Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heard, without vocalizing</td>
<td>2.93</td>
</tr>
<tr>
<td>Heard, pronouncing words in a whisper</td>
<td>3.39</td>
</tr>
</tbody>
</table>
Heard, pronouncing words aloud  2.61
Seeing, without vocalizing      1.40
Seeing, pronouncing words in a whisper  1.70
Seeing, pronouncing words aloud   1.47
Seeing, pronouncing the letters    2.10
Seeing, copying the words         1.62

Itschner disagrees with Lay as regards the favorable influence of writing and does not attribute the smaller number of errors for this method of presentation to the motor process, but to the fact that whereas, in merely looking at the word the subject has the feeling that it is learned and has no chance to test this certainty, when he tries to write the word he has a chance to find out where he is weak and can correct himself.

The following are the results of an experiment performed by Fuchs and Haggenmueller, ("Studien und Versuche über die Erlernting der Orthographie." Schiller's Sammlung von Abh'dl. aus dem Gebiete der fäd. Psych. II Bd. 4 Heft) who used school children nine years old, as subjects. Unfamiliar German and Latin words were used. They were presented in eleven ways— with the following results:

<table>
<thead>
<tr>
<th>Method</th>
<th>German</th>
<th>Latin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heard, without vocalizing</td>
<td>1.87</td>
<td>1.64</td>
</tr>
<tr>
<td>Heard, pronouncing words in a whisper</td>
<td>1.80</td>
<td>2.00</td>
</tr>
<tr>
<td>Heard, pronouncing words aloud</td>
<td>1.23</td>
<td>1.67</td>
</tr>
<tr>
<td>Heard, writing the words in the air</td>
<td>0.80</td>
<td>1.52</td>
</tr>
<tr>
<td>Seen, without vocalizing</td>
<td>0.79</td>
<td>0.90</td>
</tr>
<tr>
<td>Seen, pronouncing words in a whisper</td>
<td>0.63</td>
<td>0.84</td>
</tr>
<tr>
<td>Seen, pronouncing words aloud</td>
<td>0.58</td>
<td>0.94</td>
</tr>
<tr>
<td>Seen, writing the words in the air</td>
<td>0.34</td>
<td>0.98</td>
</tr>
</tbody>
</table>
12.

Seen, pronouncing the letters 0.35 0.82
Seen, copying the words and
pronouncing them in a whisper 0.29 0.43
Seen, copying the words and
pronouncing them aloud. 0.29 0.47

These results agree with Lay's in the advantage of copying. The number of repetitions in these were kept constant, but he says nothing of the time taken in presenting the groups in the different ways.

There are a few points of criticism to be brought out in connection with the method used in these experiments. In the first place in presenting the auditory material the words were pronounced instead of spelled out. This leaves the subject to guess at the exact spelling and the results cannot be reasonably compared with those of the visual series where the subject sees the word and gets the exact spelling letter by letter. In the experiments concerning the effect of the vocal the experimentors have determined that vocalization has some effect but they have not discriminated between letter and syllable pronunciation. In connection with this too the time element has been ignored. It will take longer to spell a word thru than merely to pronounce it over but no allowance has been made for this.

III METHOD IN PRESENT STUDY.

Our method of procedure in investigating this problem differed from others in two marked respects. In the first place where others have used many subjects we have used few. There is always the objection to using few subjects that the results obtained are
not general and may have been strongly influenced by peculiar individual differences. But, as has been said before, we have not aimed at typical quantitative results that would hold true of all persons, but at a detailed analysis of a process. The care and thoroughness with which this must be conducted makes it impossible to use a large number of subjects. The second point in which we differ widely from other investigators, and for the same reason, is that we have used direct observation as well as objective results as a method of analysis. It is evident to the most casual observer that it is impossible to make any complete analysis of a mental process without the aid of introspection. It is by this means that individual differences are brought out and the predominance of certain factors determined. For instance, it may take a person a very long time to learn a series of words presented orally. This may be due to one of many things. The subject may be unable to fix his attention on sounds. He may rely entirely on an auditory imagery which is weak and slow to be formed completely. Or he may change everything he hears into visual imagery which would take longer. In any one of these cases the objective results would remain the same and we can only discover the truth by means of introspection. In another case conclusions drawn from objective results might be entirely changed when light, as to some individual difference or peculiarity, is thrown on the result by introspection.

The apparatus used for presenting the words visually, one letter at a time, was the kymograph drum, on which was a sheet of typewritten words so arranged that as the drum revolved a letter appeared before a small hole in a screen at the rate of two a
second, with a two second space between successive words. The subject looked at the letters through two holes in another screen, shutting out from his field of vision all but a part of the screen through which he saw the letters. For the auditory presentation, a letter at a time, a metronome was used, inaudible to the subject, to mark the time, and the same rate of speed was kept as in the case of the visual presentation. When a word at a time was presented visually a "fall apparatus" was used, consisting essentially of a drop-board running vertically between two uprights. This drop-board carried the sheet of typewritten words, arranged in vertical columns of ten per column. The apparatus exposed one word at a time through a small opening in its screen. With an accessory apparatus that was regulated by a metronome and electrical connections the fall apparatus could be made to expose a word for any desired length of time, and also leave any desired interval before exposing the next word. The subject looked at the word thus exposed through a large camera like box with a ground glass screen in the farther end on which the word was projected through a lens. This enabled one to regulate the size of the letters and the distance at which they were seen, independently.

The four subjects taking part in the experiment were laboratory trained observers. One hundred and thirty-eight groups of words of ten words each were used as material. Sixty-nine of these groups were unfamiliar foreign words. The other sixty-nine groups were unfamiliar and difficult English words. With these, four different series of experiments were undertaken, each designed to determine a given point. Comparison of results from two of the series determined a fifth point, called the the fourth series be-
low, although no separate experiments were made in this case.
(1) Groups $1_e - 10_e$ were presented on the kymograph. Groups $11_e - 20_e$ were read aloud to the subject at the rate of two letters a second with a pause of two seconds between each word. (2) In groups $31_e - 48_e$ and $31_f - 48_f$ we controlled the vocal process and attempted to determine its influence and other value. All of these were presented visually and successively on the fall-apparatus and each word was exposed seven seconds with an interval of one second before exposure of the next word. The learning process was varied. For six groups the subject was allowed to pronounce the syllable to himself but not the letters. For six others he was allowed to pronounce the letters to himself but not the syllables, and for six he endeavored to rule out vocalization as much as possible. (3) Groups $49_e - 69_e$ and $49_f - 69_f$ were presented visually and simultaneously for four minutes, this being the total time given to learning a group when the words were exposed successively. Half of them were typewritten with the syllables separated and diacritical marks of pronunciation added. The other half were simply typewritten as usual. In this series we ascertained the influence and help of the separation into syllables, and of the diacritical marks. (4) The results of series (3) for the words for which no pronunciation was indicated, and of series (5) give a comparison of simultaneous presentation of all the words of a group with the successive presentation of one word at a time. (5) Groups $1_e - 30_e$ and $1_f - 30_f$ were presented visually and successively on the fall-apparatus. The total time for the presentation of one group once was eighty seconds and each group was presented three times in quick succession. The exposure time for a word and the interval
before the next word was exposed were varied. (a) One third of the series were presented with an exposure time of three seconds and an interval of five seconds. (b) Another third were presented with an exposure time of five seconds and an interval of three seconds. Both these time intervals gave the subject an opportunity for immediate recall after he had seen the word. (c) The effect of this was compared with the effect in a third time relation of a seven second exposure and a one second interval, where the subject had practically no opportunity for an immediate recall, altho he had more time for actual perception of the word. Not all the subjects took all the series. Observers A and B each took series (1) only. Observers C and D took series (2) - (5). The full details in this matter may be seen in the following tabular arrangement.

<table>
<thead>
<tr>
<th>A Series</th>
<th>Word group</th>
<th>B Series</th>
<th>Word group</th>
<th>C Series</th>
<th>Word group</th>
<th>D Series</th>
<th>Word group</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>$l_e-20_e$</td>
<td>(1)</td>
<td>$l_e-20_e$</td>
<td>(2)</td>
<td>$31_e-48_e$</td>
<td>(2)</td>
<td>$31_e-48_e$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(3)</td>
<td>$49_e-69_e$</td>
<td>(3)</td>
<td>$49_e-69_e$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(5)</td>
<td>$l_e-30_e$</td>
<td>(5)</td>
<td>$l_e-30_e$</td>
</tr>
</tbody>
</table>

In all cases after each group had been presented the allotted number of times the words were pronounced one at a time and the subject required to spell them aloud and at the same time to give as complete an analysis of his mental process as was possible from direct observation. In the case of the last series this was repeated three times at intervals of four, eight and sixteen days, respectively, between successive recalls. In the case of the third series this was repeated once only, four days after the immediate recall. No delayed recall was used in any of the other series.
IV ANALYSIS OF RESULTS.

A General Introspective results.

In the introspective results individual differences come out with startling clearness and persistency. But there are certain features which come out with equal clearness and which we find to be general for all subjects. This is particularly true for the recall process. With regard to this recall process we find another point. That is the differences in the method of learning do not seem to affect the recall process in any way. There seem to be several types, or rather one should say stages, of the recall process. The most usual is that in which the observer reports the sound of the word as recognized the moment it is pronounced to him for the recall of its spelling, and the visual imagery of the letters immediately comes up in a more or less distinct and definite form. The word is then spelled aloud, the vocalization either being a process of reading off the visual image or else accompanying the visual image but not dependent on it. This latter is determined to some extent by individual type. At another the visual image of the word is recalled only after the word is pronounced by the subject. There seems to be a close connection between this type of recall and that in which the visual is dim at first but grows more distinct as the subject spells the word through. Wherever the visual is indistinct the vocal comes in to a more or less degree to aid and fill in the gaps. Wherever the vocal fails to furnish reliable recognition of correctness the visual comes in to help. In every case there is an interdependence between the two. Indi-
individual type determines which of the two is depended on more. An extreme visual type says "until the visual appears the spelling cannot be begun" although this same observer notes that the visual often grows clearer as the word is spelled. In cases where there is no recognition whatever of the word as it is pronounced the process is one of more or less phonetic construction. Here again the type determines whether the construction shall be mainly vocal or visual. If by chance the subject hits on the correct construction it is usually recognized. There is one striking variation to the usual course of procedure in recall. Sometimes the sound of the word when heard would not be recognized but the visual would flash up before the observer and be recognized, and from this visual a recognition of the sound would follow. This may be due to one or both of two factors. The position of the word in the series may have been so well impressed that the visual flashes up in its proper order even if the recognition of the sound is for the moment gone. Or it may point to a complete correlation between the sense departments with regard to that certain word as the final stage in the learning process. In view of the fact that the word thus recalled was invariably spelled correctly the latter seems more reasonable. As we have said before the recall process shows a very close interdependence between vocal and visual but to understand the extent and significance of that dependence we must investigate where it is formed; in the learning process.

B. Objective Results.

(1) Comparison of visual and auditory presentation.
The direct observations invariably state that the process of grouping the letters into syllables is necessary for the retention of the word and is a much longer process with the auditory presentation than with the visual. During the visual presentation the letters can be held in groups by means of syllable pronunciation as the word is being presented, but in the case of auditory presentation the letters must first be visualised and then grouped. If the attempt is made at syllable grouping without visualisation the subject is lost. If the subject merely pronounces the letters as they are heard he has no means of getting them fixed in their relations to one another. On the other hand we find the vocalisation entering as a necessary element in the grouping of the words presented visually.

Table for series I

<table>
<thead>
<tr>
<th>Subject</th>
<th>Auditory</th>
<th>Visual</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>21 errors per group</td>
<td>19 errors per group.</td>
</tr>
<tr>
<td>B</td>
<td>16 errors per group</td>
<td>12 errors per group.</td>
</tr>
<tr>
<td>average</td>
<td>18 errors per group</td>
<td>15 errors per group</td>
</tr>
</tbody>
</table>

This difference in the average number of errors per group in favor of the visual presentation is undoubtedly considerably smaller than it would have been had more time been given to the learning in both cases. A group was presented three times in immediate succession in order to give a total time for learning approximately the same as in the other series. But in the immediate recall the observers did not recognize the majority of the words as they were pronounced to them for spelling. The results for the two methods of presentation were therefore largely reduced to a common level and their difference decreased because of the low degree of memory induced in each case. But the visual series is by direct obser-
viation as well as by objective results the more satisfactory. The subject finds it absolutely necessary to visualize the letters as they are heard. This is a longer process than that of pronouncing the letters as they are seen, hence we find more errors in the series in which it is necessary for the subject to construct his visual image for himself rather than in that in which the visual picture is presented to him. We have found then that the fundamental factor which we must introduce into our learning process is the visual image. But we have also found that the vocal must enter as a necessary element and in the next series we endeavored to so control it as to determine exactly its value and the proportion in which it is most useful.

(2) Control of the Vocal Process.

In this series we find one, the series in which the subject was allowed to pronounce the syllables only, that appeals to the observer as the most natural. It is the way in which he would proceed of his own accord and the easiest and most satisfactory from the point of view of direct observation.

Table for series II

<table>
<thead>
<tr>
<th>Subject</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>syllables only pronounced</td>
<td>4.3 errors per group</td>
<td>8 errors per group</td>
</tr>
<tr>
<td>no pronunciation</td>
<td>5.7 &quot; &quot;</td>
<td>13.6 &quot; &quot;</td>
</tr>
<tr>
<td>letters only pronounced</td>
<td>14.7 &quot; &quot;</td>
<td>7.6 &quot; &quot;</td>
</tr>
</tbody>
</table>

In this series there is an example of the effect of individual type. For C who is of strong visual type the slight vocalization in syllable pronunciation is an aid but the pronunciation of the letters proves a powerful distraction. D, of mixed type, shows by the objective result that there is little difference for him be-
tween the syllable and the letter pronunciation; but the effort to rule out the vocal is the powerful distraction in his case while this does not distract so much in the case of C.

Since syllable pronunciation is so favorable a factor we have attempted to discover if it would be still more an aid if, in visual presentation, the words were divided into syllables and the diacritical marks of pronunciation added.

(3) Comparison of Words with Pronunciation indicated with Words with no Pronunciation indicated.

Again in this series we find individual type entering as a factor. The visual type C finds the breaking up of the word and the pronunciation marks an unsurmountable distraction. As the word is to be remembered through the visual image it is imperative that the image be as simple and unencumbered as possible. It was necessary to put the word together again and eliminate the pronunciation marks, in short to construct an entirely new image. D noted the same distraction, but the time that was saved for him in not having to break up the word into syllables and determine the pronunciation more than overbalanced this distraction.

Table for series III

<table>
<thead>
<tr>
<th>Subject</th>
<th>Pronunciation not indicated</th>
<th>Pronunciation indicated.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Immediate</td>
<td>4 day recall</td>
</tr>
<tr>
<td>C</td>
<td>3.1</td>
<td>16.8</td>
</tr>
<tr>
<td>D</td>
<td>4.1</td>
<td>21.9</td>
</tr>
</tbody>
</table>

The indication of the pronunciation for the strong visual type was distraction. This distraction was more than balanced by the help the pronunciation indications were to the mixed type, since it saved him the time necessary to determine the pronunciation and
and break up the word. This closes the determination of the relative value and influence of the auditory, visual, and vocal processes in learning and in recalling.

(4) Comparison of Simultaneous and Successive Exposure.

The observation of the subjects in regard to this matter was that there was an opportunity in the simultaneous exposure to discover what words were harder and to linger on them; there was a chance for trial recall on the other hand, and the possibility to return again to the word or syllable that had not yet been learned. Easy words were dismissed from the attention as learned before they really were so as to be permanently remembered. Hence a hard syllable in a word might be learned thoroughly at the expense of several easy words only partly learned. On the other hand, in successive exposure the easy words were learned thoroughly and the few hard words were learned as well as possible. There was also a noticeable difference in the ease with which the attention was kept on the series. The appearance of each in the successive exposure being a spur to the attention whereas it was apt to wander when the whole series was presented.

Table for series IV, on the comparison of successive and simultaneous exposure.

<table>
<thead>
<tr>
<th>Successive exposure</th>
<th>Simultaneous exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate recall</td>
<td>4 days recall</td>
</tr>
<tr>
<td>C 4.5</td>
<td>17.6</td>
</tr>
<tr>
<td>D 6.0</td>
<td>11</td>
</tr>
<tr>
<td>Av 5.3</td>
<td>14.3</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate recall</td>
<td>4 days recall</td>
</tr>
<tr>
<td>C 3.6</td>
<td>17.7</td>
</tr>
<tr>
<td>D 2.9</td>
<td>18.0</td>
</tr>
<tr>
<td>Av 3.3</td>
<td>17.9</td>
</tr>
</tbody>
</table>

In the immediate recall there are less errors for the simultaneous exposure. The easy words are learned just to the point at
which they may be retained for a short time and the different words are learned better than in the successive exposure. But in the recall after a four days interval the successive exposure has the advantage, for all the easy words easily learned are as quickly forgotten in the simultaneous exposure, whereas these are the words that are remembered after four days in the case of successive exposure. Simultaneous exposure is better for immediate results but for lasting results successive exposure has the advantage.

From the influence of what was called trial recall above, with the return of the word or syllable a second time when it is found that it has not yet been learned, must be distinguished the influence of such recall in itself when the opportunity is not given to return to the unlearned word. In the simultaneous exposure a recall instantly after the partial or complete learning of a word was left to the choice of the observer. In the successive exposure of the present series no recall at all was allowed until the word was pronounced to the observer for spelling. We have attempted to determine more exactly the significance of this factor of immediate recall in the fifth and last series.

(5) Value of Immediate Recall.

The learning process is considerably different when there is opportunity for immediate recall from what it is when there is not. When the subject recalls at once the word seen he discovers immediately what he knows and what he doesn't know. His process from then on is one of correcting and filling in, until all the word is uniformly impressed on his mind. When he has no chance to recall all his energies are given to the impressing of the word on his mind as it is perceived. Naturally his attention will be given more or less equally to the easy and the difficult syllables and the
word will not be uniformly learned.

Table for series V

<table>
<thead>
<tr>
<th>Subject</th>
<th>C</th>
<th></th>
<th>D</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval</td>
<td>3 - 5</td>
<td>5 - 3</td>
<td>7 - 1</td>
<td>3 - 5</td>
<td>5 - 3</td>
</tr>
<tr>
<td>Immediate recall</td>
<td>3.4</td>
<td>4.7</td>
<td>5.4</td>
<td>4.8</td>
<td>5.0</td>
</tr>
<tr>
<td>4 days recall</td>
<td>19.0</td>
<td>25.0</td>
<td>22.2</td>
<td>14.1</td>
<td>13.0</td>
</tr>
<tr>
<td>8 days recall</td>
<td>14.9</td>
<td>18.4</td>
<td>18.9</td>
<td>10.5</td>
<td>10.1</td>
</tr>
<tr>
<td>16 days recall</td>
<td>15.4</td>
<td>17.1</td>
<td>16.2</td>
<td>10.6</td>
<td>9.6</td>
</tr>
</tbody>
</table>

(Series 5 was the first series taken in the experiment, and D was the first observer. It was soon discovered that there was considerable general practice effect with the progress of the work, but too late to arrange the order of presentation of the different relative exposure time and time for immediate recall so that this practice effect would be equally distributed over all. The figures in the table for D's results are therefore computed figures, computed so as to eliminate this unequal practice effect. In all other cases the order of giving the different groups was arranged so as to avoid this difficulty.)

The 7-1 relation, in which there was absence of recall, is decidedly the least favorable one. There is little difference between the 3-5 and the 5-3 relations, the result being only slightly in favor of the former. An immediate recall is of the utmost importance to efficient memory. We are well aware that the explanation offered in the statement of the direct results above is only a partial one. The necessity for immediate recall is shown in every instance of memorising, no matter what the material may be. It is
a universal tendency and like most of the truths of which we are most thoroughly convinced it is one for which no adequate explanation has yet been given altho we see it illustrated in ourselves and other people every day. Our mind consists of ideas acting and reacting on one another and it may be that an idea cannot become a part of our mind until it has had a chance to act on and react to some other idea. Whatever the explanation, it is to our advantage to recognise the truth and use it to the best of our ability. It will be noted that the results for the eight day and sixteen day recall are more favorable than those for the four day. It is probable that this is due to the repeated recall. Each time that the material is recalled what is remembered is impressed more firmly on the mind and a little more suggested each time.

V CONCLUSION AND SUMMARY.

In brief, then, our results can be reduced to five main points. Visual presentation is more favorable for this kind of material than auditory. This is largely because the auditory material must be visualised as it is heard and consequently necessitates a longer process than is required to learn the visual material.

Vocalization enters into the learning process rather more than into the recall process, and the most favorable means of employing it is in the pronunciation of syllables. The attempt to pronounce the letters is too distracting for the visual type and the attempt to inhibit it altogether is too distracting for the mixed vocal-auditory and visual type to produce good results. Syllable pronunciation on the other hand is an aid in both cases.
The indication of pronunciation and also the spacing of the word presented into syllables is an aid to learning. However to a strongly visual type the distraction caused by the increased visual material will overbalance the aid received in vocalizing.

Simultaneous exposure is more favorable for immediate recall than successive exposure but the results for delayed recall were better for the successive exposure than those for the simultaneous. There was no trial or immediate recall for each word in the successive exposure as there was in the simultaneous exposure, and this is probably in part responsible for the results. The fact that the attention is easier held by the successive exposure is probably also a factor in this.

It is a great advantage if during the learning process the subject is allowed to recall each word immediately after it has been presented to him. The results are better both for the immediate recall and the delayed recalls when this is done than they are when the subject is given no time between each word for a rapid "trying on" of its spelling. In fact from the results obtained in all the series the factor of immediate recall is the most important one in the learning process.

VI LITERATURE.


Lobsien: Die Grundlagen des Rechtschreibunterrichtes. Pädagogische
28.


Oliver: Lesebuch über die in jeden Sprache anwendbare kunst recht Sprechen, Lesen und Schreiben zu Lehren- 1804.


Apparatus for Successive Exposure.

A. Large camera, with elliptical opening and eye shade at A1, for observer, and lens at A2.

B. Fall apparatus, B1, drop-board running vertically between the upright. B2 Electro-magnet, whose attached levers allow the drop-board to fall the distance between two of the pegs with each make and break of the circuit.

C. Contact apparatus, C1, Electro-magnet, whose attached lever and ratchet wheel (the latter is behind C2) turns metal contact disc (Ca) one notch with each beat of the metronome. B. C2, Contact disc giving three seconds exposure of a word with five seconds interval following, or the reverse. Its four teeth complete the circuit with contact point C3, as the disc turns.

D. Reostat for metronome circuit.

E. Key for simultaneously making and breaking the two independent circuits, in one of which are B, D, and C1, in the other C2-3, and B2.