THE PHANTOM PLATEAU[1]

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Not so long ago, I overheard a laboratory assistant in general psychology telling one of the boys in his section about a file of old examinations that we keep in the college library for students to consult. He ended brightly with the comment that it wouldn't do much good to study these exams. "You see," he said, "we use the same questions from year to year, but we change the answers."

This disturbed me at the time. It seemed like a dangerous quip to make. What if word got around that we actually did change our answers? Might we not be investigated for Unacademic Activities? A little reflection, however, suggested that changing answers was, in truth, a sign of good health in any course of study. It suggested, too, that such changes are really quite uncommon-- especially in the beginning course. And, finally, it suggested a few answers that ought to be changed. One of these makes up the burden of the present discussion.

The answer to which I refer is commonly given in textbook chapters on learning, or habit-formation. Under such headings, it may fall within a treatment of skill, practice, or, occasionally, learning-curve plateaus.

In conformity with a well-known teaching procedure, the question itself comes after the answer, usually by several weeks. In an old-fashioned essay-type examination, it might read like this:

What is the normal course of progress in the mastery of a skill? How might a curve for ball-tossing or pursuit-meter learning differ from that for Morse code receiving? Explain this difference. (10 points)

An A-student's answer to this question might go as follows:

The progress curve for most skills is negatively accelerated. The amount of improvement from one trial to the next decreases as the number of trials increases. This is true of ball-tossing and of keeping contact with the target of a pursuit-meter. However, progress in Morse code receiving typically shows a long period of no advance-- a plateau-- midway in training. This plateau occurs only in the case of receiving plain-language material. It is said to be due to the fact that code proficiency depends on learning to respond to phrases and sentences as units, rather than to letters or words. The plateau represents the period in which word habits have not yet become sufficiently automatic for progress with phrases and sentences to take place.

[1] Address of the President at the Eastern Psychological Association meetings in New York, April 1957.

J. exp. anal. Behav. 1958, 1 (1).

This is the answer that I would like to change. It is wrong in two respects. First, the receiving curve for plain-language Morse code does not typically show a plateau. Secondly, our student has offered a faulty analysis of the receiving process. Since both errors are widespread, and since the second reaches well beyond a purely Morse code problem, it will be my aim, in what follows, to suggest some corrections.

All of you have seen the receiving curve to which our student refers. It has been a standard fixture of our textbooks for more than half a century. It is sometimes found in company with a sending curve, and sometimes with two other receiving curves. My first two figures will refresh your memory.

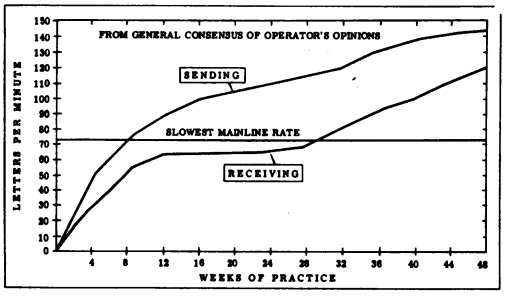

Fig. 1.

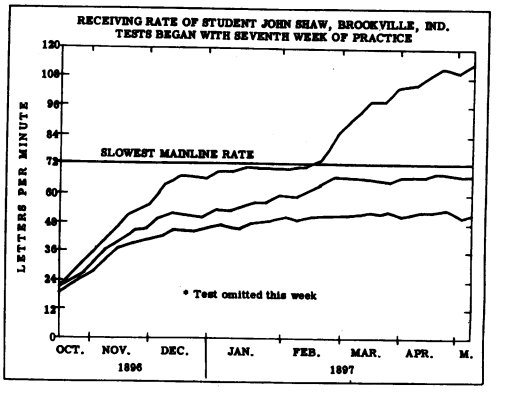

Fig. 2.

In Fig. 1, this receiving curve appears as the lower one of the two. The upper one is for progress in sending. In each case, code speed, in letters per minute, is plotted against weeks of practice. The line drawn parallel with the base indicates the lowest acceptable speed for practical communication-- 72 letters per minute. Just below this line is the famous plateau, extending throughout most of a 16-week period.

Figure 2 contains a similar plot. The plain-English receiving curve is here the upper one. The next curve below is for receiving disconnected words, and the bottom curve is for receiving disconnected letters. The plateau appears only in the plain-language curve.

The two studies from which these curves were taken are classics in the psychology of skill (1, 2). Both were published in the Psychological Review, one in 1897 and the other in 1899; and both resulted from the joint endeavor of two men: William Lowe Bryan and Noble Harter. Bryan, the senior author, was then professor of psychology at Indiana University; Harter, an ex-telegrapher, was a graduate student, working under Bryan's direction.

The 1897 Bryan and Harter paper contained the first known records of advancement in sending and receiving Morse code. These records were obtained in several ways. First, Harter cross-examined 37 railway and commercial telegraphers, asking them about their experience in mastering the code. From their answers he was led to construct the pair of curves that are shown in Fig. 1. Four more pairs of "typical" curves were drawn from data supplied by schools of telegraphy with which he made contact. There is no need to present them here, since they are practically identical with the pair that you can see. This is also true of two pairs that were collected by friends of Harter's-- railway telegraphers, each of whom tested weekly the progress of a student in his office.

Then Harter got some first-hand information. He tested for himself the weekly progress of two young students in the Brookville, Indiana, Western Union office. The results are pictured in Fig. 3 and 4. Except for their greater irregularity, they are like all the others, especially in showing the same receiving-curve plateau at a point just below the main-line level of acceptability.

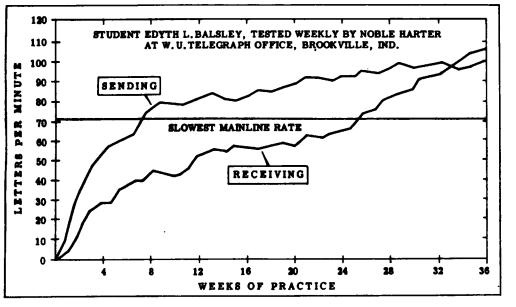

Fig. 3.

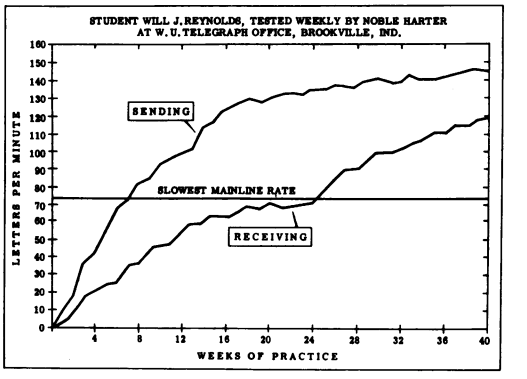

Fig. 4.

In their first paper, Bryan and Harter point out the existence of this plateau in all of their receiving curves for connected discourse. They note that many students become discouraged at this level of their code-receiving proficiency. They suggest that foreign-language learning goes through a similar phase of no improvement. But they do not tell us why the plateau occurs.

In 1899, they went further. They began with a report of some new findings. Harter had followed the progress of John Shaw, a student in the Brookville office, from the 6th through the 35th week of code practice. Shaw had been tested every Saturday, in sending and receiving. The receiving tests made use of three kinds of material: disconnected letters, disconnected words, and connected words-- i. e., plain English.

Three receiving curves were generated from these tests. Observe once more the curves of Fig. 2. The uppermost, plain-language, curve resembles all the earlier curves that had been plotted. The same plateau is there, with a main-line

breakthrough at about the same place as before, in the 24th week of practice. The word and letter curves, however, appear to have reached their limit of advance. This limit, even for the curve of disconnected words, is well below the main-line requirement of 72 letters per minute.

The second aim of the 1899 paper was to explain the plateau. Bryan and Harter had by this time questioned more telegraphers; they had considered the way in which blind children read Braille; they had heard of a "period of depression" in learning college chemistry; and, especially, they had John Shaw's word and letter curves to think about.

The result of all this is now an old story, but still appealing. It runs as follows. In learning Morse code, one acquires a hierarchy of habits. Letters must first be mastered; then syllables and words; and, finally, phrases and sentences. Mastery of the higher-order habits depends on mastery of the lower-order ones. To receive sentences, that is, one must first have acquired the component word-habits; to receive words, one must have acquired the letter-habits.

As for the plateau, let us go straight to Bryan and Harter:

> A plateau in the curve means that the lower-order habits are approaching their maximum development, but are not yet sufficiently automatic to leave the attention free to attack the higher-order habits (2).

As the receiving curve ascends from the base line, "no plateau appears between the learning of letters and of words, because very soon these are learned simultaneously." It takes a large vocabulary of words, however, before one can form the phrase and sentence habits needed for high-speed receiving; hence the plateau. When the vocabulary has become automatic, the curve ascends for the second time, to a level that marks the peak of achievement for most telegraphers.

Bryan and Harter have little to say about those who go still higher, beyond noting that "complete freedom in the telegraphic language" is reached only after years of apprenticeship, and comes as suddenly as did the ascent from the first plateau. Presumably, this depends upon one's mastery of language units that are highest in the habit hierarchy.

There were some puzzling features of these two papers. More puzzling today, perhaps, than they were in 1890. For example, there is the remarkable resemblance of all the receiving curves in the first Bryan and Harter report. We know, from the more recent studies, that progress in receiving the International form of Morse code is affected by many factors. It depends on the number of hours of practice per day; on the content of the practice materials employed; on the criteria of perfection used in passing a student from one speed to another; on the size of the steps in practice speed; and so on, and on. We know, too, that progress curves from different schools today are often quite unlike. Was there more uniformity of procedure in the code schools of the '90's than in those of our time? Is American Morse less affected by these variables than International Morse? Or, was Thorndike (6, p. 285) right when he suggested that the similarity of the Bryan and Harter curves was due to the inadequacy of the questionnaire used in collecting the data?

Then, in the second paper, there is the matter of John Shaw's curves for receiving disconnected words and letters. Why did these curves never reach the

main-line level? Even in those days there must have been telegraphers who copied stock-market reports and ciphered messages at speeds higher than 72 letters per minute. In Signal Corps schools today, even low-speed operators receive mixed letters and digits at rates well above this; and high-speed operators, using typewriters, reach nearly twice that rate. Had this student really reached his limit? Or did he fail to go further because he had so little chance to copy disconnected words and letters in his daily practice sessions?

We shall never know the answers to such questions. Except for a brief mention of the manner in which Harter conducted the speed test in the Brookville office, Bryan and Harter tell us nothing about training methods, practice material, steps in speed, criteria of passing, or any other influence that might be at play. For more light upon such matters, we are compelled to await the studies of later men.

The investigation of code learning requires an intimate acquaintance with a rather unusual training situation. It depends on more than a casual interest in practical goals. Also, it requires special experimental subjects-- young men or women on whom one can rely for long-term class attendance and high motivation. It is for these reasons that war time has been the best time for research in this field. There is then a shortage of men with code skill. Investigators are then willing to work long and hard in the interest of the purely useful; and the government is usually ready to help them with funds and facilities. Experimental subjects, often in uniform, are plentiful and tractable.

The first major attack upon the Bryan and Harter position came in World War I. It was made by Rees Edgar Tulloss (7), at Harvard University, as part of a doctoral dissertation entitled, "The Learning Curve-- with Special Reference to the Progress of Students in Telegraphy and Typewriting." In the code-learning field, this was a very important study; yet, for some reason, it was never published. In fact, its existence was barely noted until early in World War II. At that time, Donald W. Taylor (5), another Harvard code researcher, dug it out of Widener Library for a Bulletin review.

In the section of his dissertation that deals with telegraphy, Tulloss offers us, first, an improved method of testing speed in code receiving-- a method in which each test was based on two or three short runs of signals, sent at each of several different speeds, and including as many as four distinct types of test material. There were runs of English text, in which all the letters of the alphabet were represented; there were runs of disconnected letters, covering the alphabet, but with a frequency of appearance like that in plain English. Finally, there was a special test, called "alphabetical code," in which the 26 letters were represented randomly in each of two or three alphabet runs.

Using one or more of these tests, Tulloss measured the weekly progress of 23 students in International Morse code, including 19 from a Navy school that had been set up at Harvard. The latter were tested, during most of their training, with all four kinds of test material, along with a plain-language test that was given by the school itself.

Three members of this class had no prior experience with any form of Morse code when they started training. The record for one of these men was clearly atypical, for known reasons. The other two records were remarkably alike, and typified the progress of the entire group throughout most of the training period.

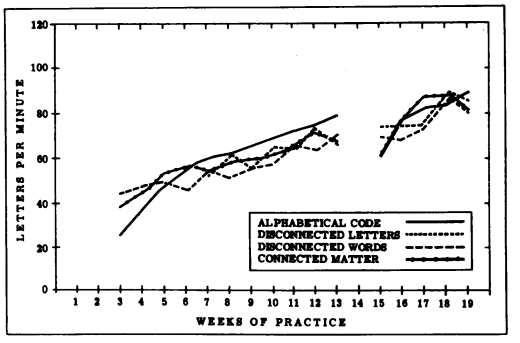

Fig. 5.

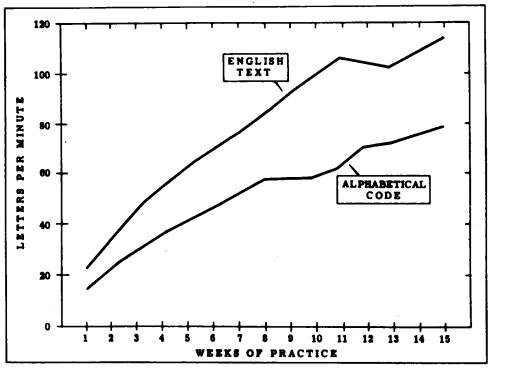

Fig. 6.

One of the two provided the data for Fig. 5. Letters per minute are here plotted against weeks of practice, with about 20 hours of practice to the week. Progress is most rapid at the start, followed by a slower, fairly straight-line advance, or a slight deceleration up to the end of training. All of the curves reach a level well above the Bryan and Harter main-line speed-- even in the case of disconnected letters, as in Tulloss' alphabetical code. Finally, except for one or two obviously abnormal records, there is no sign of a plateau in any of the Tulloss curves-- plain-language or otherwise.

These curves are, of course, for progress in International Morse, a code that differs from American Morse in two important ways. Its signals are composed of long and short tones, rather than patterns of clicks; and six of its letter signals are different from those of the older code in their dot-dash construction. Hence, one might fairly argue that Tulloss had no right to expect a confirmation of the Bryan and Harter findings.

To meet this objection, Tulloss measured the progress of four students of American Morse, in a special class at Simmons College. As test material, he used only the alphabetical code, although the Western Union instructor of the class added his own weekly tests with plain-language material.

These students received approximately 10 hours of practice every week, and all four of them went ahead at about the same pace. The record for the slowest student of the group, throughout her 15 weeks of study, is shown in the two curves of Fig. 6. These curves, and those from the other three subjects, are like the ones obtained with the International code. Even the slowest student shows a fairly steady climb in speed with disconnected letters to a point beyond that reached by John Shaw; and we see again that plain-language receiving may pass the main-line test without the appearance of a plateau.

The Tulloss studies did much to advance our knowledge of Morse code learning. They were not, however, without flaws, one of which Tulloss himself had found in Bryan and Harter. In trying to account for their plateau, he concluded that it was due to lack of practice with the more difficult signals of the code. Yet, in his own work, except in the case of one student whose only training came while taking tests,

there was no control of the practice materials employed. His results, it might be argued, were equally a function of an unknown state of an unknown state of affairs.

The code researches of World War II were free from this defect. In service schools especially, both practice and test materials were commonly specified from start to finish of a student's training. As a rule, however, they lacked variety, being restricted mainly to military cipher, with little or no plain-language code. It was not until 1953, 35 years after Tulloss' work, that the problem of practice materials was faced in an adequate manner.

The study to which I refer was conducted at Columbia University, under Air Force contract, by Donald A. Cook (3). Its aim was to measure progress in receiving International Morse code when students were not only tested, but trained, with five different kinds of material. These were as follows:

(1) A zero-order approximation to ordinary English text-- a random presentation of the 36 basic signals, in equal frequency, with punctuation signals, and in word-like groupings. This is probably the most difficult material that an American code student has ever been asked to copy.

(2) A first-order approximation to English, in which the signals for letters, digits, and punctuation again appeared randomly, but with a relative frequency like that of ordinary English.

(3) A second-order approximation to English, comprising material in which the succession of letters was slightly more predictable than in the first-order case. Each letter had as its nearest neighbor a letter, a number, a space, or a mark of punctuation such as might be expected to occur in English text.

(4) Disconnected discourse, another form of approximation, in which ordinary English words appeared, with a frequency close to that of their occurrence in our language, but in a scrambled sequence. This was probably similar to John Shaw's "disconnected words."

(5) English text, which came from a variety of sources, mostly nonfiction. Cook's aim was to use material that was neither esoteric nor literally familiar, and to avoid selections of specialized interest.

All these materials were presented in cycles. Each cycle contained samples of everything then in use, at each of several speeds, and sent in runs of about 300 signals each. From these runs, for all the cycles, it was possible to construct progress curves of the Bryan and Harter type for every kind of material with which each student worked. The curves in Fig. 7 are those for a student whose record was most like that for the group as a whole. In this graph, E-zero, E-1, and E-2 refer, respectively, to zero-order, first-order, and second-order approximations to English. Text, obviously, refers to connected discourse. (The amount of training with disconnected discourse, for this subject, was not enough to provide a progress curve for such material.)

It is quickly apparent from these curves that progress went on quite steadily for each kind of material throughout the practice hours in which it was employed. There are ups and downs, as in the Tulloss curves, but nowhere do we find the classical plateau. Moreover, the old main-line speed is again, in every case, exceeded. This would be true even if we were to handicap the International code severely in making our comparisons.

In this graph, and most of the others, something else appears-- something noted earlier by Tulloss, and in sharp contrast with the Bryan and Harter findings. That

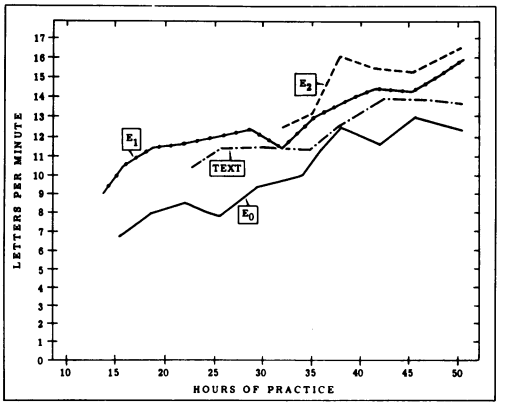

Fig. 7.

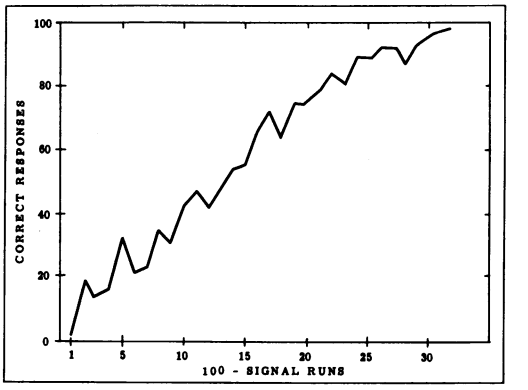

Fig. 8.

is, progress with text was actually slower than that for any other material except the zero-order approximation to English. To this matter I shall return in a moment.

From the findings of these two investigations, you will probably be led to agree that the answer should be changed to our original question about "the normal course of progress in the mastery of a skill," at least when this answer states that Morse code progress typically shows a plateau. There is, however, one more study to be noted here, as a sequel to the John Shaw story, and as one last look for the classical curve.

This study deals with the progress, in American Morse, of one experimental subject, who was given daily code practice during 10 weeks of the summer of 1955. This subject, Anne Simmons, was an 18-year-old high-school graduate who was working to earn money for college expenses. Her instructor, who shall be nameless, was an elderly ex-telegrapher, trained in American Morse, and with a lively interest in the proper conduct of the experiment.

Practice sessions for Anne Simmons were held on 7 days of the week, usually in the early afternoon. The practice material included four of the five kinds of material used by Cook in the study just described, with supplements from Treasure Island and Tom Sawyer. The material omitted was Cook's second-order approximation to English. Digits were included with the letters, as before, but punctuation was limited to the comma and the period.

Initial mastery of the 36 basic signals was brought about with the code-voice method (4). This is a procedure in which the instructor names each signal a few seconds after sending it, and the student tries to respond with the correct letter or digit during the pause. All 36 of the signals were used from the start. They were sent in runs of 100 each, in random order, and with rest-pauses and error-tallies between runs.

For the first 12 days of training, this method was in effect, with 1 hour of practice daily. There were two 100-signal runs on the first day, and three on each day thereafter. The subject's progress throughout this phase of the study is portrayed

in Fig. 8. The number of correct responses per run is here plotted against the number of runs. The over-all picture is crudely linear, up to the point of near-perfection, but you will observe a cyclical effect that is clearly due, in the first half of training, to overnight losses of skill.

Then the speed runs were begun, for 2 hours a day and with all four types of material. The speed at the start was one of four words (20 letters) per minute. It was increased, in 1-word-per-minute steps, as the subject met each passing criterion of 95-per cent correct copy in three runs for a given material. The runs were generally 1 minute long (never shorter) and, in all but a few cases, they were checked for errors by the "call-back" method immediately after being copied. Each run, in a sense, was treated as a test, and the subject was informed of each test score.

The subject's progress with the four materials is shown in Fig. 9. For each week of practice, the point plotted on each curve is for the final speed reached and passed in that week. The lower curve, for E-zero (letters and digits in equal frequency), is a faintly undulating curve, barely deviating from a straight line. The upper three curves, for English text, disconnected words, and a first-order approximation to English, are negatively accelerated and almost indistinguishable from each other.

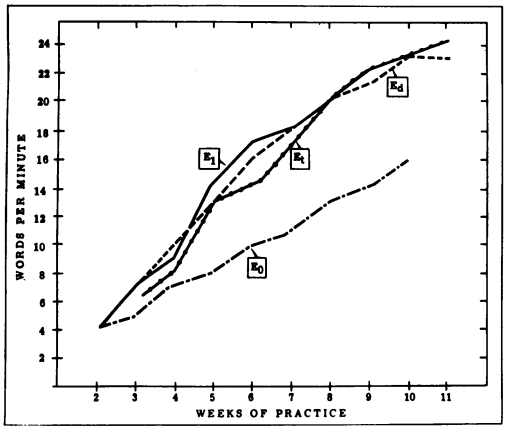

Fig. 9.

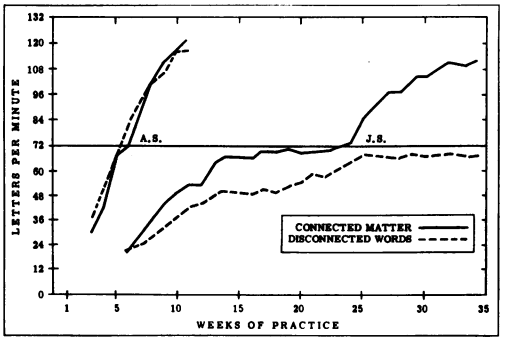

Fig. 10.

These curves, unlike Cook's, are based on American Morse, the code that Bryan and Harter studied. Unlike the Tulloss curves, they deal with the entire code and they result from a known and equal amount of practice on all the types of material with which the student was tested. Yet, in their appearance, they are little more than smoothed-out and speeded-up versions of the Cook and Tulloss curves. There is no plateau, at any place, for any kind of material. In addition, the curves for disconnected discourse and disconnected letters (plain-English frequency) reach heights that John Shaw never dreamt of.

To see this vividly, compare, in Fig. 10, the records of Anne Simmons and John Shaw for plain English and disconnected words-- materials that were probably nearest alike for the two students.

This little experiment was brought to an end, at a prearranged date, to provide the subject with a well-deserved vacation. It could have gone no further, anyhow, without drastic changes in procedure. Anne Simmons was close to her limit in speed of handwriting, and her instructor, using a standard telegraph key, was barely able to reach the topmost speeds employed with each material. By using a typewriter,

and a higher-speed transmission of signals, the curves would surely have continued to climb. Perhaps they would have paused for a while in their ascent, on that second plateau of which Bryan and Harter made mention. Or perhaps they would have marched on, at a slowing pace, but steadily, into the realm of the expert. I would guess the latter, but I might be wrong. This is country into which no Morse code researcher has ever yet entered.

In 1918, having looked in vain for plateaus in all his progress curves, Rees Tulloss began to re-examine the code-receiving process. The result was a multi-stage analysis of this skill which has not yet been improved upon, and which I venture to outline here as an alternative to the Bryan and Harter view.

At the very start of training, according to Tulloss, the code beginner has usually memorized a list of visual dot-dash symbols, one for each letter and digit. Hence, his first response to an auditory signal is one of visualizing or covertly verbalizing its dot-dash elements. This reaction sets off, in turn, a subvocal articulation of the appropriate character; and this articulation is itself followed immediately by the copying response-- the writing (or speaking) of the letter or digit. In every case of reaction to a signal, there is this little chain of events. In responding to a simple combination of a short and long tone, for example, a student might visualize a dot and a dash, utter subvocally the letter "a," and then write the letter down-- all within a second or two of time.

As practice continues, however, several more things happen. First, the initial visualizing or verbalizing within each chain is replaced by a "duplicative" or "imitative" response. Instead of reacting to the tonal compound by saying "dot-dash" or seeing the dot and dash, the student says to himself something like "di-dah"-- a muscular approximation to the tonal pattern. The complete sequence will then be as follows: (1) the auditory dot-dash; (2) the imitative "di-dah"; (3) the silent articulation of "a"; and (4) the copying response-- the writing of "a."

With further practice, the duplicative response drops out of the chain. The signal pattern now leads directly to covert articulation of the letter, after which the copying response occurs. The reaction time of the copying response to each signal is thus appreciably shortened, first to the "easy" signals, and then to the "hard" ones, and the student's code speed is correspondingly increased.

The next main feature of the process, with still further practice, is one in which each response chain begins to overlap in time with its neighbors. The student is gradually enabled to begin a second, or even a third, linkage before the first one has come to its end. This permits, of course, another increase in his speed of receiving, and lets him "copy behind," at least by one or two letters.

You might imagine that the next advance would be another shortening of reaction time-- that the middle link of each chain, the covert articulation of letters and digits, would then drop out, and that each signal would come to evoke, directly, the copying response. Tulloss would possibly have agreed that for students who deal mainly with meaningless transmissions of disconnected letters and numbers, something like this might really occur. But he would certainly have denied that the link drops out for those who go on to the next stage of the code-receiving process.

This stage is one of word-articulation. It is a kind of "spelling-out" stage, in which the articulation of letters is still a basic feature. Consider the case in which plain language is being sent. The signals come along as usual, one by one. Each

signal continues to evoke the articulation of a letter-- however fragmentary, however covert, this letter response may be. The letters, of course, spell out words, and if they come in close enough succession, they lead the student to say the words to himself. Thus, having subvocalized "t," "h," and "e," as the signals call these letters up, he finds himself, like any other speller, articulating "the." To each sequence of his own letter responses, he makes a single, unitary word response, even before he puts his pencil to the paper.

To appreciate this argument fully, and to get the feel of code-receiving at high speed, you have only to listen to someone's dictation of the letters in a series of words, at a rate of two or three letters per second. The effect will be even better if you try to write the letters as the message is sent. For example, see if you can "copy" the following:

THISISASIMPLIFIEDVERSION

("This is a simplified version")

You can understand, after listening to this message, how unlikely it is that ten successive letters, as in the word "simplified," or seven, as in "version," could ever function as an auditory whole. There may be word responses, just as there are letter responses, but code signals are never word stimuli, except in the case of very short words or uncommonly high speeds.

You can also see how word articulations arise from the articulations of letters and must always depend upon them in the receiving process. These word responses are not compounds of letter responses, but are merely evoked by them, just as any response evokes another. Often the word response comes up before the letter chain has been completed. Some of you may have uttered "simple," subvocally, before the sixth letter of "simplified" had been spoken; or you may have articulated "version" before that word was half spelled. In the first case, a mistake was made, which may or may not have disrupted the receiving process. In the second case, no harm was done, since the letters that followed your precocious word response served simply to confirm it.

This "guessing" behavior occurs primarily in the case of plain-language or disconnected-word receiving. It is obviously related to one's spelling experience, and it probably accounts for the fact that progress with text and mixed words may actually be slower than with almost any other kind of material. As I have already noted, both Cook and Tulloss had students who gave them such results. In the case of Anne Simmons, there was no clear effect of this sort; but even at the end of her training she was still copying "close behind"-- responding letter by letter to most of each transmission. Ultimately, in her case, as in others, we would expect words to be articulated in advance of being written. We would also expect that with increased knowledge of common pitfalls-- the different ways in which letter sequences may get off the track-- there would be fewer and fewer mistakes. Plain English would, in the end, be easiest to copy.

Tulloss goes two steps further in dealing with high-speed code reception. First, he argues for a second stage of overlapping, in which each of several word articulations may, at the same time, be in process of arousing its own copying response. He likens the process to that of ordinary writing, in which the word being written may be several words behind the one from which it stemmed. Secondly, he has something to say about the expert's ability to copy behind by 10 or 12 words or more:

What we can and do have (here) is a present articulation of the word, without immediate writing response, and then later a repeated articulation of the word which does result in its writing.... The words are articulated as they are spelled out. They are remembered and repeated (7).

These analyses, however, carry less conviction than the earlier ones. In particular, Tulloss' appeal to "memory" in the final stage is not very helpful; and the need for repeating a word sequence before writing it is not very clear. One might just as plausibly argue that successive words, like successive letters, directly induce the writing of those familiar patterns to which they belong.

This is the Tulloss story, told briefly and, perhaps, with distortion. It is probably incorrect in detail, and it is certainly incomplete. It also assumes the existence of events that you may think of as undesirably subjective, as, for example, the subvocal articulation of letters, words, and "duplicative" responses. But nothing metaphysical is here involved; the private events differ from the public only in their magnitude, not in kind.

Tulloss did not explain the plateau because he had no plateau to explain; for him, the plateau was a phantom, or the outcome of bad training methods. But he did throw light on the Bryan and Harter doctrine. He helps us see how they could talk of receiving words and sentences, without asking us to believe that a series of 20 to 100 or more dots and dashes of code, requiring many seconds for transmission, may function as an auditory unit.

His analysis fits readily within the framework of modern reinforcement theory, and it suggests a much closer tie between code learning and other verbal activities than we have been wont to consider in the past. I am thinking of its relation not only to such skills as those of shorthand, typing, and reading Braille, but also to those involved in reporting, listening, and understanding. The theoretical gain that accrues from relating code to such transactions should be more than enough to compensate us for the loss of that mysterious power bequeathed by Bryan and Harter to the telegraphic art.

The further study of this problem need not involve Morse code at all. High-speed receiving is simply a form of taking dictation, and can be investigated with signals that are no more elaborate or unfamiliar than the spoken letters or words of our mother tongue. Indeed, the patterns of Morse code are but awkward, slow-moving, and hard-to-master counterparts of letters, digits, and marks of punctuation. For some rather special purposes, they may still be preferred. For others, we ought to employ their less-demanding mates. From the study of dictation, by letters and words, we might then move on, in orderly fashion, to verbal report and note-taking, testimony and rumor, and the "comprehension of ideas."

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