(From the Psychotechnical Laboratory of the P.T.T. Holland.)

The Training of Aural Reception in Radiotelegraphists.

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Faithful translation, read directly from the uploaded scan (pp. 147–151). Biegel's own phrasing has been followed as closely as possible; unusual forms in the German original (such as „kürzer wie angegeben“, „gleich als 2:5“, „zu wissen 40“, „betreffend Korrektur“, „handelt es nur um“) have been rendered in their original sense. Nothing has been modernized. The bold section titles are taken from the „Contents“ list; in the running text the sections begin only with the numeral.

Contents.

1. Aural reception.

The work of the radio operator falls into two parts, both of which are equally important: sending and receiving. For mainland traffic, instruments almost always take over both activities. But the operator who works on a ship, in an aeroplane or at a coastal station must, throughout his whole working time, both send and receive. The present work is concerned only with the activity of aural reception; for sending, a second treatise is in prospect.

By international agreement it has been laid down that there shall be two operator's diplomas. For the operator's diploma of the 2nd class the candidate must be able to receive 100 signs (20 groups of 5 signs) per min when it is given in the mother tongue, and for agreed language (code) he must be able to receive 80 signs (16 groups). For the operator's diploma of the 1st class, 125 signs (25 groups) are required for the mother tongue and 100 signs (20 groups) for code.

To reach so great a speed, a long period of practice is needed. One begins with few signs per min — about 30 in the method followed up to now. The speed is slowly increased until the desired limit is reached.

The Morse signs are, as is well known, composed of dots and dashes. In aural reception one hears, according to the type of buzzer used, singing or rasping tones of varying length. At greater speeds (from about 80 signs onward), however, one no longer hears a succession of shorter and longer tones, but each sign is heard as a rhythmic Gestalt of a characteristic stamp. These Gestalten are, for the practised ear, very different, and confusion occurs only rarely. As soon as the operator hears such a Gestalt, he must make his choice among the signs known to him. This choosing requires much time at first; the further practice has advanced, the faster and surer one chooses. Whereas at first the choice is an act of thought, later it proceeds entirely automatically. One may therefore speak of a skill that is to be learned. Not everyone has the right disposition to acquire this skill, and the candidates are to be selected by means of an aptitude test. In Psychotechnische Zeitschrift 1931 I reported on an aptitude test for radiotelegraphists[1].

2. The old training method.

Once well-disposed candidates have been selected, the task is therefore to lead them to the goal in the fastest and most comfortable way. The goal is: rapid choice (125 per min) between known sound-images. The logical course is therefore: at first slow, then ever faster choice between known sound-images. At the

[1] Dr. R. A. Biegel, Eine Eignungsprüfung für Funkentelegraphisten. Psychot. Ztsch. 1931. 2. pp. 41—45.

beginning of the training the candidate should impress upon himself as firmly as possible the sound-images with which he has to deal at the end.

Practice has up to now not proceeded in this way. It did indeed reduce the number of choices per min, but it did so through such a slowing of the sending speed that the whole process was stretched out over a longer span of time. The ratio of the sign-interval to the sign, and of the word-interval to the sign, was kept unchanged. With a slowing of the speed down to about 30 signs, the sign-interval and word-interval were thus lengthened fourfold, but at the same time the sign itself was too, in that every dot, every dash, every part-interval received four times its length.

The consequence of this lengthening of the sign, however, is that its character as a sound-image is completely lost. A sign is no longer a rhythmic Gestalt, but falls apart into a number of successive longer and shorter tones. The sign can, and indeed must, be conceived atomistically. Counting off dots and dashes is unavoidable. The pupil comes to guess, already while the sign is still sounding, what may become of it.

This counting off, this atomistic conception, is however only possible up to a certain speed limit, which seems to differ for different pupils and lies somewhere between 80 and 100 signs/min. On approaching this limit the pupil must drop what he has hitherto been accustomed to and accustom himself to something quite new: the discrimination and choice between unitary rhythmic Gestalten. In the practice curves for aural reception this re-accustoming showed itself through plateaus, which at times extended over a large number of practice hours. In the graph of Fig. 1 these plateaus can be clearly recognized in the practice curves 3 to 5 for the old training method.

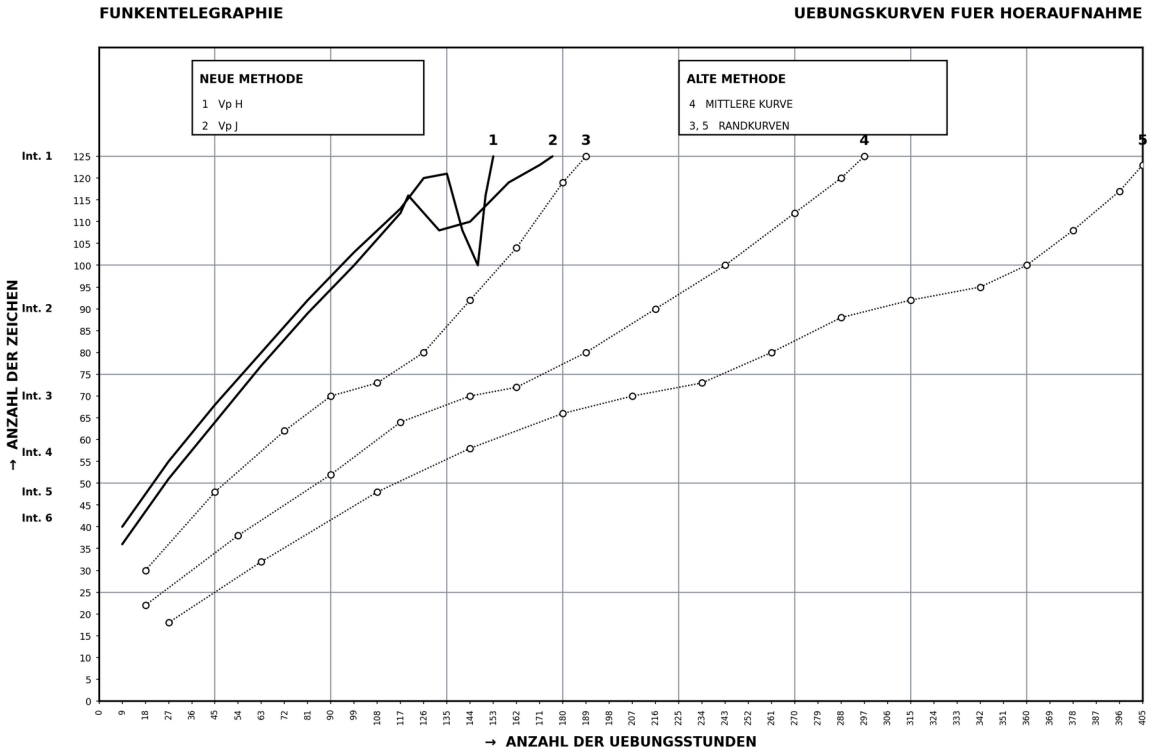

Abb. 1.

One cannot, therefore, say that the training method applied up to now brings the pupil to the goal in the most comfortable way. On the contrary, it is a very hard road that he has to travel. For not only does the number of choices to be made increase almost from hour to hour; what has to be chosen also changes continually, and

midway along the road it moreover changes completely in kind. That the road to the attainment of the set goal thereby became a very long one need not surprise us.

3. The new training method.

I have attempted to set up a training method for aural reception in which the unnecessary difficulties of the old method are avoided. In this new method the indivisible sound-images are offered already at the very beginning of the training; they remain unchanged until the end. At the beginning, however, they are offered with very large intervals, and only these intervals are shortened during the training, until they have reached the length of the normal interval.

To achieve this, the signs are given with the automatic Creed transmitter. Throughout the whole training, a tape length of 160 cm runs through per min, which corresponds to a speed of 125 signs/min. Between the various signs there are at first, besides the normal interval, a further 5 strokes of the space key; these are then reduced to 4, 3, down to 0 strokes. Where this paper speaks of interval 2, what is meant is: normal interval + 1 stroke of the space key. Interval 3 is: normal interval + 2 strokes, and so on.

In Table 1 various figures are given, concerning the old and new training methods. In calculating the mean sign-length and the mean sign-interval, the greater length of the word-interval has been neglected. In fact, therefore, both the sign-length and the sign-intervals are somewhat shorter than indicated. All calculations have been carried out by means of the reversals (current reversals of the Creed transmitter), which have the same rhythm as the small holes in the middle of the Creed tape by means of which the tape is fed. The tape length between these holes is denoted in the technical literature as Rev.

Table 1.

A. On the Creed tape, at a speed of 125 signs/min, 632 Revs are run through in 60 s, hence 1 Rev = 0.095 s. The normal interval between the signs = 3/2 Rev = 0.14 s. 1 stroke of the space key = 2 Revs = 0.19 s. At a speed of 125 signs/min we therefore have: 125 intervals = 125 × 0.14 = 17.5 s; 125 signs = 42.5 s; 1 sign on average = 0.34 s.

B. At the normal interval 1, the time span between the signs is:

Interval	Time span between the signs
1	0.14 s
2	0.33 s
3	0.52 s
4	0.71 s
5	0.90 s
6	1.09 s

C. New training method.

Interval	Sign	Interval	Number of signs
6	0.34	1.09	42
5	0.34	0.90	48
4	0.34	0.71	57
3	0.34	0.52	70
2	0.34	0.33	90
1 (normal)	0.34	0.14	125

D. Old training method.

Delay	Sign	Interval	Number of signs
4 times	1.36	0.56	31¼
3 times	1.02	0.42	41⅔
2 times	0.68	0.28	62½
4/3 times	0.45	0.19	93¾
none	0.34	0.14	125

As a first advantage of the new training method, the fact was mentioned under 3 that the sound-images remain unchanged from the beginning to the end of the training.

A second advantage is shown by the figures of Table 1. The ratio interval/sign is, in the new method, incomparably more favourable than in the old. In the latter the ratio is always equal to 2:5, whereas in the new method it is, at the greatest delay, 3:1, and at a speed of 90 signs still 1:1. The largest interval in the old method is 0.56 at 31¼ signs/min; this interval is reached in the new method only at 70 signs/min.

The time during which a choice must be made is therefore, especially at the beginning, very long in the new method. The sign itself is so short and presents itself so much as a whole that the pupil is not even tempted to ponder, while the sign is sounding, over what is going to emerge. The fantasizing that is, with good reason, so much feared is rendered impossible by the new method.

It may be mentioned in passing that a second kind of fantasizing — about the meaning of the text — was suppressed by giving, up to interval 2, only unknown foreign languages or agreed language (code). The subjects of the new training method became accustomed to grasping a text as a succession of sound-images, each of which is chosen on its own. Errors thereby occurred only sporadically; the garbling of whole groups was an exception. The subjects received, right up to the end, agreed language better than the mother tongue, so that the distinction with regard to difficulty in the international agreement appears unfounded.

4. Application of the new training method.

By means of the new training method, a number of subjects were trained in aural reception at the Psychotechnical Laboratory of the P.T.T. in The Hague. The results are shown in Figure 1. The subjects were selected, by means of the aptitude test mentioned under 1, from a group of young precision mechanics and electrical technicians employed at the Central Workshops of the Telegraphy in The Hague and the central telegraph and telephone office there. Where I wished to make a comparison with the old training method, by means of which the pupils of the training school for radiotelegraphists in Amsterdam were trained, I chose subjects of the same age as the pupils there. The schooling of my subjects was somewhat lower, especially with regard to foreign languages.

The pupils of the training school in Amsterdam were at their teachers' disposal the whole day long; aural reception was practised during the first months for three, in the last months for two hours per day. Instruction took place from 9 to 12 and from 1 to 4. My subjects were young employees who work 48 hours per week; for my experiments they were placed at my disposal each day from 11 to 12 and from 2 to 3 (before and after the lunch break). At the beginning of the first practice hour they had 3 or 3½ hours of work behind them. As regards fatigue, then, I was by no means in a favourable position with my subjects.

At first I worked with 3 subjects. One of them, however, fell behind already in the first hours. I tried to remedy this by having this subject practise both hours, the others only one hour or none at all per day. But when it turned out that the arrears grew ever greater, I dismissed this subject. I regard his selection as an

error in the screening, of which after all one cannot demand 100% certainty either. Thus two subjects remained until the end.

At the beginning of the training, sending was at interval 6, which corresponds to 42 signs/min. The signs were, as usual, first learned in groups of signs resembling one another; mixing with other signs took place only when a group was completely mastered. The signs were easily learned at this speed. Thus, at the beginning, many groups of signs were practised at the same time, and the aim was to give all the signs as soon as possible, so that each sign would be heard equally often and that later no difference between difficult and easy signs (read: little-heard and much-heard signs) could arise. It then turned out, too, that the one sign is by no means more difficult than the other; every pupil seems to have particular signs that he confuses, but for each they are different ones, and by reverting to the group concerned, errors in choosing can be almost entirely eradicated. There then remain only the errors due to gaps, in consequence of not yet mastering a particular speed.

Where I wished to compare my results with those of the training school in Amsterdam, I taught the same number of signs as there, namely 40. In mainland traffic some signs are almost never used; in Amsterdam these were taught only after the actual training had run its course. Although I do not agree with this separation of the signs, I had, for the sake of comparability, to abide by it. While in Amsterdam a lenient method is applied as regards the number of signs, in respect of correction one is there as strict as possible. Every wrongly chosen or missing sign counts as one error. This manner of correction I have of course also adopted.

At the beginning, then, sending was at interval 6, first in groups, then gradually mixed signs, until all signs were equally well mastered. As the measure of mastery at interval 6 it was assumed that the subject should deliver at least one daily sample with 1% or fewer errors. The samples were taken arbitrarily from the hour's output; neither the pupil nor the experimenter knew in advance what would count as a sample and what would not. By this it was achieved that the subject exerted himself the whole time, because a slackening of a few minutes could result in the spoiling of the hour's sample. Such practice is very fatiguing, and I finally went over to having practice for only one hour per day, since the second hour had little success anyway. Very strenuous activities should not be practised for several hours daily; for aural reception one hour is sufficient, provided it is used to the full. Moreover, a considerable part even of this one hour was set aside for resting, according to the indications of the experimenter.

For the transition from interval 5 to interval 4, and so on, the same limit was set (1% errors or fewer). For the mastery of the speed of 125 signs/min (the goal) the requirements were substantially raised: here, in 2 out of 4 consecutive hour-samples, 0.5% or fewer errors were to be made.

Practice was thus carried out successively at interval 6, 5, 4, 3, 2 and at the normal interval. The various levels are indicated in Fig. 1. The points of curves 1 and 2 at these levels are measured points; the intervening points are interpolated by means of the smoothed error curve. Up to the transition to the greatest speed everything went very well and very quickly. But then a transition had to be made from a speed of 90 signs/min to one of 125/min. This jump proved to be very difficult. I should have liked to insert interval 1½ (103 signs/min). I enquired whether practice tapes with this interval could be made for me; the answer was in the negative. Later it turned out that this was an error, and that the Creed perforator makes it possible to produce an interval 1½ (normal interval + ½ stroke of the space key). In a second experiment the speed 103 signs/min will be inserted.

Subject H., a very energetic young man, knew how to overcome the difficulties of the jump from 90 to 125 signs; his number of errors grew smaller daily, but unfortunately he could not quite reach the level of 125 signs/min, because he had to report for military service. He had not yet quite reached the percentage 0.5, but could certainly have reached it after a few hours. The last point he reached was calculated as 122 signs/min; the curve was continued with the same curvature up to 125 signs/min and ends at the 153rd practice hour.

The second subject J. is physically and mentally very sensitive. At the beginning of the training he had an attack of influenza, by which he was greatly affected. His practice curve cuts that of subject H. at the 120th hour, at an (interpolated) level of 116 signs; then a severe relapse occurred. The subject complained at the time about the demands made on his nerves by the training; but at the same time a large rebuilding was taking place at the telegraph office, and the electrical technician had to drag heavy ladders and was very fatigued, since he was not accustomed to heavy physical work. It seems to me, then, that physical symptoms of fatigue also played a part in the relapse.

The practice was first interrupted for some time, then cautiously resumed — and, in order to spare the subject, according to the old method, i.e. a transition was made to 110 signs/min old method and then a slow climb up to 125 signs, which level was reached at the 176th hour. This should not be taken as a weakness on my part. After all, one should not apply the new method further than it is advantageous and makes lesser demands than the old. Since the curve of subject H. also shows, by its flatter course at the highest practice level, that the final jump is very large and very difficult, it seems to me advisable in future to pass from interval 1½ (103 signs/min) to 105 signs/min old method, and to form the last part of the curve according to the old method. This has the further advantage that the candidate adjusts himself to the speeds between 100 and 115 signs/min, with which sending is done in practice; the speed 125 is, as is well known, an examination speed that is never required in practice.

5. The practice curves of the old and the new method.

Fig. 1 permits a comparison to be made between the old and the new training method.

In the school in Amsterdam, from 1928 to 1930 (after the elimination of the 65% unsuitable), a total of 41 non-pre-practised pupils, besides a few already pre-practised, had been trained in aural reception. For each pupil the practice curve was drawn. In Fig. 1 are shown the curve of the best pupil (No. 3), of the worst pupil (No. 5) and of an average pupil (No. 4). This last ends at the 297th practice hour; the calculated mean was 293.6.

Curves 3 and 5 are, however, exceptional curves. It has emerged that only 9.8% of the pupils have a number of practice hours below 240, and 12.1% above 340. Thus 78.1% have a number of practice hours between 240 and 340, and over this interval they are evenly distributed.

We can therefore compare the number of practice hours for the two subjects, 153 and 176, with those of the large middle group of pupils between 240 and 340. Only two subjects, it is true, were trained, but it is highly improbable that they both belong to the 9.8% of the extremely good cases. If we therefore regard the subjects as average cases, then a gain of about 44% is to be recorded. This percentage would certainly have been still higher if the level 103 had been inserted and, after reaching this level, a transition had been made to the old method.

The results obtained are very satisfactory, but experiments on a larger scale are desirable. Unfortunately I cannot carry these out myself, since for the time being no new radiotelegraphists are being appointed in the P.T.T. service in Holland. I intend, moreover, to make an experiment with the new training method, extended over all 62 signs, knowledge of which is required by the international agreement for the operator's diplomas. I suppose that the training of the 62 signs by my method will scarcely take more time than that of 40 signs.

To colleagues in other countries who would like to make experiments with the new training method at the same time as I do, I gladly place at their disposal the experience I have gathered. As I possess no data for the construction of practice curves for the training of 62 signs by the old method, I should be very grateful if these could be placed at my disposal from another quarter.

Summary.

I. In aural reception the operator is required to be able to receive 100 to 125 signs/min.

II. Training has up to now taken place according to a method in which, at the beginning, owing to the slowing of the speed, an atomistic conception of the signs was unavoidable, and after reaching a certain level the discrimination of sound-images had to be learned anew.

III. In the present work a new training method has been described, in which indivisible sound-images are given from the very beginning.

IV. By means of the new method, two subjects were trained in aural reception at the psychotechnical laboratory of the P.T.T. Holland. A gain of about 44% in practice hours was achieved.