An Aptitude Test for Radiotelegraphists.

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Introduction.

The present work reports on an aptitude test for radiotelegraphists, drawn up by Dr. J. E. de Quay and the present author by order of the Director-General of Posts, Telegraphy and Telephony in Holland. A brief preliminary communication in French was presented to the VIth International Psychotechnical Conference in Barcelona (23–27 April 1930); this communication later appeared in the »Revue de la Science du Travail« (R. A. Biegel et J. E. de Quay, La sélection des opérateurs radiotélégraphistes, Rev. de la Sc. du Tr. 1930, II, 2, p. 186).

Concerning aptitude tests for radiotelegraphists, little is to be found in the literature so far. In July 1919 there appeared from the hand of O. Lipmann: »The psychic aptitude of the radiotelegraphist« (Schriften zur Psychologie der Berufseignung und des Wirtschaftslebens, No. 9). Part of this method was taken over and used by Rieffert; as far as I know, however, nothing was published about it[1].

Lipmann's work gives an excellent analysis of the radiotelegraphist's occupation for the time of its publication. It can, however, no longer be used without further ado as a basis for an aptitude test, because radiotelegraphy has developed so much since 1919 that the demands to be placed on the operator are no longer the same. Whereas formerly the main emphasis had to be placed on analytical abilities, on picking out a particular pitch from a mass of neighbouring pitches and interfering noises, and the degree of proficiency with respect to the speed to be received was a secondary matter, today it is precisely this degree of proficiency that has become the main thing — at any rate for the radiotelegraphists who work in the central stations — and, owing to the greater perfection of the apparatus employed, the analytical ability is of secondary importance. For ship's marconists Lipmann's analysis may still be fully valid.

A second method of investigation was worked out by Klutke in 1922 (Klutke, Psychotechnische Eignungsprüfung für Funker; Prakt. Ps. 4 [10] 1923), at the request of the Department for Radio Affairs at the Reich Telegraph-Technical Office.

All the psychic characteristics are the same as in Lipmann. Here too the speed to be received still plays no essential role.

A method of investigation based on the demands that must be placed on the radiotelegraphist today was therefore not yet available. —

The radiotelegraphist is increasingly being replaced by instruments. A punched tape, inserted at the transmitting station into the Creed transmitter, conveys to the ether oscillations which are registered at the receiving station, either by an instrument that writes a wavy line, or by another that delivers a punched tape, identical to the tape of the transmitting station. For the most part the operator's work is confined to translating the punched strips or the strips of the undulator and supervising the reception of his apparatus.

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[1] Cf. the references in Rupp, »Bewährung der psychologischen Eignungsprüfungen« in »Der Betrieb« III, 1, 1920, especially page 6.

The radiotelegraphic apparatus is, however, not yet perfect, and sometimes the mechanical registration is made impossible by atmospheric disturbances (parasites). Then the radiotelegraphist must take the place of the apparatus and pick out, from the various tones that reach his ear, those of the transmitting station.

When aural reception takes place, the transmitting speed is lowered; but in order that no too great congestion may occur, the radiotelegraphist is required to be able to receive up to 125 letters per minute. This speed is so fast that only people with a special psychophysical disposition can carry out the operator's work. —

In Holland radiotelegraphy is more and more preferred by the public. The number of wire telegrams is steadily decreasing, so that a surplus of wire telegraphists is available. It was therefore obvious to train a number of wire telegraphists as radio operators. The Head Directorate of the P. T. T. made it possible for the telegraphists to take part in training courses for radio operators. Participation was large, but success less so, since it turned out that very many could not reach the required speed of 125 letters/min. Partly this was the consequence of the fact that many telegraphists had their early youth — and with it the period of greatest adaptability — behind them; but partly, too, the fact certainly played a role that up to now anyone could become a telegraphist without any attention being paid to special aptitude.

The Head Directorate then decided to offer young people aged 17–19 the opportunity to enter a school for radiotelegraphists. This school has existed since 1928; up to now 7 classes have been trained. Besides aural reception, the pupils are also trained in operating the typewriter and receive technical instruction.

The selection of the pupils has so far taken place in the following way. By means of a notice in the official gazette, newspaper advertisements and announcements posted in the P. T. T. buildings, young people in possession of the diploma of the continuation school (3 years of instruction after completing primary school) were invited to apply for admission to the radio school. On average there were about 200 applicants. From these the director of the school picked out the 100 with the best school reports. These were invited to a personal interview, which lasted about an hour. The personal impression, together with the marks of the school reports, finally decided the admission of 50 applicants; they were taken into the school in groups. Of this selected material, however, 65% had to be dismissed, almost exclusively on account of the inability to reach the required speed of 125 letters/min in aural reception.

It was therefore obvious to try whether a psychotechnical aptitude test could provide a remedy here.

Analysis of the radio operator's work.

At a speed of 125 letters per min it is no longer possible to break the Morse signs down into dots and dashes; each letter then forms a little rhythmic melody, a quite definite sound-image. The operator's work is thus nothing other than a continuous series of complex choice reactions. As soon as he has perceived a stimulus, the operator must choose between the 67 different signs at his disposal, and he must react, either by writing down the chosen sign, or by pressing the relevant key of a typewriter.

At the speed mentioned, the interval between the signs amounts to $\frac{1}{6}$ s; within this interval either the whole process (choice and reaction) must have run its course, or the operator must be able to divide his attention in such a way that he can at the same time perceive a new sign and carry out the reaction to the preceding one.

In the present method no attempt is made to analyse the operator's work extensively and to test each partial aptitude separately. The method follows the occupational work entirely; it is really nothing other than a strongly simplified work sample. Simplified, because the number of possible choices has been reduced, while on the other hand the time within which a reaction must be made has been lengthened. The simplification is so far-reaching that anyone is able to carry out the work after a brief instruction, although with very different quality, according to aptitude.

In order that we might be able to design the test so that the special aptitude of the candidates should influence the quality of the work as strongly as possible, it was necessary to define the characteristics that are absolutely indispensable for the exercise of the profession. For our analysis of the occupation we obtained valuable information from the director of the school and the instructors; furthermore we learned aural reception ourselves. We came to the conclusion that the following characteristics are absolutely indispensable:

a) Great speed, both in perceiving and in reacting. If one of these two is lacking, then from a certain speed onward it is impossible to reproduce the stimuli.

b) Presence of mind. A candidate who lacks this becomes, if he has failed to reproduce a stimulus, quite confused and is for a longer time unable to react further.

c) Rhythmic talent. The lack of this characteristic makes itself noticeable in those who cannot distinguish between signs that are mirror images of one another (e.g. q and ij, f and l).

It seems unnecessary to make a great analytical ability with regard to picking out tones of a particular pitch a condition. In the training school aural reception is practised with interfering background noises. An operator who is able to take up to 125 letters/min seems in practice very soon to grow accustomed to picking out the tones of the transmitting station. Lipmann too mentions in his work the ability to abstract from interfering stimuli (p. 32), which we can now also observe daily in the radio amateur.

Apparatus.

The stimuli were given by means of a Creed transmitter connected to a buzzer. It was set to the speed of 125 letters/min. The individual signs were thus offered as sound-images which cannot be broken down further. The largest interval between the letters was 1 s; this went down during the test in differences of $\frac{1}{6}$ s as far as $\frac{2}{6}$ s. In comparison with the normal interval one may therefore speak of intervals varying from 6 to 2.

The tests took place in the training school in Amsterdam. The arrangement of the buzzer room permits up to 22 candidates to be tested at the same time.

The test.

In Figure 1 a scheme of the test is given. It consists of 2 sections. By means of the first section we try to investigate characteristics a and b, by means of the second section characteristic c.

Scheme of the Psychotechnical Test.

Part	Interval	Structure
First section: Characters 1, 2, 3.		
I	Interval 6	Introduction
		3 series of 10 characters
		1 series of 30 characters
	Interval 5	3 series of 10 characters
		1 series of 30 characters
II Same structure as I		
III	Interval 4	3 series of 10 characters
		1 series of 30 characters

	Interval 3	3 series of 10 characters
		1 series of 30 characters
	Interval 2	3 series of 10 characters
		1 series of 30 characters
IV Same structure as III		
Second section: Mirror-image characters.		
V	Interval 6	Introduction
		3 series of 10 characters
	Interval 5	3 series of 10 characters
	Interval 4	3 series of 10 characters
	Interval 3	3 series of 10 characters
	Interval 2	3 series of 10 characters
VI Same structure as V.		

Fig. 1.

For the first part we chose 3 Morse signs that are easy to distinguish. We gave these signs in groups of 30 with ever shorter intervals between the signs.

For each interval we first gave a group of 30, divided by small rest pauses into 3 groups of 10, afterwards an undivided series of 30 signs.

If the required receiving or reaction speed (characteristic a) is lacking, the candidate will, from a certain speed onward, no longer be able to keep up.

If presence of mind (characteristic b) is lacking, interruptions of several signs show themselves in the undivided series.

The candidates receive the instruction to write the figures 1, 2, 3 for the 3 chosen signs. We deliberately avoided having them react by means of the letters for which the signs are the symbol; among the candidates there are always some who already know the Morse signs: these have an advantage, which we tried to compensate in this way.

For the second section of the test we chose two signs that are mirror images of one another. We gave these signs only in groups of 30, divided into groups of 10, since reliable correction of undivided series is not possible. Here too the intervals go down from 6 to 2, so that characteristic a is here tested once more along with the rest.

It can be seen from the scheme that two parts of the same structure are always present. In the calculations the mean of the results of two such parts is always taken. Chance irregularities, which easily occur with a single presentation, are thereby largely evened out.

The test was repeated three times at intervals of 2 hours. On the one hand we hoped, by combining the 3 repetitions, to even out the chance irregularities still better; on the other hand it gave us the possibility of gaining insight into the candidates' capacity for practice.

Scoring of the test results.

In our calculations we used only the sign-groups that showed differentiation. In the first section, parts I and II showed no differentiation: this only begins in part III (IV) at the undivided series with interval 4. In the

second section there is differentiation from the start. In the calculations, therefore, 10 groups are used, of which 5 with the signs 1, 2, 3 (3 undivided, 2 divided series) and 5 with mirror-image signs.

In the calculations an error was counted for each sign that was absent or wrongly chosen. Where a series was not complete, certain correction rules were followed, especially for the mirror-image signs. These correction rules I shall gladly place at the disposal of interested parties.

The maximum for each group is therefore 30 points. These are converted into percentages (30 points = 100%). For each repetition a mean percentage is formed by adding together the percentages of the 10 groups used and then dividing by 10. This is admittedly a very crude method: all series receive the same weight; but it gave satisfactory results. In the series with the larger intervals all candidates did fairly well, so these influenced the final result but little. It is, however, not excluded that some other scoring method will later be introduced.

In a similar way one can, by combining the results of the three repetitions, obtain mean percentages for the entire test.

Prognoses.

With the aid of the test method described above, prognoses were made for the pupils of 3 classes of the training school, consisting of 17, 21 and 18 candidates. The pupils had been selected by the director in the manner customary up to now. Classes 1 and 3 were tested on the day of entry, class 2 some time beforehand. The results of the prognoses can be seen from Fig. 2.

The pupils of each class are arranged according to the mean percentages obtained in the entire test, that is, by combining 3 repetitions. In Fig. 2 they are plotted at regular intervals along the abscissa. The ordinate indicates the height of the mean percentages.

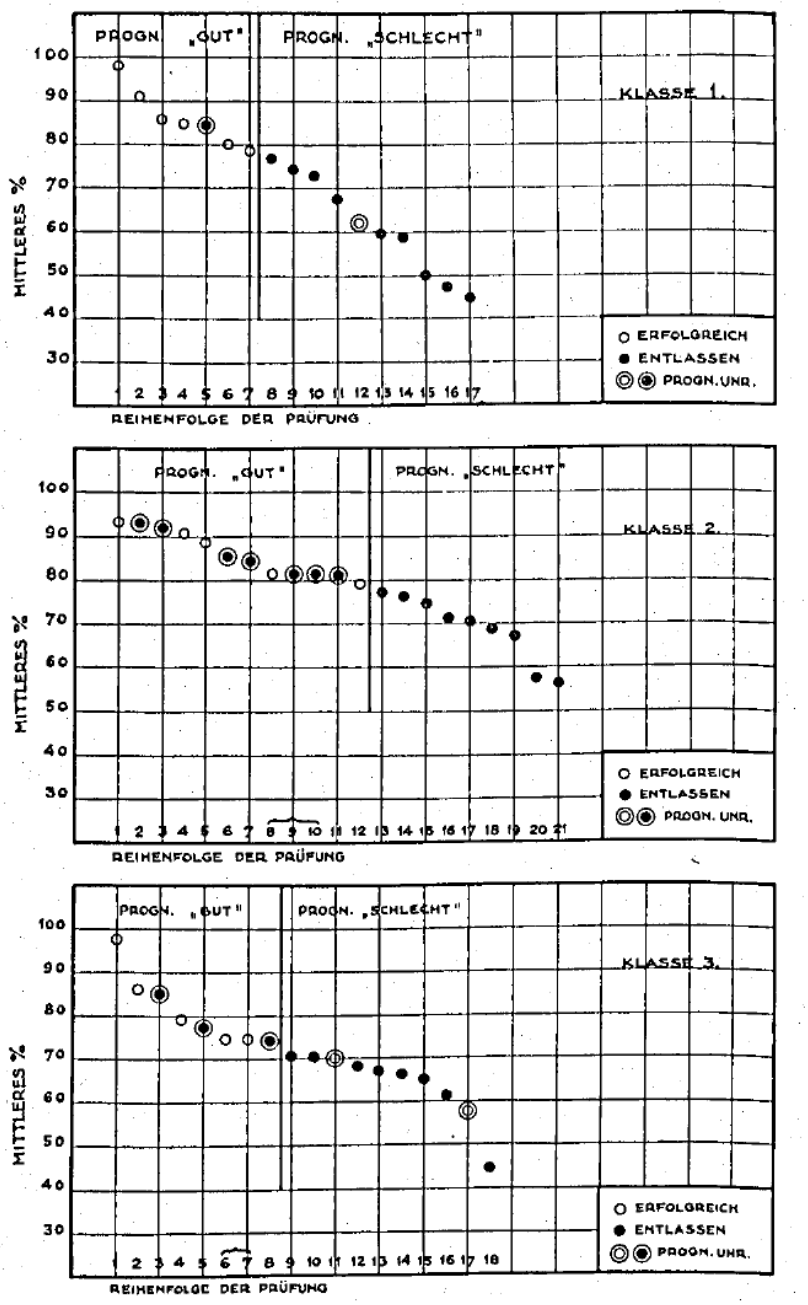

Abb. 2.

The line in each group indicates where we thought the dividing line between »good« and »poor« pupils had to be placed. For class 1 this line was drawn after No. 7, on the basis of 40% »good« to 60% »poor«. For class 2, which was tested with the same test series as class 1, the dividing line was placed after the pupil who had the same mean percentage as No. 7 in class 1. For this class, therefore, 12 out of 21, i.e. 57% »good«, were assumed.

It later turned out that there is no reason to regard this class as better than class 1; on the contrary: it produced only 5 good pupils out of 21, only 24%, which was lower than ever before. Our high rating of this class is

probably to be attributed to more practice in correcting the test forms and to the fact that the correction rules were only gradually formulated unambiguously. It would have been better, for this class too, to keep to the percentage of 40 for the »good«.

Class 3 was investigated with a new test series, consisting of different signs. Comparison with the other classes was therefore not possible, so that we again kept to the 40% »good« and drew the line after No. 8.

Of these classes a number of pupils completed the course successfully; they are indicated in the diagram by empty circles. A number of others were dismissed on account of insufficient aptitude. They are denoted by black discs. Our prognoses were not known to the director.

Dismissed pupils before, and successful pupils behind, the dividing line represent the errors of the prognoses. They are denoted by a second circle around the first circle or around the disc, respectively.

We can now therefore draw up the balance:

In all there were 56 pupils, of whom 19 (34%) completed the course and 37 (66%) were dismissed. Of the 19 successful pupils the test recognized 16 (84%) as such. Of the 37 dismissed pupils, 26 (70%) were designated as »poor«. The test would thus make it possible to single out most of the »good« pupils and to keep a large percentage of the »poor« ones away from the course.

Taken over the whole group, the prognoses are correct for 42 out of 56 pupils, that is, for 75%.

The ratio of successful to dismissed pupils was, for the whole group, 19 : 37, that is, about 1 : 2. Had a psychotechnical test been carried out, this ratio would have been 16 : 11, that is, about 3 : 2.

This result is very satisfactory. It is quite possible that, when larger groups are tested, the accuracy with which the »poor« pupils can be excluded will be substantially increased. Small groups, like those now investigated, are too dissimilar in their composition.

For several reasons, however, it will always happen that poor pupils are given the diagnosis good, and good pupils the diagnosis poor.

A poor pupil may, for example, be given the diagnosis good if he is pre-practised in buzzer work. Nos. 2 and 3 of class 2 were pre-practised; they were pupils of average talent whose inadequacy in the course was discovered only after several months. No. 1 of class 3 was also pre-practised, but his performance was so outstanding that here it was correctly surmised that a special aptitude was also present. It appears to me that really gifted pupils with pre-practice will always show outstanding performances; that pupils with poor aptitude will, even with pre-practice, not obtain a sufficient mark in the test; but that many a one of average aptitude will give the impression of being better than he really is. It is regrettable that pre-practice influences the test results here; but this is probably the case with every test that stands as close to the occupational work as the present one. In future a declaration will be required from every candidate as to how far he is pre-practised; after all, no one has any advantage in forcing his admission to a course which, with insufficient aptitude, he will in no case complete.

A second reason is that many pupils, at the beginning of the training course, move from the small town or the countryside into the big city. The altered living conditions, the adaptation that is demanded, will cause many a well-disposed pupil to fail.

A third reason for discrepancy is that the psychotechnical test uses sound-images such as are offered in the school only at the end of the training, when a great speed has already been reached. The instruction uses for training the punched strips of dispatched telegrams, which at the beginning are run very slowly through the Creed transmitter. In doing so, not only are the intervals enlarged, but the signs themselves are stretched

apart, which makes a breaking down of the signs — an atomistic conception — unavoidable. Pupils who have an aptitude for whole-perception are thus at the beginning compelled to proceed atomistically. Many a one will fail in this and so be excluded from further training, long before he can reproduce in accordance with his aptitude.

That instruction takes place according to this method seems to me, from a psychological point of view, incorrect. There is therefore also the intention to make an experiment with a method of instruction which, like the psychotechnical test described above, aims from the very beginning at reaction to indivisible sound-images. This method of instruction, however, requires a long preparation, since in this case special practice strips have to be made for the whole course.

Nervousness and disturbances of health, too, will always depress the level of performance for some candidates.

Application of the method.

In view of the fact that the prognoses made were correct for 75%, it was decided to introduce psychotechnical testing for radiotelegraphists according to the method described above.

In February 1931 a new class entered the training school. The pupils of this class have for the first time been selected by psychotechnical testing. The result of this test will in due course be reported in this journal.

Supplementary remarks.

In conclusion I should like to remark that the present test is a non-verbal test which, after translation of the instruction, can be applied in any country under the same conditions. Where there is radiotelegraphy, there are Creed transmitters, and where these instruments are to be found the test can be carried out. It would even, if one does not have a Creed at one's disposal, be conceivable to conduct a test at a distance.

By comparing the test results in the various countries one could gain an insight into the differences between the nations with regard to capacity for aural reception. The international agreement that a radiotelegraphist must be able to receive 125 letters/min came about without any prior examination of the capacity to attain so high a speed.

For the psychotechnician there is here an attractive incentive to examine how far the international agreement represents an attainable performance for the members of all the nations concerned.

Summary.

I. In the present work an aptitude test for radiotelegraphists is described.

II. By means of this test, prognoses were made for 3 classes of the training school for radio operators in Amsterdam.

III. The test correctly recognized 84% of the good and 70% of the poor pupils.

IV. The Director-General of the P. T. T. has approved the introduction of the test.

V. The test is a non-verbal test, whose international use is possible.

Note on the transcription: Faithful copy of the scanned original (Psychotechnische Zeitschrift, Vol. 6, No. 2, pp. 41–45). Fig. 1 is rendered as a table, Fig. 2 taken over as an image detail from the original. Original page breaks are marked with "— p. … —". The spelling and punctuation of the original (including »…« and ß) have been retained.