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Occupational psychology study of the activity of recording Morse code, at the same time a new training procedure for radio operators [1]

From

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With 12 illustrations in the text

Contents

A. Introduction

The goal of all work psychology research must be to create optimal impact opportunities for human work. This goal is achieved by t

[1]Disscration of the Technical University of Braunschweig

The mutual adjustment between the psychological structure of the human being and the design of all working conditions under which the respective work to be examined takes place. The An. Adaptation between man and work can be achieved in two different ways with fundamentally different starting points, namely either man or work, but with the same goal.

Taking the human being as a starting point, work psychology's task will be to recognize the individual human being in his psychological structure through a thorough psychological examination (aptitude test), in order to find for him a job that matches his aptitudes, for which he is thus truly "called," in the true sense of the term.

Occupational activity, on the other hand, is not only shaped by aptitudes, but is also made up of a set of transferable abilities for which the original aptitudes are only prerequisites. The development of psychologically proper training processes, which are to build actual professional skills from the basic aptitudes determined in the aptitude test, will arise as a further problem of industrial psychology in the correct pursuit of this way of adapting man to his work.

However, even the best-suited and semi-skilled professional representative will not be able to have a full effect in his work unless the working conditions are fitted to the human being in his entire mental and physical structure. This leads to the second work-psychological approach, which must begin with a thorough examination of all working conditions. This examination will have to focus not only on the design of the specific conditions of the work to be performed, such as the design of the workplace, the tools, the machine, accident prevention measures, working posture, and so on, but also on the design of the general working conditions, such as the design of the working space, the working hours, the break arrangement, and so on.

While the aptitude tests adjust to the psychological attitude of the individual in his individual

Thus, analyses of working conditions must naturally begin with the working person's normal mental and physical constitution and build the conditions for these in such a way that they are as closely as possible fitted to this normal performance.
Only by following both paths and complementing them can the greatest possible adaptation between man and work be achieved, and therefore the prerequisite for the most favorable influence on the working person be established. In both circumstances, a basic psychological examination of the working environment will be required, since aptitude testing and training must also be founded on this understanding of the psychological processes involved in the occupation. As a result, the current research on the radio operator's job is based on a psychological examination of the work process and its settings. Because the recording of Morse signals is at the heart of the radio operator's job, this technique must first be submitted to a thorough psychological test. The essential basic factors influencing the work of the radio operator will emerge from this, as will be shown in the current work, from which will follow the development of a new training procedure corresponding to all psychological conditions and certain points of view on the question of aptitude tests for radio operators.

B. General considerations on the study of radio operator activity

I. Field of application of the radio operator

The work of the radio operator consists in its essential content in the recording and giving of Morse signals; in addition, certain technical operating knowledge must also be present. The requirements in terms of speed, i.e., the quantity of characters per minute when recording and transmitting, are set more or less high according to the various operating conditions of radio communication. For example, as a result of the extraordinary importance of radio for the guidance of aircraft, the requirements for the radio operator must also be increased accordingly.

As a result, in order to be admitted to the flight radio operator service, the requirements of the radio operator diploma l. class must be fulfilled.

In the marine service, radio communication is conducted under the same conditions, i.e. perfect mastery of a speed of 100 Char/Min. The text of the code. The radio operator course's examination conditions, for example, are as follows:

> "Keying a telegraph of 100 words of 5 letters each in 5 minutes on the Morse apparatus in faultless handwriting, recording a code telegram of 100 words and an open text of 125 words of 5 letters each in 5 minutes on the typewriter; transcription of the latter is done on the typewriter1."

In the case of other applications, the average radio operator's regular operating speed is between 60 and 90 Char/Min. The radio operator, for example, works with the army's message troop within this speed range. Even if the wire-connected telephone replaces the wireless electrical message transmission for tactical reasons (eavesdropping and eavesdropping activities), the radio will remain crucial as a message medium for rapid readiness.

Wireless audio reception is no longer widespread in business and traffic, as more sophisticated technology have supplanted human sensory tools. Today, the postal office, for example, uses high-speed telegraphs with speeds of up to 400 Char/Min. Due to human performance, auditory reception has a defined limit. The worldwide agreement that a telegrapher must record 125 letters per minute was achieved without any prior testing of the telegrapher's capacity to do so (see RULE 2). Although technological advancements have lessened the need for human radio operators, radio reception will always be necessary in situations where humans cannot be replaced owing to unique circumstances.

1 Plan and examination regulations for the radio operator course I. Class with special regulations for the training of the Debeg- and Trans radio service. Berlin 1925-

* BIEGEL, A Qualifying Examination for Radio Telegraphists.

6. Jg., H. 2. 1931.

II. The Morse code

For the timing of Morse code, specific proportionality constraints are set by international agreement. Short and longer tones, whose pitch varies depending on the type of transmitter, make up the characters. At all speeds, the ratio of short to long tones, as well as their spacing, should remain consistent. The short element is the unit of measurement for this proportionality. The elements of Morse code will be referred to as dots and dashes in the following sections, in accordance with the language frequently used by radio operators, which evolved from the optical symbols for Morse code (• , —-).

The international agreements on the proportions of drawing specify the
following :

The unit of measurement is the dot length.

The stroke has triple dot lets.

Within Morse code, the pause between the individual elements of the character has the duration of one dot length.

The interval between each Morse code character is the length of a stroke. These globally specified Morse code proportions are suitable only for aural recording at speeds above around 50 Char/Min, as current investigations reveal, a pace that will always be attained in practical radio communication.

The reason for this is that the Morse code's acoustic reception, like the perceptual contents of other sense areas, is linked to the holistic and Gestalt perception's overall psychic appearance.

III. The problem of wholeness and shape in Morse code

The findings of Gestalt psychology study led to the fundamental assertion that our sensory world's impressions are holistic in character. "In psychic conditions of whatever kind, the psychic whole consistently wins qualitatively and functionally," FELIX KRUEGER writes in his book "On Psychic Wholeness." "We speak of wholeness when a whole created by a whole formed”

[1] F. KRUEGER, On Psychic Wholeness. NeupsySt 1. 1926.

> The whole has supremacy of essence over its components; the entire cannot be formed from a valid arrangement of pieces. The whole takes precedence over its components in terms of essence; it is impossible for the whole to form itself from a valid order of parts. 1

The concept of wholeness or being whole cannot be logically defined, yet only wholeness can be represented.

A quadrilateral created on a sheet of paper, for example, is not simply a relationship or the sum of four lines colliding; rather, it is viewed as a whole, an optical structure that stands out immediately and directly from its surrounds.

In reading, the same gestalt formation event happens. A person who can read does not read individual letters, but rather grasps the entire word as a whole. The development of the well-known whole reading approach for learning to read results from the actual implementation of this concept.

In the acoustic field, the military bugle signal might be regarded an example of the idea of gestalt. The significance of such a signal is grasped by grasping the tone complexly in its entirety, i.e. as an acoustic shape in its overall structure typical for this signal, rather than by dosing individual isolated tones. Similarly, every melody is made up of tone complexes, or partial shapes, rather than individual tones.

This living completeness of things includes not only the fleeting grasping of perceptual contents, but also the storing and replicating of any imprints of mental events and experiences in the memory.

It is considerably more difficult, for example, to go through individual tone sequences of a melody from memory than it is to replicate the same tone sequence if it is contained in a melody.

As a result, structured complexes are more repeatable than unshaped complexes. As a result, if any content has to be memorized and preserved, it is possible to reproduce it rapidly and reliably.

[1]O. BUSS, Mother Tongue Gestalts evaluated from the point of view of wholeness. *ZAngP8* 46. 1934.

As a result, learning processes must begin with holistically absorbed and formed content. As a result, the previously mentioned DECROLY I whole-reading approach is based on these preconditions, because no single letters but full word pictures are memorized from the start, just as the literate's reading process is later dependent on the shape of the whole word 2. The Quite read method's success attests to the procedure's correctness. Just as the application of these ideas correctly and successfully leads to a learning procedure for reading in the optical field, the same conclusions will have to be derived for a procedure for learning Morse code in the acoustic field.

Even if in some cases - by no means everywhere
Although there are initiatives in this direction in past and still popular ways for learning to pick up and transmit Morse code, it must be stressed that no method incorporates all of the components that come from the examination of Gestalt experiences when listening to Morse code for learning.

A deep psychological analysis of the phenomena during the recording of Morse code is required in order to truly permit this use of Gestalt psychology results for a learning technique, which will be done in the following.

C. The study of psychic phenomena during the recording of Morse code

The pace with which the signals follow each other clearly influences the mental events that occur during Morse signal receipt. With increasing speed, not only will recording become more difficult due to the increased pressure on the perceptual faculty, but there will also be changes in the overall acoustic impression, which are strongly tied to the shape-forming variables, gates.

[1] HAMADE, The Decroly Method. Weimar, Böhlaus Nachf. 1928.
[2] KERN, Is our reading method correct? Freiburg (Breisgau). 1931.

The most significant goal will be to explore this tempo dependence in depth, as it will become clear that practically all coming problems will be answered as a result of this.

Now, in this inquiry, the seemingly obvious path of investigating psychic phenomena during hearing, i.e. during the recording of signs, has been bypassed. As will be shown later (p. 19) in the studies of this type employed for comparison, an exact experimental evidence through analysis of the processes during hearing would face numerous obstacles,

Rather, the experiment was carried out in such a way that the rhythm of the constituent pieces of each Morse code symbol were provided at various speeds by experienced radio operators was investigated. This method allows for a close examination of the time durations obtained for the elements, as well as their spacing inside the character and between characters.

The justification for inferring recording processes from the manner of giving lies in the fact that the subject, who hears the sign given by him in a headset at the same time, will generally give that rhythm within the sign that appears to him to be the most adapted not only motorically but also acoustically at the tempo in question.

Later, when the results of the offered tests are compared with the direct analysis of the processes during the recording of the characters at different speeds, a good agreement will be shown, the theoretical assumption will be confirmed.

Only those individuals can be chosen for the calling experiments who have an excellent performance in calling owing to extensive practice, because only those are able to adjust to the acoustic rhythm naturally without being influenced by other distracting factors. If, however, there are universal links between Morse code design and pace, these relationships will have to be demonstrated despite minor individual variances.

I. The experimental arrangement

The following experimental setup was utilized for temporal registration in accordance with the experimental objective to precisely explore the temporal relationships in the giving of Morse code at varied tempos.

An unending paper belt with a soiled surface is guided across two drums (HERING loop). A motor can rotate the driving drum at any speed, but it must be constant in each situation. An electromagnetic writing lever and a tuning fork with 100 oscillations per second are written on the soiled paper to mark the passage of time.

The Morse key is linked to the recording lever in a series. At the same time, the radio operator listens to the signal he transmits through headphones to get an acoustic impression of it.

To allow the subject to give entirely unbiased feedback, we separated the Morse key from the recording equipment spatially.

At all speeds tested, all vpn. produced the same sequence of indications, hence the following series was chosen:

b c v q f l h y z x

II. Evaluation of Test Results

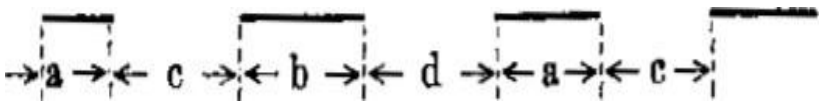
At all speeds studied, all vpn. produced the same sequence of indications, hence the following series was chosen:

For each of the tests, the relationship between the recorded lengths and the corresponding timings is determined using the following test data, from which a numerical sample is to be selected.

The length of the whole paper tape was 208 cm, the time for one revolution was 35 seconds.

One centimeter traveled on the paper tape thus corresponds to 0.168 seconds.

Let the dimensions for the points, strokes, and spaces be denoted by a, b, c, d, as shown in the following sketch:



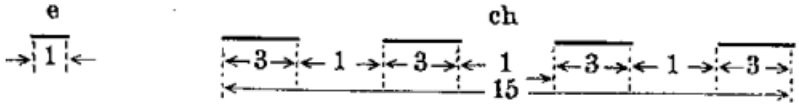
Calculation of the giving rate

At each attempt, the giving speed is prescribed by the VP. The radio operator, on the other hand, can only preserve a defined giving tempo in more or less close approximation, especially if he is giving low tempo. As a result, the actual observed call speed must be estimated from the recorded call samples in the following fashion for the evaluation of our investigations :

The total length for the 10 recorded characters	= (cm)
Time factor :	= 1 cm — t (sec.)
Therefore time for 10 Char	= l * t
Speed	$= \frac{10*60}{l*t} Char/Min$

It's also worth noting that the size of the providing speed is determined by the Morse code used to create a Morse code sequence, as there are longer and shorter Morse codes..

If the duration of a "dot length" is used as a unit of measurement for the character duration of a Morse code (i.e. the time during which the character sounds), then the character duration of the letter e (-) to ch (---------) behaves like 1: 15 in Morse code, according to the international agreement (p. 5).:



The speed of a sequence of commands is heavily influenced by variances in the character duration of particular Morse letters. As a result, because an average character duration, which might be used as a unit of measurement or relationship for each call sequence, is not identified in practice, the speed of the call can only be guessed. The average character duration of a sequence of characters in plain text, for example, would be determined by the frequency of the letters in the sequence. The average character duration in code text is determined by the encryption's composition. The average character length for the complete alphabet of letters A-Z is 8.4 points.

In the present case of our recorded samples, which are composed of relatively long Morse characters, the average character duration of the 10 selected characters is 10.2 dot lengths. In relation to the average character duration of the alphabet from A-Z, the tempo of our sequence, for example, if it has 25 Char/Min. calculated absolutely, would be relatively
$25 \times \frac{10,2}{8,4} \equiv 30$ Char/Min. instead of absolute calculated 85 Char/Min.

would increase the speed relatively to $85 \times \frac{10,2}{8,4} \equiv 30$ 100 Char/Min. growing.

After clarification of these relationships, which must always be observed, the evaluation of the test results can now take place.

With the described recording device, the 10 Morse signals, which were given by 4 practiced radio operators with different high speed, were recorded. From these 10 Morse code signals, the arithmetic mean values were determined for the elements a, b, c, d for each VP

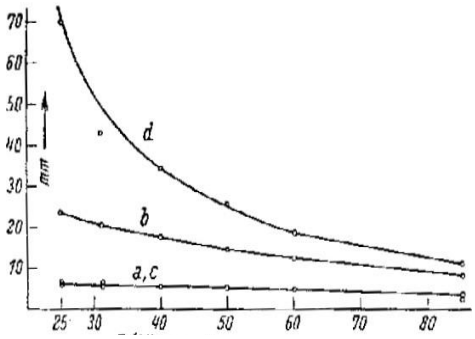
$$\left(AM = \frac{\sum_{i=1}^{n} w_i}{n}; \quad (w_i = \text{Measured values of the individual elements} \right)$$

and compiled in each case with the corresponding calculated speeds in the curves of Figs. 1 to 4. Furthermore, the mean dispersion MV

$$\left(\text{medium variation: MV} \quad = \frac{\sum_{i=1}^{n} [AM - W_i]}{n} \right)$$

of the individual values. It can be seen that the values for a, b, c and d were observed with sufficient consistency by the radio operators. Greater uncertainty can be observed in part for the AM value of d at low speed. This is because it is very difficult to keep the intervals between two Morse code signals approximately consistent at low speed because the pauses between them become too long. With increasing speed, the value for d therefore also becomes more constant. For a better overview of the given values, they are shown in Figs. 1 to 4 in 4 curves for one VP. each. The curves show the dependence of the temporal ratios of the Morse. Character from the Give velocity.

The dimensions for a, b, c and d are plotted on the abscissa or ordinate in mm. The abscissa (1 Char/Min 2 mm) is used to represent the time.



Char/Min

Fig.1 VP. I. The temporal proportions of the subjectively provided Morse code as a function of Tempo (reduced to 12 size). M.1Char/Min= 2 mm (reduced to 1/2 size).

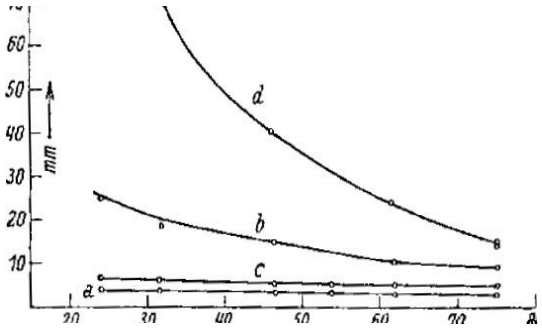
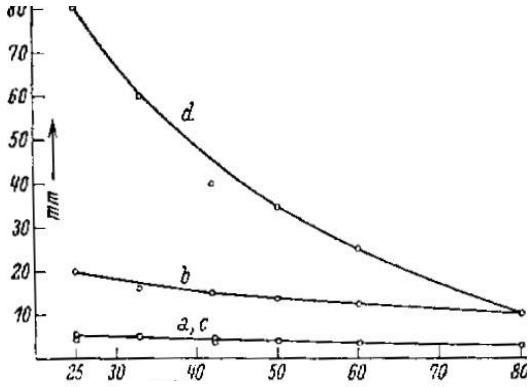


Fig. 2. Vp. II



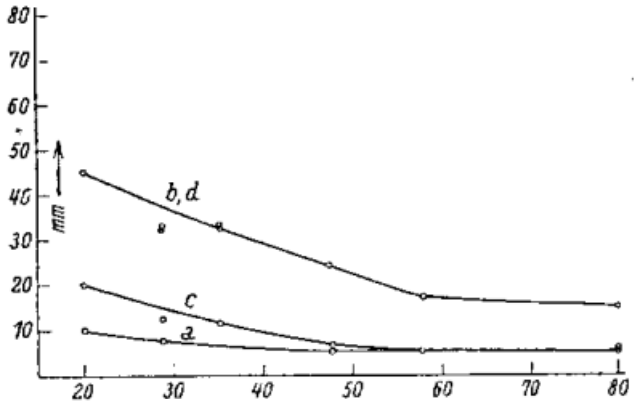
Char/Min

Fig. 3. VP. III

These curves especially the curves I to 111 - at VP, illustrate the links between the lengths of the parts of the subjectively provided Morse code and the tempo and indicate, at first glance, a fundamentally identical trajectory. IV There are unique ratios to be clashed subsequently - that the reliance between the provided tempo and the timer has a certain regularity. Individual Morse code elements are stored here.

To go deeper into these relationships, it's crucial to compare these temporal quantities of the subjectively provided and heard sign with the mathematical dimensions of the Morse code, which is composed at the same high speed according to the proportions of the international agreement.-

The transposition is shown in the graphical representation (Fig. 5 to 8). At the same high speed, the subjectively given character and the corresponding Morse code character with the internationally determined 80 proportions are counter- 70 superimposed each time.



Char/Min Fig.4 Vp. IV

The elements a, b, c, d of the subjectively given character are lined up 30 in such a way (in mm) that they 20 correspond exactly to the temporal 10 course of this Morse code at the respective tempo.

In the same time period of this subjectively given character (s), the Morse code with the proportions of the international agreement (o) would take the form as it can be seen from the graph.

III. Interpretation of results

a) General laws about the relations between the permission of the Morse code and the tempo of the call.

The discussion of the curves will provide information about the timing and design of Morse code, at the same time answering the question of the usefulness of the proportions according to the international agreement.

If the designations of the elements of the Morse code a, b, c, d chosen by us are taken as a basis, the proportions of the Morse code according to the international agreement set:

Unit of measurement for the point length is a.

b=3a, c=a, d=3a.

Of the curves in Figs. 1 to 4, only the first three for Vpn. I, II, III, starting with the lowest speed of approx. 25 Char/Min. It can be seen that the dimensions for a and c do not differ greatly from each other.

The stroke length b is 3 to 4 times, for VP. III even 8 times the length of a, while the international agreement prescribes b = 38.

The dimensions a, b, c, which are more or less close to the dimensions of the international agreement due to individual differences of the donor, will be discussed later.

More important for our investigation is first a consideration of the distance d between two characters. The international agreement sets this distance d=b=3a, whereas in our recorded values the distance d is 3 to 4,5 times b.

The radio operator therefore does not give the ' character in the prescribed proportions at slow transmission speed, but he contracts it more, even if not to the most favorable form (b=3.5 to 8a instead of 3 a). Instead, it makes the distance d between the individual characters considerably longer.

Thus, even at low speeds, the subjectively given sign is compressed to the acoustic unit of a figure by the experienced radio operator.

This merging of the individual elements of the Morse code into one shape becomes very clear when comparing the subjectively given character with the dimensions of the character still of the international agreement at the same speed (graphical representation Figs. 5 to 8).

The comparison shows how the stroke length b of the international dimension is stretched out at the observed speed of 25 Char/Min. This stretching out of the stroke length will have a particularly striking effect on the human being with the acoustic impression which such a Morse code with the international dimensions offers with the auditory recording. If one would keep these mathematical proportions at slow speed, a tortured, long stretching out of the single character would arise during the recording, the acoustic shape of the character would fall apart completely. The example of the subjectively given sign confirms the fact, which is also known from other psychological investigations, that shapes urge towards union and completion.

The graphical representation Figs. 5 to 7 shows that with increasing velocities the ratios for the condition -

come acoustic wholes, gestalts, become more favorable. At the same time, the proportions of the international agreement thus also approach the most psychologically favorable conditions.

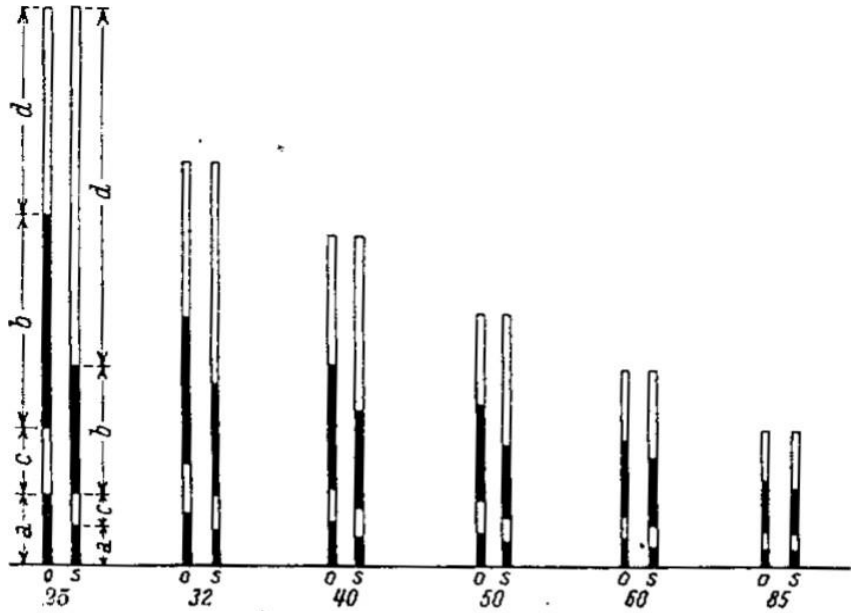


Fig. 5. VP. I. Comparison of the subjectively given Morse code with the Morse code according to the international. Proportion at different Speed. S=subj. character, o = character according to the international agreement.

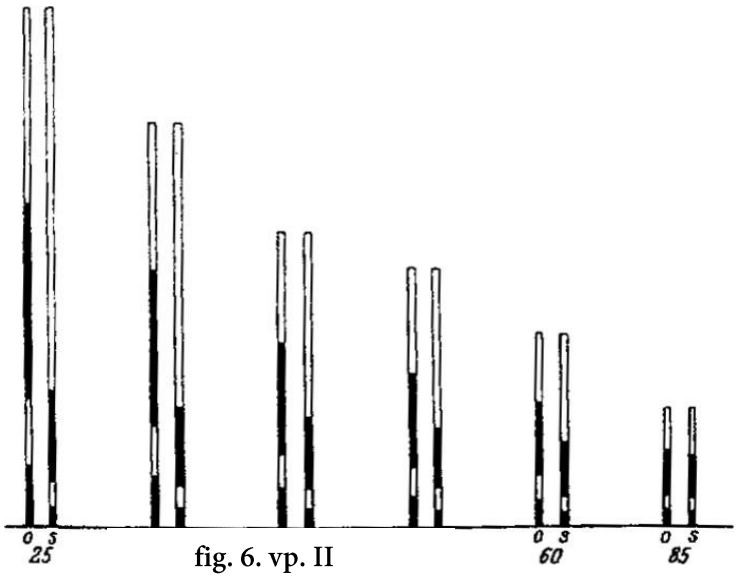


fig. 6. vp. II

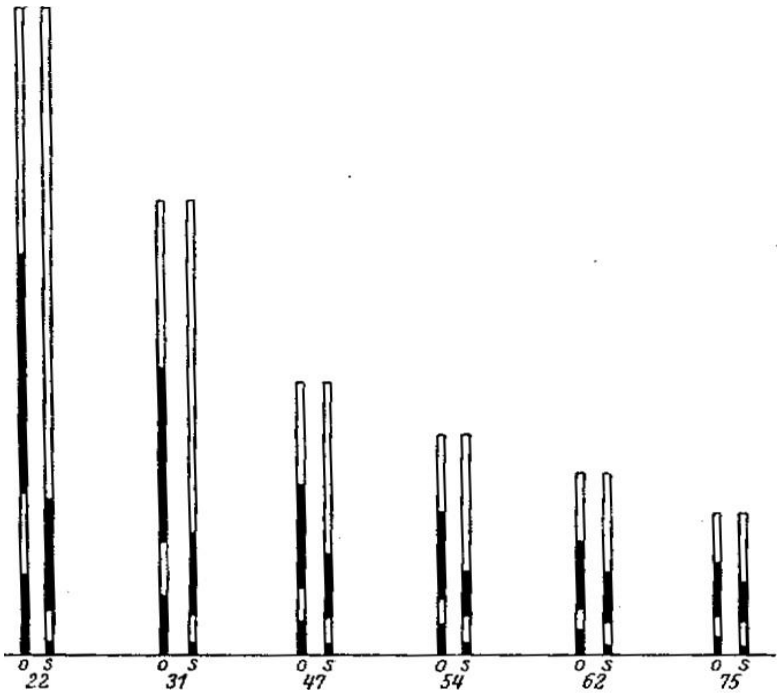


fig. 7. vp. II Char/Min

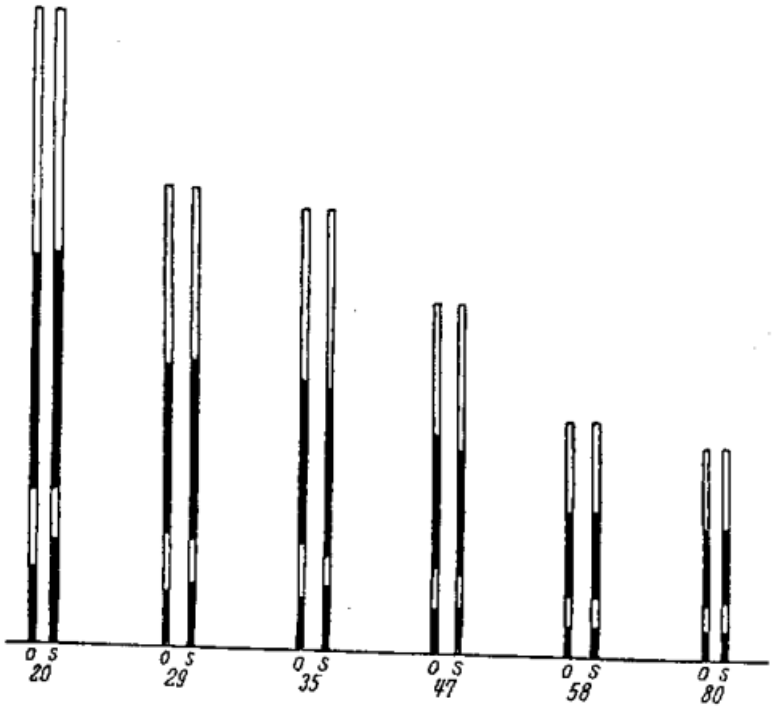


fig. 8. vp. II Char/Min

We can recognize this fact in the graphical representation Figs. 5 to 7 insofar as with increasing tempo up to the highest human hearing and gesturing speed, an ever greater correspondence between the mathematical proportions and the design of the subjectively given sign can be observed. In the curves Figs. 1, 2 and 3, this correspondence is shown by the fact that the b- and d-lines approach each other more and more as the tempo increases, and finally almost merge into each other. The curves prove in general that the Morse code must always take a shape independent of the tempo, because it is impossible "to let the whole constitute itself from a lawful order of parts" 1.

This is true in our case, when at slow speed due to the wide spreading the parts can no longer merge into one unit.

It can therefore be concluded from the illustrations in Figs. 5 to 7 that the proportions of the international agreement at low speed are not adapted to the mental disposition of the human being, but only accommodate this disposition from a speed of about 50 Char/Min. onwards..

We have drawn this conclusion first of all on the basis of the investigations which start from the way of giving, presupposing (cf. p. 8) that the way of giving will generally adapt itself to the psychic conditions during hearing. In order to prove this assumption, experiments were also completed to clarify the conditions of hearing.

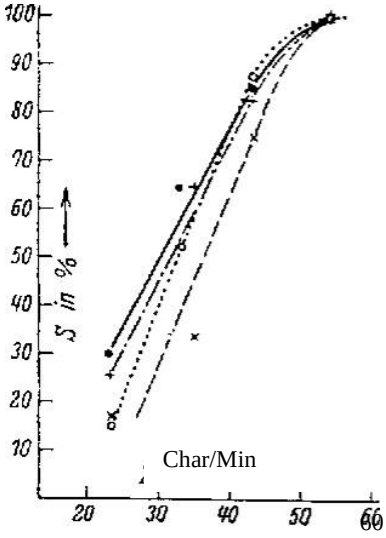
For these experimental purposes, a number of arbitrarily composed Morse code characters (30 characters) were combined to form a commanded data and were given and recorded at different speeds.

The Morse code characters were composed according to the proportions of the international agreement and their 'temporal' ratios could be precisely maintained at any tempo by means of an automatic transmission device (see p. 66)..

Since in this way the international proportions were automatically maintained for each tempo, signs were thus created that were designed in their temporal proportions like the signs

[1] 0. BUSS, Native language design evaluated from the point of view of wholeness. ZAngPs 46. 1934.

in Figs. 5 to 8. For the experiments, a number of Radio operators are available, who can professionally record and give speed 100 Char/Min. The signs were given to these operators at different speeds, starting from approx. 25 Char/Min.



The control of the usability of the given type for the recording was done by counting the wrong and omitted characters in the recorded dictation..

At low speed, it turned out that the reliability of our operators in picking up the audio sequence was very low. At a speed of 25 Char/Min, only 5 to 8 characters out of 30 given Morse code signals were correctly picked up by these experienced radio operators. With increasing speed, the auditory perception improved to finally reach sufficient certainty in the 40 to 50 Char/Min speed range. The results of the listening tests are shown in the curves Fig. 9. Each curve represents the certainty of the auditory recording of a

Fig. 9: Recording reliability of Morse code according to the international agreement depends on the speed.

speed. 1 Char/Min . = 1.5 mm,

single VP. Recorded on the ordinate. The measure "one hundred percent S" corresponds to the 30 error-free recorded Morse signals.

From the findings of these listening tests the agreement with the obtained results of the giving tests Fig 5 to 7 is evident. .

Here, too, in agreement with the earlier experiments, the fact arises that the international proportions begin to adapt to the psychic disposition of the human being only from the speed range of about 50 Char/Min. At a lower tempo, if the mathematical dimensions of the international agreement are adhered to, the character's shape decays, which results in the low level of reception reliability.

The Morse code, therefore, if it is to correspond to the psychic disposition, must always possess Gestalt character, independent of the tempo.

That this conclusion is correct is proven by another experiment, which we completed with the same subjects, who were available to us for the preceding tests, in order to verify the meaning of the acoustic gestalt effect.

With the same low speed at which we had automatically kept the mathematical dimensions before, we now gave signs whose distance d was increased (twice). Since even at low speed the acoustic shape of the sign was already clearly visible, this recording did not cause any difficulty at all for our subjects, whereas the reliability of the previous experiment with the mathematical dimensions was so low.

The acoustic impression of these "designed" signs corresponds to the design as it occurs in the subjectively given sign of our give samples (Figs. 5 to 7 sign s) at low speed.

In both cases, the distance d is noticeably greater than the mathematical dimension dictates at the same speed, and the character itself is more crowded.

This correspondence of the subjectively given sign of the walking samples (figs. 1 to 3, VP. I, II, III) with the "designed" acoustic impression of the sign of our listening test provides further evidence that the way of conducting the investigations on the way of walking can also give information about the mental processes during listening and was therefore justified.

The necessity for this procedure arose from the fact that the listening tests have as the only possibility of measurement the counting of errors (certainty of recording). However, this measure is quite rough and does not lead into the subtleties of the individual relationships as the exact recording during the giving, although it could confirm us, sufficiently for this purpose, the correctness of our methodological approach and the conclusions drawn.

On the other hand, however, in the study of listening there are still some possibilities to draw further conclusions from the interpretation of self-observations and observations of others, which at the same time

can be secured by the exact derivations during the giving tests.

These interpretations will give the opportunity to penetrate even further into the mental processes during the recording of the Morse signals.

First of all, in this way it is necessary to explain in more detail the reasons which lead to the extraordinarily strong failure of the practiced radio operators when Morse signals are given to them at low speed according to the proportions of the international agreement.

With the appropriate will setting every radio operator will finally be able to translate the thus acoustically disassembled Morse code. The pause d between two signs is sufficiently long that the sounded apart sign can be put together again by thinking. The subjects used for these investigations are, as already mentioned, professional radio operators, who are accustomed to the rhythm of the 100 Char/Min. tempo and to the sound pattern of the signal by daily practice. The subjects could not easily adapt to the tortured disassembly of the sign and the reassembly required on it. If the analytical acoustic presentation of the sign, as shown, is generally directed against the psycho-physical disposition, then the disintegration of the gestalt occurring in the process will prove to be particularly disturbing if, as is the case with our subjects, a firmly accustomed rhythmic setting is present. This probably explains this great uncertainty. Our subjects during the investigations of hearing at low speeds.

If, therefore, the radio operator thus adjusted is able to reassemble the heard signal, provided it was given at low speed with the mathematical dimensions, at most still by thinking in the pause d, he 'Will, however, with much greater difficulty be able to give such a Morse code with the mathematical proportions observed,

For example, one of our radio operators (VP. l, Fig. 1) was eager to turn on the mathematical dimensions as much as possible at low speed when giving, but he did not succeed, as can be seen from Figs. 1 and 5.

These inhibitions to analytical giving will be especially strong in persons who, like this VP. I to the

acoustic type of imagination. These acoustic types have a good predisposition for the auditory reception, because they will not have the tendency to learn and to perceive via the decomposed optical symbol even by themselves in contrast to the optical type.

That such correlations actually exist is shown by the behavior of VP. IV, who belongs to the optical type. This VP. has actually been able to keep the international proportions when giving at low speed. As curve IV, Fig. 4 shows, for all speeds the time values for the elements b and d are almost equal and also the values for a and b are almost in the correct ratio of 1 : 3 prescribed by the international agreement.

The closer analysis of the psychic behavior of this patient, in which her optical predisposition has a strong effect, is very revealing. The VP. IV did not learn sparking by hearing, but started from giving, based on the optical symbols, so that she has great practice in giving the sign in mathematical proportions after the optical symbol. In spite of this, however, this student also stated that this way of giving was very unsuitable for listening, because she herself could only record such a presentation of the Morse code with great uncertainty.

The effect of this training method and the disposition of the patient, as belonging to the optical type of imagination, can be seen in the fact that despite long practice the present level of training in listening and giving of our VP. IV is such that she is able to give 110-120 counts/minute without any problems, but in recording she does not exceed 60-70 counts/minute. VP. IV reports that learning to listen has always been very difficult for her, especially the increase of tempo, which is quite understandable after all our previous deductions and is a further confirmation of the correctness of our conclusions.

For the optical setting of VP. IV is further also characteristic that she never gives the signs acoustically or aloud when talking about the different processes, but always paints the optical symbol on it.

Thus or these peculiarities that appear in the curves of VP. IV are understandable, on the one hand, from the individual disposition of the VP. IV (visual type), on the other hand from

the way of learning Morse code, which was autodidactic and according to this type via the optical symbol and giving and not via hearing. Probably the conclusion will be justified that VP. IV is unlikely to achieve higher performance in recording because of this type-moderate attitude. In contrast to VP. IV, Vpn. I, II and III are set entirely to the acoustic impression of Morse code. Of course, also in the curves of these Vpn. Differences occur.

For example, it can be seen in the curves of VP. III that both a is shorter over all velocities than the intermediate space c, which should actually be the same length, and in fact is for the other Vpn. Similarly, it can be seen that in VP. III the values of b and d at higher velocities do not approach as far as in the other Vpn. and as it corresponds to the ratios of the international agreement. Here, too, the bid length (b) is shorter than the corresponding Pause (d).

If one now observes the VP. while playing, one sees that the reason for this deviation does not lie in the acoustic, but in the motor area. The VP has become accustomed to giving the signs in a more percussive, short and choppy manner; this is the reason why the elements a and b produced by pressing down the key are shorter than the corresponding pauses c and d, which are actually of the same length, despite otherwise good adjustment to the sound pattern.

The investigations of this kind have been limited to these 4 voices, since they clearly show the characteristic and at the same time show certain extreme cases in the existing peculiarities, between which, of course, many transitional forms can still occur, especially with regard to the more acoustic or optical attitude of the voices.

b) Individual design of single Morse code characters

The investigations just discussed already indicate that within the general regularities found there are also peculiarities which depend on the individual character of the transmitter and lead to a typical, individually conditioned sound pattern of the Morse code, although it retains its holistic, designed character as a whole. .

It is a frequently observed fact in radio communication that radio operators on different transmitting stations recognize each other by the particular way they give. Each radio operator has a way of giving that is typical for him and depends on his motor and rhythmic attitude. Consequently, also the subjectively given sign will have certain deviations in its acoustic impression even at speeds at which, as a result of adaptation to the psychic disposition, the dimensions of the international agreement coincide with those of the subjective sign. The sound image is bound in more or less approximation to the agreement with the mathematical proportions, but it is moreover "typically" shaped.
If one records at a higher speed (60-100 Char/Min.) any sequence of Morse signs given by hand, and then presents the same sequence at the same speed with the mathematical dimensions exactly observed (by automatic giving device), the difference of both types of sound image can be clearly heard.

When listening to these differences of the two types of sounds, one has a similar sensation as when a musical work is played down by an automatic musical instrument (orchestrion) or performed by the hand of a practiced musician.

The automatic instrument gives the sequences of notes in a mathematically exact and choppy way, while the emotional connection of the sequence of notes and its shaping can only be produced by the person performing it according to his individual disposition.

Thus, the typical design of Morse code is also caused by the psychic disposition of the radio operator. In order to investigate the so individually conditioned sound pattern formation, series of Morse code signals were recorded on the recording device of several radio operators according to the method described on p. 9.

From the results obtained in this way, some particularly characteristic examples may be singled out. In order to recognize the differences of the two formations, i.e. the individual and the corresponding mathematical formation, they are described in

Table 1 with their visual symbols juxtaposed. Here, the distances between dots and dashes correspond to the temporal intervals in the sound images.

Table 1

Charakters	Mathem. Form	Individ. Form
l		
f		
c		
q		
x		
y		
k		
d		

The deviations of the individual forms from the design according to the mathematical proportions, which can be seen in table 1, could at first give the impression that elements of a sign which belong together are torn out of the designed unit apparently without sense and without rules. In reality, however, design effects are decisive for this, too, because the sign breaks down into partial shapes.

In order to overlook these connections more easily, we choose an example from the optical field. Here, too, the reception of a perceptual content is all the easier, the more this content has a gestalt character.

1 2 3

Looking at the above figures, it can be seen at first glance that the entire shape is characterized by the shape character of the parts. This effect is so strong that it appears even with very short observation in the tachistoscope, i.e. that four pairs of lines are seen. The overall shape is divided into partial shapes. We take the division of the

The more the perceptual content stimulates the emergence of the partial shapes, the more clearly the overall shape is perceived. Thus, in row 1, if all the lines are equally spaced, no partial shapes will appear, which has the consequence that in tachistoscope observation even the number of lines will be recognized only uncertainly. In row 2, on the other hand, partial figures appear, which are even more prominent in row 3 because of the smaller spacing of the lines belonging to a pair.

We now observe the same occurrence of the highlighting of partial shapes from the overall shape in the acoustic field with the different shape images of subjectively given Morse code. The radio operator can hear certain partial shapes in the Morse code, which are formed according to the kind of stimuli, which the Morse code in question gives by its form, or also according to the individual arrangement.

Accordingly, he will also emphasize these partial forms during the transmission and thus color the character individually. Let's look at the shape of the letter c from this point of view, for example.

Not every radio operator will take this sign as an unstructured whole: - -, more often one observes a division into two partial shapes : ------ (da dit. . . da dit), more rarely into : -------- (da dit da dit), as it were a main partial shape, to which the short dot is then attached.

In a similar way, the other signs in table 1 are divided into subforms. However, it can be seen from this table that this phenomenon only occurs with those signs which suggest a division. This is shown by the fact that partial shapes do not occur, for example, with the character s or similar characters.

Particularly noticeable is the tendency to subdivide the whole into partial shapes in the samples of beginners, but even more experienced radio operators often cannot get rid of this without difficulty.

In addition to this division into sub-forms, some other individual peculiarities which influence the design of Morse code should be mentioned only briefly.

For example, some radio operators particularly emphasize the stroke length b for certain characters, i.e., they consider the time of transmission to be

b longer than the mathematical dimensions prescribe. Still others give the dot length a short and choppy, i.e. shorter than the mathematical dimension requires (cf. e.g. the case of VP. III described on p. 22).

In addition, it is still to be mentioned as characteristic that before and after short Morse characters the distance from neighboring characters is somewhat increased. Probably this arises from the feeling to prevent a merging of the short character with the neighboring characters, a danger which is very obvious with the short characters. In fact, the radio operator also has this time available due to the shortness of the character, without lowering his transmission speed (cf. the remarks on the relationship between the length of the character and the transmission speed, p. 10). All these deviations and individual contributions are individually conditioned; they are in themselves very small and move only in the order of magnitude of seconds, but nevertheless they give an individual character to a sequence of Morse signs given by a human being, similarly as this is to be observed e.g. also with the handwriting, without the basic appearance of the holistic organization of the Morse sign being destroyed thereby.

IV. Summary of the results and conclusion

Apart from the small individual variations, as they were described last, the previous investigations about the Morse signal have shown that for the reception by the human being as a basic principle the working of the Morse signal as an acoustic wholeness, Gestalt, is a prerequisite. From this basic principle it follows that Morse code, according to the proportions of the international agreement, is usable only from about 50 Char/Min. on. Then, however, this basic principle is quite satisfied. Below 50 Char/Min, the proportions according to the international proportions are unusable, because then shape decay occurs.

For the question of learning Morse code, this leads to the conclusion that a learning procedure must establish the learning of Morse code as acoustic shapes as the first basic principle.

If possible, one will also have to try to make the acoustic shape more memorable for learning by further measures. For the development of a learning procedure, further aspects will result from an analysis of the learning process, which will be carried out in the following section.

D. The psychological learning process

I. Investigation and criticism of the previous training procedures

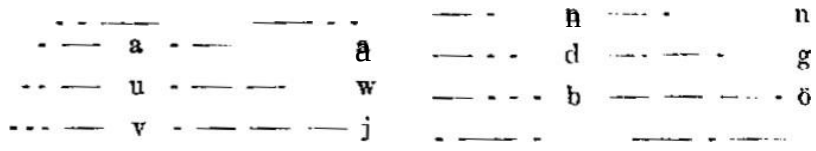
The analytical method

In general, the training for listening reception by this method begins with memorizing the optical symbols of the Morse code. In practice, various methods are used to facilitate memorization of the symbols,

Some examples are given below:

The composition of the characters from 1, 2, 3, 4 dots gives the mnemonic wordish the composition of the characters from 1, 2, 3, 4 strokes gives the mnemonic wordtmoch.

Characters related in structure are combined to form a scheme:



r inverse like k

v inverse like b

u inverse like d

After the learner has become familiar with the optical symbols of Morse code and has consolidated them in the course of the exercise, the recording of the characters is begun at a low tempo. In this method of learning, the radio instructor tries to keep the international proportions of the Morse code as close as possible during transmission. Thus, characters are produced which are 80 in their temporal proportions like the character o shown in Figs. 5 to 8 at low speed. The point length extends over a certain time.

stretch. The stroke length is widely spaced in the corresponding ratio to the dot length. Due to this approximation of mathematical proportions at a low tempo, the acoustic unit of the character is completely torn apart (see p. 17). The shape decay has the effect that during the recording of the sign the counting or memorizing of single dots and strokes or of shorter and longer sounds is unavoidable. In the time, during which the sign sounds, the listener has in addition still the possibility of thinking about what can develop from the momentarily sounding sign. For example, while the learner is listening to the character ------ stretched out so agonizingly long, he might be thinking about or waiting to see if there are one or two more dots or dashes to come for the character that has just sounded. In this case, his concentration is unnecessarily occupied and distracted from clearly grasping the character. After the Morse signal has faded away, the listener has to reassemble the character he has just heard by thinking about the sequence of dots and dashes that has been imprinted in his memory. This reassembling is usually done in a roundabout way by translating the optical symbol, which was already mastered before the actual hearing. Since the pause d is sufficiently long at low tempo, the assembling of the faded sign does not make yet large difficulties. This changes, however, when the listening speed increases in the course of the training. The learner must change from this translation to the immediate relationship between the characteristic sound pattern and the corresponding letter, if he wants to reach a higher tempo at all. In the meantime, however, the learner has inevitably had to get used to the composition of the decomposed Morse code in the pause d. The increase of the listening speed now not only shortens the pause d, but also changes the character itself in its sound effect. In the graphical representation Figs. 5 to 8 it is shown which change the character o, i.e. the character with the observed mathematical dimensions, undergoes up to the speed at which the international proportions begin to adapt to the psychic disposition of the human being. In the course of the progressive course of education, therefore, with each increase in tempo

the international sign changed in its character. The learner must adjust himself again and again to this change of the sign, which is already addressed to Sieh in the acoustic effect against his psychic nature. In addition, the pause d between the Morse signs becomes shorter with increasing tempo, so that the thinking about the present sign must be accelerated. In the tempo range 50 Zu/Min. where the adaptation of the mathematical dimensions to the psychic disposition is generally reached, the Morse code has assumed the acoustic shape, the sound image. From the agonizing decomposition of the sign, at this rate of 50 Char/Min, has finally become the shaped acoustic unit. For the learner, this development in the absorption of the Morse code from the decomposition to the sound image means a heavy burden and requires a constant changeover to the character dependent on the tempo.

As a further evil it is added that with too low a tempo a deficient overall rhythm must develop. Every time the tempo is increased in the further course of training, the rhythm changes with the tempo and this change requires the learner to constantly adjust to the new rhythm.

If one briefly summarizes the various disadvantages of this training method, the following points emerge as the most important ones:

1. Learning with detour via the optical symbol.
2. guessing which sign could come, distraction.
3. the decomposed sign does not correspond to the psychic structure of the human being.
4. switching from decomposed signs to listening to the designed unit.
5. switching from guessing and translating via the optical symbol to the immediate connection of sound-image-letter.
6. changeover in the overall rhythm.

All these disadvantages lead to a complication and slowing down of the learning process.

This analytical method of training has already been replaced in many cases by a method which has overcome the laborious path of development from the decomposition of the Morse code to the acoustic gestalt effect.

The sound image method

The training begins also here with low auditory tempo, but the Morse code is offered from the beginning temporally briefly contracted in its character as sound image. It is given in the same way as the signs in Figs. 5 to 7, i.e., the acoustic impression of the sign takes on the character of a shape, it acts as a sound image. The conversion from the decomposed sign to the acoustic shape of the sign is avoided here. As in the analytical method, however, the memorization of the optical symbols is often started before the actual beginning of the recording, or they are given at the same time. Since the learner has already mastered the optical symbols, he will inevitably want to translate the heard sound image via the optical symbol and this means again nothing else than a dissection of the formed acoustic impression into parts. The sound image, however, after the foregoing, must act directly as a whole and in this sound unity must be directly connected with the meaning content, the letter. Thus, at this point, the knowledge of the optical symbol, which causes or reinforces the tendency to disintegrate the sound image, 8is disturbing and better to be avoided. This translation over the optical symbol is favored still by a further appearance, which arises from this method of giving. Since the sign itself is given briefly, the slow tempo can only be achieved by increasing the pauses d between the signs (cf. sign s Fig. 5 to t at slow tempo). During these long pauses between the individual sound images, therefore, the learner becomes accustomed to thinking about the sound image that has faded away. With increasing listening speed, however, the pause d between the sound images is shortened more and more and finally, as the practice progresses, a tempo is reached at which the pause d becomes so short that thinking about the Morse signal just heard has become increasingly difficult and finally impossible. This case occurs at a listening tempo that fluctuates around 50 Char/Min, so here the student has to change his mental attitude while picking up the signs. The curves in Fig. 10 show that the described Er. The curves in Fig. 10 show that the described learning processes do indeed have a significant influence on the training. These curves represent the progress of performance during several weeks of training according to the sound image method.

The performance curves are shown in Fig. 10. There are four such curves picked out of a large number 1 in Fig. 10, but they show the general typical progression in this training 2. The power curves indicate the increase in the rate of uptake as a function of the training duration of a course. This training duration is plotted on the abscissa in weeks, although the daily practice time plays a role; but since this daily training remains relatively the same, it can be neglected.

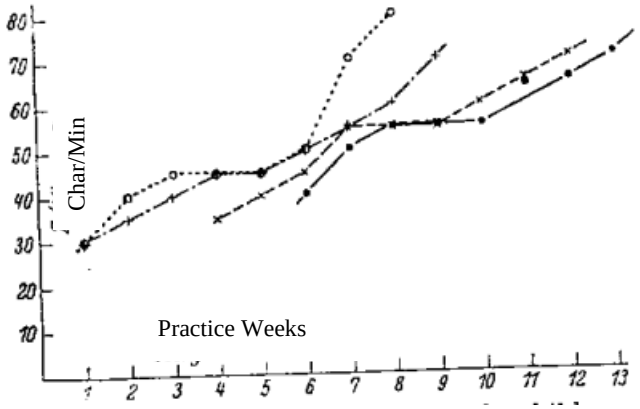


Fig.10. Power curve sound image formation.

After an initial more or less steep rise, the curve generally flattens out in the area of the tempo 50 Char/Min. to an 86 plateau that extends over a certain period of time (1, 2, 3 weeks). The recording speed in this area of the hearing curve has become so high that in the pause that occurs between the sound images, thinking about the sound image that has faded away has now become very difficult. During that time of plateauing of our curve, therefore, no progress can be recorded in the learner's practice level, since he now has to make the already mentioned changeover. It was already stated that the reflection in the pause d in the area of that recording tempo, at which the plateau process in the performance curve begins, is no longer possible. If, however, after a certain period of time (plateau time) of continuous practice in listening to the tempo 50 Char/Min - with our curves up to 3 weeks --- the performance curve rises again, then the learner must do the now impossible thinking and translating

[1] The curves have been kindly provided by the German Commercial Aviation School Braunschweig.

[2] The same plateau formation is shown in a curve of American training procedures published by GIESE (Methods of Economic Psychology, Handbook of Biological Working Methods, 1927, on p, 333). The plateau here is about 60 Char/Min. and extends to about 6 weeks of training.

have overcome via the optical symbol in the pause d. By continuous practice in recording the tempo 50 Char/Min. the absolutely necessary unity of meaning between acoustic sign and letter is gradually established. Immediately after the Morse signal has faded away, the radio operator mechanically writes down the letter which the sound image means, without having to think in the least about this sound image or to translate it via the optical symbol. Recording at a higher speed is impossible without this acquisition of the unity of meaning between the sound image and the letter and its mechanization. The plateau time is therefore a conversion time for the radio operator from thinking about the sound image to automatically grasping it. This time varies according to predisposition and daily practice duration. For many people, as will be shown later (p. 62), this changeover is virtually impossible for lack of aptitude. Also with this method, as with the analytical method, the necessity of changing over and over again to a different overall rhythm of the character sequence arises as a further difficulty. It can therefore be stated with this sound image method that although the essential error of breaking up the uniform sound image of the Morse code is avoided, various errors still remain, which have a rather disadvantageous effect above all on the duration of the training period. If one summarizes the disadvantages of the procedure briefly, they result in the following essential points:

1. learning with detour via the optical symbol.
2. thinking about the sign during the long pauses.
3. switching from thinking about and translating the optical symbol to the direct connection between the unit of meaning, the sound image and the letter.
4. changeover in the overall rhythm.

From the present study of the training procedures hitherto in use, certain guidelines now emerge for the development of an improved teaching procedure, which, if it is to lead to success, must take into account all psychological aspects.

The most important conclusion, which fundamentally determines the training procedure to be developed and also principally distinguishes it from the previous procedures, relates to the giving-

speed during the training. Both the detailed studies of the relationship between the rate of call and the acoustic pickup by the radio operator and the study of the previous training procedures have shown that the critical rate for the changeover in the mental behavior during the pickup is 50 t/min.

Therefore, if all these disadvantages associated with the changeover are to be avoided, the training speed must be above this critical speed from the beginning.

The new procedure is based on this fundamental point of view and determines it in its most essential parts. Before going into the details of the new procedure, the errors identified so far should be briefly recapitulated so that the principles for the new procedure can be developed from them and the resulting possibilities for improvement. (The errors marked I and II refer to the analytical procedure (I) and the sound image procedure (II), the indices to the points listed on p. 29 and 32).

1. errors that prevent the formation of acoustic wholeness (shape, sound image)

Error :	Improvement:
Detour via the optical symbol	Switching off the optical symbols.
b) Decay of the acoustic shape of the Character 13	signs in the form of the sound image give.
c) conversions from listening to the decomposed sign to listening to the sound image I,	Sound image immediately at the start of the emptying.

2. Errors that interfere with the creation of the unit of meaning between the acoustic impression and the letter.

Error :	Improvement:
a) Guess which sign might come I	Giving the sign as a sound image.
b) Reflecting on the sign During the long breaks	Giving at a higher pace.
c) Switching from thinking and translation to unity of meaning between acoustic sign and letter 15 IIs	Already at the beginning of the learning high tempo.
d) Changeover in the overall rhythm 10 114	Begin with a high tempo and keep it up.

From these points of view, a new learning procedure is now to be developed.

II. Development of a new learning process

In the development of the new procedure, a theoretical foundation should first be given following the errors just highlighted, and then the practical design of the training should be based on this.

a) Theoretical foundation

The Morse code must of course remain unchanged in its character as a whole, as a sound image, even with this training method. It is also already a mistake if the optical symbols of the Morse code are already impressed on the learner before the actual hearing. The already known optical symbol of Morse code will necessarily stimulate or reinforce the learner's tendency to break the sound picture into dots and dashes during the pause d. Moreover, the fact that the symbol is already mastered brings the disadvantage that a translation is made from the sound image to the meaning via the visual symbol and not directly from the acoustic impression to the letter. There is no doubt that the immediate grasp of the sound image without thinking, i.e. the formation of an immediate unit of meaning between the sound image and the letter, which is the aim of the training, is made more difficult by the mastery of the optical symbol. Only at an advanced stage of practice, when the learner is immediately able to automatically write down the meaning of the Morse code he hears, will the optical symbols introduced only then no longer be able to cause any harm in the progress of practice. The previous measures should achieve that the learner is adjusted from the beginning to the acoustic whole impression of the sign, without being distracted by disturbances. It is therefore justified to further consider whether this achievement of the designed acoustic impression can be increased by special measures. For this purpose, the two-tone method has been introduced.

The two-tone formation method consists of dots and strokes being formed in two different, but closely adjacent

pitches are given. This gives the Morse code an even stronger typically melodic character and thus an even greater formative effect. From about the middle of the formation, the two tones are then gradually approximated again until the signs are given with one tone, into which the characteristic melody of the individual signs is then subjectively heard. With these measures, therefore, all errors of group 1 (p. 33) are avoided, which counteract the necessary gestalt effect of the acoustic impression of the Morse code and lead to inhibiting conversions during training. The use of the two-tone method is not absolutely necessary, but it results in a further facilitation. Measures are now necessary to eliminate the errors of group 2 (p. 33), i.e. those which impair the formation of the unit of meaning: Morse code - letter.

The plateauing of the auditory curve at about 50 Char/Min, which brings a greater loss of time for the training, arises, as previously explained, from a gradual and laborious changeover of the learner. This inhibition of changeover must be avoided in order to establish for the learner from the outset the immediate unity of meaning of sound image and letter, which is an absolutely necessary prerequisite at a higher listening speed. This leads to the conclusion to start the training immediately with the tempo 60 Char/Min, i.e. above this critical tempo and the position of the plateau of the training curve. In this way, all the disadvantages and the lengthy path of training from slow to higher speed with the associated conversions are overcome. If the decision is made to start the training at a high speed, it is necessary to make further changes in the training process compared to the previous methods. In the latter, in general, the learning of all the characters is fast. If one were to do the same at high speed, the normal scope of comprehension would very quickly be exceeded. Therefore, the training can begin according to the tempo with only two characters, which are practiced until the learner is able to write them down mechanically. In the same way, letter by letter is gradually added.

The previous way goes from the fast learning of all signs to the increase of the tempo, the new way, however, from high tempo to the very gradual learning of all signs.

By setting this tempo, the purpose is fulfilled that the sound image must be automatically grasped immediately and thus any reflection is made impossible from the beginning, so that all tedious changes are avoided.

The purpose of tempo training is therefore to avoid, from the very first moment of learning, anything that might hinder the formation of the unity of meaning between the acoustic sign and the letter, in order to achieve from the outset that attitude in the learner which alone can enable him to reach an auditory tempo that satisfies practical requirements.

The consolidation of this relationship between sign and letter can, of course, only be achieved by intensive practice ; therefore, only one letter at a time will have to be newly added to those known so far and practiced until this close link is achieved, so that the transfer from sign to letter takes place without reflection and detours. The process is thus automated, in that the thinking is already replaced by unconsciously working attitudes during the learning and thus is also relieved.

One thinks comparatively of the example of the soldier who learns his grips.

EHRENSTEIN describes this exercise process in his "Introduction to Holistic Psychology" as follows :

"First the soldier must perform each partial movement with full participation of consciousness. This task usually requires his full attention during the first exercises. The well-rehearsed soldier, on the other hand, can think of anything else during the execution of the grip without causing legs movement to lose accuracy. Consciously executed sequences of movements give rise to unconsciously executed attitudinal units. The biological purpose of all exercise is to be found in the relief of the consciousness by unconsciously working attitudes."

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[1] EHRENSTEIN, Introduction to Holistic Psychology. Leipzig 1934.

It is similar with the acquisition of the skill in the use of a foreign language. Initially, one laboriously assembles the vocabulary in memory and then translates it into the foreign language. Through continued practice of the vocabulary, expressions, etc., one finally gets on the right track to thinking and speaking immediately in the foreign language.
In the same way, in the proposed method, a close connection between the acoustic sign and its meaning is created, first with two signs, by continuous practice at the rate of 60 Char/Min, which then always runs automatically without thinking. Therefore, only one character can be added at a time, so that the unity of meaning between the sound image and the letter is also clearly created for this character from the outset. If one would introduce several characters at the same time, this would exceed the scope of perception too easily and the formation of this firm relationship would be prevented.

This tempo design also has an influence on the question of the importance of rhythm for learning. From a certain tempo on, the Morse code signals present themselves to the ear as a rhythmically structured sequence of stimuli. The regular up and down of the following Morse signals and pauses creates a rhythm accompanying the sound images for the listener.

It is well known that rhythm has a beneficial effect on all work processes, since it facilitates the work impulses. 1 Thus, the rhythm which is created by the sequence of the signals in a certain tempo can also have a favorable influence on the performance, if the learning conditions make these effects favorable. However, this is not the case with all previous methods. By giving the signs in a certain tempo, a rhythm is forced upon the learner, which does not have to correspond to his own psychic disposition, his own rhythm in every case. In this case, the learner must gradually adjust to this rhythm until the rhythm can have any beneficial effects. If this adjustment has not yet taken place, the imposed rhythm can even have a disturbing effect. If the rhythm is also changed again and again during the gradual increase in tempo in the previous learning procedures,

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[1] BÜCHER, Work and Rhythm. Leipzig 1924.

the trainee has to make repeated adjustments, which in turn complicate and therefore lengthen the learning process.
With the new method, the pace and thus the rhythm is kept the same throughout the entire training, so that these obstacles to changeover no longer exist.
In addition, special measures will have to be taken to adjust the learner to this rhythm right at the beginning. That and how this is possible will be explained in the section on the practical organization of the process. The measure to begin the training immediately with the tempo of 60 Char/Min. therefore proves to be extremely expedient in all directions, because the formation of the Morse code as an acoustic whole, shape, sound image is thereby inevitably achieved, and furthermore the changeover from guessing and thinking to the immediate grasping of the meaning and the changeover in the rhythm is avoided. All these circumstances explain the superiority of the method over the previous ones, which will be demonstrated later.
However, one question remains to be clarified; the speed of 60 Char/Min. does not yet represent the speed sufficient for practical operation. Mau could therefore first think of raising the speed even higher from the outset, possibly to the level required for the intended purpose. This attempt was actually made by selecting a speed of 100 Char/Min during a training course. It should be noted that it is quite possible to master the first letters at this pace from the first lesson onwards. In the course of the course, however, it became apparent that, if the students were not particularly well-suited, the range of comprehension becomes very tense, so that the addition of newer and newer letters is associated with greater difficulty. Therefore, it seems to be more appropriate for general conditions to start with a speed of 60 Char/Min. It has also been shown that progressing to a higher speed from 60 Char/Min. does not cause any fundamental difficulties. This is proven by the fact that even a tempo of 70 to 80 Char/Min can be taken up without any further practice. Also the earlier theoretical

derivations indicate that after the speed of 60 Char/Min no more fundamental changes in the overall psychological behavior are necessary, as occurred around the speed of 50 Char/Min. The correctness of this assumption can be seen from the course of the exercise curves in Fig. 10, which show a steady increase after the tempo 50 Char/Min without further plateauing.
Thus, after mastering the tempo 60 Char/Min, it will only be possible to bring the tempo up to the speed required for the practical operation in question by further practice without any new difficulties in principle.
By automating the relations between the sound image and the letters, which must be absolutely present for the radio operator activity when recording the Morse code in practice, it is further achieved that the radio operator can write down the heard character and during the writing hears the new sound image (without thinking). It forms more or less fast with the auditory recording of a trained person from the writing down of the heard sign and the hearing of the next sound picture this shift, as one can observe frequently with practiced radio operators.
b) Practical allowance of the procedure
The conclusions drawn from the previous investigations and theoretical considerations must be tested for their practical usefulness in order to prove the effectiveness of such a method - compared to the previous ones. From the course of the training further points of view for the special structure of the procedure can be won.
For this purpose, a radio room was set up in the Psychological Institute with the appropriate listening and hearing equipment. Several courses were held here, which were set up in various ways according to the experience gained, in order to obtain documentation for the clarification of the various questions that arose.

> Thus, two questions arise for further treatment, namely, on the one hand, the conclusions to be drawn from the practical training procedures for the design of this procedure and, on the other hand, the proof of the good performance of the procedure by the practical results of the training (II, c, p. 52).

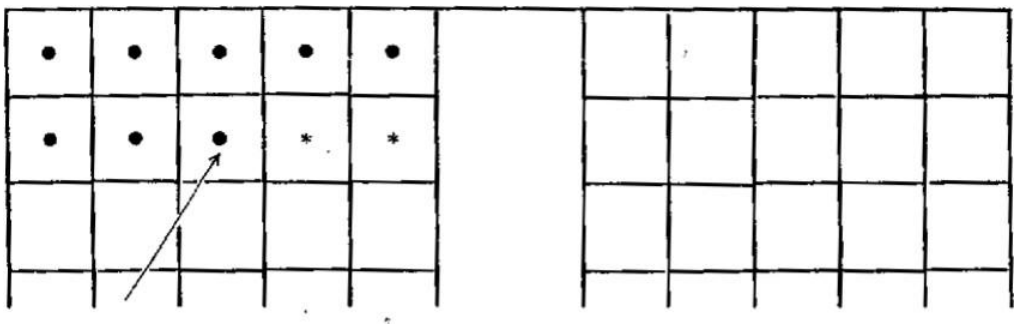
The conclusions for the practical design of the method will concern on the one hand the general structure, in which the questions about the gestalt effect of the sound image, the rhythm and the tempo are to be clarified, and on the other hand special questions, which deal with the different difficulty in learning individual letters, the distinction of similar letters etc., In the following the general problems are to be clarified first, in order to then prove the practical successes.

1. General structure

a) Sound pattern and rhythm

The learner is first introduced to the rhythm of the training tempo 60 Char/Min. Since this rhythm is imposed and therefore does not always have to correspond to the learner's own rhythm, the learner adapts to it more or less quickly depending on his disposition, so that the training must begin with an adjustment to the rhythm. For this purpose, it is advisable to start from two well-differentiated sound patterns, presented by means of an automatic fingering device (p. 66), in order to keep the tempo exactly. In practice, when using coded text, it is usual to arrange groups of letters of 5 characters each, which are given with correspondingly noticeable pauses between the groups of five. The learner should be accustomed to this general arrangement of practical radio* traffic from the beginning, so that this grouping of letters was carried out in our training from the beginning.

With more or less difficulty, the learner hears the acoustic shape of the individual character from the first two sound pictures presented one after the other without any rules. The letters belonging to the sound pictures are not mentioned yet, because the learner is to be adjusted for the time being only by listening to the sequence of prayers to the acoustic shape of the sign and to the rhythm.
Some people are immediately caught by this rhythm because the imposed rhythm coincides or is related to their own rhythm.
The training procedure uses a form for writing down the letters according to the following arrangement:



In order to initially introduce the learner to the rhythm, he should place a dot in the free fields of the form each time he hears the acoustic shape of a sign from the listening sequence. In this way, he rubs dot after dot into the fields of the scheme and is thus gradually introduced to the imposed rhythm. The insertion of the dots at the beginning of the exercise has the additional

the significance that it creates a chord between the acoustically recorded rhythm and the rhythm of the writing hand. Above all, however, this training on the rhythm also has the effect that the learner is inevitably led to listening to the underlying sound image. The optical symbol is therefore, as already mentioned before, completely kept away from the learner.

Only after the first two sound patterns are heard as different and the learner has adjusted to the rhythm, the letters belonging to the sound patterns are named. Writing down these letters does not generally cause any difficulty. Of course, it still happens from time to time that the learner in this first training period has not immediately automatically grasped a character that has just sounded. He will therefore want to try to think about which character just sounded during the much too short pause until the next character sounds.

The following sound image, however, sounds into this reflection and causes the learner to lose his composure and thus to lose the connection with the rhythm of the auditory sequence altogether.

This disturbance must be prevented from the beginning. It must therefore be impressed upon the learner that in such a case, where the sound image is not immediately grasped automatically by him or her

places a dot in the relevant field of the scheme in place of the sound image that is not understood. The learner thus remains in the rhythm of the auditory sequence. The sign that is not automatically grasped must be dropped immediately; the learner must not want to make the slightest effort to think about it. With this attitude, he is able to actually recapture the sound pattern following a Morse signal that has not been understood. Therefore, this first conscious rhythm training will also be of essential importance for the entire learning process.

After a short period of practice (about 10 minutes), the relationships between the acoustic impression and the represented letters of the first two signs are so firmly established that an immediate transfer from the acoustic sound image to the letter takes place. Only when this is achieved, the next Morse code character may be added to the two sound images. This is expediently done in the following way.

The listeners are made aware of the fact that from now on a new sound image appears in the sequence of giving. In the order of giving, the two known Morse code signals come first, the third Morse code signal is the new unknown sound image. For this new sound image a point is to be set in the free field of the scheme. In this sequence of giving, the new sound pattern occurs several more times without any rules, and the learner must therefore place the dot in the relevant field of the form each time. The radio instructor checks the listening logs to make sure that the learners have actually put the dot in the right place. If this is finally the case, 80 the letter for this new sound picture can be called by several practice letters the three first sound pictures are strengthened. Whenever new letters are added, special care must be taken not to exceed the learner's comprehension range, i.e., it is not necessary or allowed to proceed excessively fast with the addition of new letters. This is especially true at the beginning of the learning process, so it is sufficient to practice only three sound patterns in the first half hour, even though those who are suitable are able to do more. The further learning happens in such a way that letter by letter is introduced gradually. The introduction of the other letters is done in such a way that the new letter is repeated twice at the beginning and twice at the end

then scattered randomly among the other letters (cf. letter arrangements [pp. 56 and 57]). By the fact that again and again the new letter is marked first by a point, one reaches besides that that the attitude is practiced again and again not to think after misunderstood signs, but to mark by a point.

The most important condition for each introduction of a new letter is, however, that this addition may always take place only when the level of practice for the absorption of the previous characters has been sufficiently consolidated, since otherwise the scope of comprehension is immediately exceeded when new letters are added.

If the scope of comprehension is exceeded, this can lead to considerable disruption and inhibition of further learning. We had to convince ourselves of this fact through practical experience in a training course where two letters were introduced at the same time. Especially when a large number of letters was already known, this led to an excess of the scope of comprehension, which then - as is also known in other areas - not only endangered the security in the absorption of these new letters, but also sensitively disturbed the entire absorption, i.e. also of the already known characters. The practical success was then that for the new consolidation much longer exercise times were needed, than if the letters were switched on individually. In the later course of the training also the optical symbol can be given, because if only once the fundamental attitude of the learner for the admission of the sign is consolidated directly over the sound picture and not over the optical symbol, then also the knowledge of the optical symbol will have no more harmful effect.

ß) Amplification of the gestalt effect of Morse code.

Two-tone process

While the learner is introduced to and accustomed to the rhythm of the 60 Char/Min. tempo, he adjusts to the differentiation of the first two sound patterns. This requires not inconsiderable concentration, especially if later, as the practice progresses, several sound images are already present at the same time

high tempo are known and always new signs are added.
We sought to relieve this concentration by further adapting the sound effects of the sign to the psychic disposition. In the sense of this adaptation we investigated the question whether the acoustic gestalt effect of the Morse code could not be further enhanced by emphasizing the characteristic features of the sound pattern. The suggestion for this question was given by the following observation.
There are radio teachers who - more or less consciously - make their students understand the sound pattern very characteristically. The radio instructor forms the sound patterns of Morse code into a small melody, i.e. dots and dashes are sung or sounded by him in two different pitches, the sound pattern is thus made more vivid. In the generally known way, the stroke length is acoustically represented by ditt in different pitches, so that e.g. the character for "l" is acoustically represented as: ditt daa ditt ditt or "q" as: daa daa ditt daa.

It can be seen that the acoustic shape of the sound image is particularly emphasized by this tonal difference of dot and dash. This facilitates both the differentiation of the various sound images and at the same time the formation of the immediate unit of meaning between acoustic signs and letters (number, punctuation).

These considerations led to the attempt not to achieve this characteristic shaping of the Morse code by a detour via phonation, but by making the code itself melodic by giving dots and dashes in different pitches 1. The giving in two different pitches was achieved by a mechanical giving device, which is described further below (p. 67). The stroke is given in a slightly higher pitch than the dot, but the difference in pitch must be small so as not to change the sound too much and not to make the later transfer to a single tone more difficult.

In fact, it is not necessary to keep this two-tone method until the end of the training. The two-tone Method Servers

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[1] The suggestion for this experiment was given by Dr.-Ing HABENBERG

merely to facilitate the beginner's introduction to the activity of listening. After a certain advanced stage of training, one will go back to one tone. We therefore gradually, imperceptibly to the learner, bring the two tones closer and closer together until only one tone is heard. In our courses, we gave about a third to a half of the training workload in the two-tone method, then gradually switched back to one tone. Of course, it would not be wrong to do the whole training at 60 Char/Min in the two-tone method, because switching to one tone does not cause any difficulties later on. However, according to our experience, it is sufficient if the training in the two-tone method is used only in the first part of the learning, since the learner, once he is used to this melodic effect of the sign, always subjectively hears the melody even with one tone and thus characteristically forms the sound pattern himself.

7) Giving tempo in the learning process

The international agreement specifies that the radio operator must record 125 Char/Min in plain text, and 100 Char/Min in code text. So, up to this highest listening speed required internationally, all training must continue.

After our training has maintained the once firmly established listening speed of 60 Char/Min in code text until all characters are mastered, the increase up to the required highest listening speed would have to be carried out by further training from 70 to 80, 90, 100 Char/Min. As has already been pointed out in the general theoretical discussions, one might now ask whether training for some required operating speed of 80 or 100 Char/Min might not be accomplished by immediate training to that speed.

Just as one automates the relationship between sound image and letters at the 60 Char/Min training speed, this procedure should also be applicable at, say, 100 Char/Min speed. We have made such an experiment. It turned out that the demands on the learner's concentration increase significantly at this speed of 100 Char/Min, especially if several characters are already mastered in the course of the procedure and new sound images are added.

This kind of training is therefore too strenuous and exhausts the person to be trained quite strongly after a short period of practice, if he does not exceptionally possess very good aptitude. According to all experiences it can therefore be stated.

The listening speed of 60 Char/Min is an optimum learning speed for training as a radio operator.

Once the student is confident in recording at this speed of 60 Char/Min, he will be able to master the speed of 70 Char/Min without difficulty and without special training. The further increase of the tempo to 80, 90, 100 Char/Min can be done without difficulty with appropriate practice and perseverance. As already developed in the theoretical discussions, above the speed of 60 Char/Min no new fundamental difficulties or changes in the mental behavior occur. Therefore, in the development of the new learning procedure, we have limited ourselves to carrying out the tests at the constant speed of 60 Char/Min.

2. Special Questions

In addition to the questions just discussed, which essentially establish the general structure of the procedure, some specific questions now arise which will determine the design of the procedure in detail within the framework of the general guidelines.

a) Different difficulties in learning individual letters

The Morse characters are composed quite differently with respect to their acoustic gestalt effect. For this reason, the learner has more or less difficulty in grasping individual Morse characters. Some people, who have a good aural reception ability and are making good progress in their training, may have difficulty grasping one or more sound patterns. The learner would always be confused by such a Morse code, which is particularly difficult for him to pick up, if he did not first get used to consequently placing a dot in the field of the scheme in which the letter for the incomprehensible sound image belongs.

The performance curve shows for such a case of special difficulty of a letter a plateau formation, even if only slight. This letter difficulty is different for each learner; one learner grasps the sound of the letter v poorly, another learner has difficulty with the sound of the letter d or any other letter.

In addition to such individual peculiarities, however, we have found in the course of our investigation that, although not uniformly among all learners, the sound patterns for x, y, p, q were very frequently relatively difficult to grasp. Therefore, it will be appropriate to take these rather general circumstances into account in the construction of the procedure. If this group of difficult letters were to be placed at the beginning of the training, the inhibitions that would arise would have an unfavorable effect on the beginner's willingness to learn - it would be more appropriate to place the difficult letters in or after the first third of the training. In this way, in accordance with the structure of the method, these sound patterns appear again and again in the sequences of prayers until the end of the training, and it is achieved that they are constantly practiced and consolidated. If these groups of letters were placed at the end of the training because of their difficulty, the permanent training effects would be eliminated and the training would be prolonged, since these difficult letters would then have to be practiced longer at the end.

The sequence of letters chosen for our method on the basis of these considerations and other practical experience is given on p. 56.

If, in the series of letters to be introduced one after the other, a letter occurs which causes greater difficulties, the speed of the training at this point is slowed down, since a longer time is needed until the character is completely consolidated. For this reason, small plateaus will appear in the power curves of the training at these points (cf. Fig. 11). However, these are not due to fundamental difficulties of conversion and similar factors discussed earlier, as in the previous procedures. They have their reason only in the difficulties in the registration of more difficult letters, which are in the nature of the thing and not to be avoided, at the most in their effect-

The following measures are to be influenced according to the previously mentioned measures.

ß) Distinguishing similar letters

Those Morse code symbols whose sound patterns are confusingly similar can be difficult for the beginner to distinguish at a higher speed. The learner must make some effort, for example, to correctly distinguish between the sound patterns of the letter s (----) and b (----) at the training speed of 60 Char/Min. at the beginning. With this quickly strung together sequence of dots and the relative brevity of the entire sound image of s and h, the ear must be particularly sensitive in order to hear the characters correctly during the period of their sounding. Only through appropriate practice and strong concentration is discrimination finally possible.

According to the experience we have gained in longer training courses, at a higher tempo, among the easily mistakable sound patterns are those Morse code signals in which the acoustic shape is the same in its basic structure and the distinguishing features are only slight. Therefore, in addition to the above-mentioned sounds of 8 and h, the beginner will easily confuse the signs for u----- and v---- or d ---- and b ---- at a higher tempo.

These signs are acoustic shapes whose optical symbols are composed in such a way that before or after the stroke the dots - as is evident - act as prefixes or suffixes, so to speak.

The acoustic shape of two such confusable signs is little changed in its total effect, because the time difference in which the two or three dots are heard as prefix or suffix is very small at high speed. Thus, the ear must already be trained to distinguish these similarities.

At a higher tempo, it is less difficult to distinguish between characters whose optical symbols are composed of stroke lengths, e.g. o ---------- and ch ----------.

The stroke is three times longer than the dot, so that it is easier to distinguish between three and four strokes at high speed than between three and four dots. For the same reason, there are also fewer difficulties

when distinguishing the sound images, e.g., for the letters g ---------- and ö ---------- or w ---------- and j ---------- Such characters, whose optical symbol are mirror images, give little possibility of confusion as acoustic shapes despite their optical similarity. Signs like v - - and b - are too different in their sound images to be confused.

Therefore, when it is occasionally concluded that they would be similar and therefore difficult to distinguish 1, one again falls into the error of starting from the optical symbol rather than the acoustic gestalt.

In order to avoid unnecessary difficulties for the learner during the introduction to the activity of auditory perception, the question of distinguishing similar letters in the order of the letters to be added must also be considered. If the training starts with similar sounding characters, then unnecessarily at the very beginning particularly high demands are made on the concentration which the learner has to exert. We have carried out such an experiment in the form that the training began with the presentation of the characters for e (-), i (--), s (---), h (----). One could assume that this would train the ear especially well in the beginning to distinguish fine differences. However, it has been shown that the negative effects resulting from the great demands on concentration exceed the advantages of such auditory training. For this reason, it is better to begin the training with signs that are noticeably different from each other. Gradually, the learner hears the subtleties of the differences of sound patterns more sharply, and his hearing is thus trained to hear the differences as the training progresses.

These points of view are also taken into account in the list of the order of the letters (p. 56).

y) The practice of groups of letters

As already mentioned in passing, it is important for the progress of the practice level of a course to note that only when there is sufficient confidence in picking up the respective already

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[1] BINGEL, An aptitude test for radio telegraphists. PsvchotechnZ, Jg. 6, H. 2. 1931.

The instructor thus avoids the disturbances that would result from the learner exceeding the comprehension range. In this way, the radio instructor avoids the disturbances that exceeding the learner's comprehension range would cause. How easily the learner's comprehension range can be exceeded was shown by experiments in which we practiced groups of letters in the course of a training course and then added the whole group to the previously practiced characters.

We started the training at a speed of 90 to 100 Char/Min. with such sounds whose optical symbols are composed only of strokes, t, m, o, ch (1---4 strokes). After an appropriate duration of practice and sufficient confidence of the subjects in picking up this group of letters, which was practiced according to our new method, we stopped the practice of this group again. Instead, a new group of letters was practiced in the same way, the optical symbols of which consisted only of dots: e, i, s, h (1---4 dots). When these two groups were mixed together, the certainty of recording was very low in our vpn. In a sense, we had to restart the training of these eight characters almost from the beginning until these two groups were mastered together. At itself the high training tempo will bear some blame for the disturbance, because the demand on concentration is thereby particularly high. In addition, in this case, the coincidence of similar sound patterns, especially the signs of s and h, which are incredibly difficult to distinguish at the high tempo of 100 Char/Min, has an effect, as has already been explained. Since each group was previously mastered perfectly, these reasons alone cannot be responsible for the failure of the test persons. Only when both groups are combined, the range of perception is suddenly extended to such an extent that the recording is no longer successful and long practice is then necessary.

After the aforementioned eight characters were picked up reasonably confidently, we stopped practicing this group further, as before.

Now we practiced a group of the three letters d, b, g and then again u, v, w separately. Both groups brought together showed the same unsatisfactory result as when the first two practice groups were connected together.

When we added to the last group composition after appropriate practice time

---- d, b, g, u, v, w - the first characters of the previously mastered group of eight letters were added, it turned out that these first characters were as good as forgotten again.

This is due to the fact that the first characters were no longer covered by the exercise, on the contrary, they were still overlaid by the exercises with the new characters. Thus, practicing groups of letters influences the training quite unfavorably. One will therefore have to conclude from these experiments, on the one hand, that only one letter may be newly switched on at a time, in order not to unnecessarily strain the comprehension range and, on the other hand, that this new letter must be practiced again and again together with the already known characters13 , in order not to lose any character from memory.

Ö) Exercise Distribution

These considerations lead at all to the consideration of the findings from the psychological investigation of the memory and de8 learning also with the learning of the Morse signs.

For the present purpose the results about the effect of repetitions and their distribution on the learning success are especially interesting. For example, JOST 1 found :

"The more number of repetitions are distributed, spaced apart in time, the faster one learns and the better one retains."

For example, 24 repetitions can be distributed in different ways as follows:

to 3 days of 8 repetitions each

„ 6 „ „ „ 4 „

„ 12 „ „ „ 2 „

When rechecking the amount of. JOST found 7, 31, and 55 hits, respectively, for these three types of memorization; d. b. the same number of repetitions had a stronger effect on retention the more the repetitions were distributed. In the 3rd case, for the same

[1] JOST, The association ability in its dependence on the distribution of repetitions. Zpsychol 14. 1897.

According to these results, the position and temporal distribution of the training hours will also have a not inconsiderable influence on the training result in the design of the entire training course.

The repetition of the achieved amount of mastered Morse code should therefore not be crowded together too much. One should not practice in one day for hours in the morning with appropriate rest breaks and continue in the afternoon in the same sense. The value of such a practice is only small, since once already the strong load by the necessary high concentration works much too fast tiring and furthermore the distribution of the repetitions so important for the retention is not reached.

According to the experiences made in many courses, it can be stated for the length of an exercise that half an hour of continuous practice is the most favorable duration.

Especially practicing from the beginning at a high speed makes great demands on concentration, so that it has been practically shown that extending the practice to three quarters of an hour or an hour already creates so much fatigue that the success is worse than intensive practicing for half an hour.

In this way, the necessary distribution of repetitions is achieved at the same time. According to our experience, if the possibility is given in the context of an also otherwise closed training, one could probably practice in the morning and in the afternoon for half an hour each, in order to come to the best and fastest success. Of course, this refers to the new training method proposed here, since the older methods - e.g. for the fatigue question - have different conditions.

c) Practical results of the training

After clarification of the general guidelines for the practical design of the procedure, proof of its performance is now to be provided by the practical results of the training. We have conducted several courses using the new procedure, the results of which will be reported below.

To this end, some general preliminary remarks about the nature of our vpn. and courses are first necessary, as they are important in assessing the performance of the procedure.

In the training of professional radio operators (Navy, Air Force, Army, etc.) the learners are kept together in some form (barracks, camp, school) and are regularly available to the radio instructor for training at a certain time. We could not count on this self-evident prerequisite in our training, because for our practical testing of the new procedure only Vpn, who could be trained outside of the profession, came into question. The candidates were students, tradesmen and businesswomen. Apart from the fact that with these Vpn. Apart from the fact that drives such as professional interest, ambition, compulsion to go to school, eagerness to learn or the like were missing or were only stimulated in the course of the training, the training hours also had to suffer from the fact that they followed each other very irregularly and inconsistently. The courses could only take place on two or at most occasionally on three week evenings. Another disadvantage was the fact that the exercises were more often held at times when the patients were tired from their daily work. For all these reasons, we could not observe in a systematic way the value and the effect of a distribution of the exercises as they would logically be carried out according to the points of view mentioned earlier. Of course, the result of the training had to suffer under these unfavorable circumstances. Probably, under more favorable conditions, even better results would be obtained, also with respect to the number of necessary training hours.

In general, it was shown in all courses that the automation of the relationship between the sound and the letters is possible without difficulty at the training speed of 60 tpm. In the first half hour of practice, four or sometimes even five characters could be safely absorbed at this speed by those who were suitable.

The training then continued in such a way that in the successive practice hours the already mastered material was always first repeated. It proved ------- as in other cases ------ that what has already been learned once is absorbed vividly during the first repetition.

It is not possible, of course, that every learner will be able to add three or four new sounds in the second lesson.

If the average range of comprehension of the learner were so large, then we would be able to be already at the goal with e.g. 30 Morse signs to be practiced. with 10 repetitions.

As practice progresses, more and more is learned, but the increase in the number of Morse signals does not remain uniform, but decreases sharply. It is therefore necessary, before each progress of the exercise, to convince oneself by adding a new letter whether the characters learned so far are mastered with sufficient certainty. Therefore, checks are constantly inserted into the exercises by determining the number of errors of all students in a given sequence of characters. This also had the pedagogical value that the students themselves constantly had a precise control of their performance, which certainly acted as an incentive for the eagerness to learn.

In this way, the time at which a new character could be added was determined each time. As a lower limit for the courses, we set that the number of errors for the whole group could not exceed 10% of the number of characters given.

Thus, at the same time, a measure of the speed of the progress of the learning is obtained, which is essential for the evaluation of the efficiency of the method.

First of all, with regard to the duration of the training, it can be generally stated that in our courses the mastery of the entire Morse alphabet at a speed of 60 Char/Min. required a time which was within the limits of 24 to 28 practice half-hours. The training took such a course, as it basically corresponded to the theoretical considerations of the method.

Particularly noteworthy are two training courses that we conducted simultaneously.

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1 RUPP, Psych. bases of learning. P8ychZ, Jg. 2, H. 2. 1927.

They differed only in that one course used the single-tone method, the other the two-tone method.

The results of the two courses are shown in performance curves (Fig. 11), which also give a general picture of the course of the training. The curve shows the performance of the entire group of the training course in question, i.e. it is a representation of the average performance.

On the abscissa is plotted the duration of

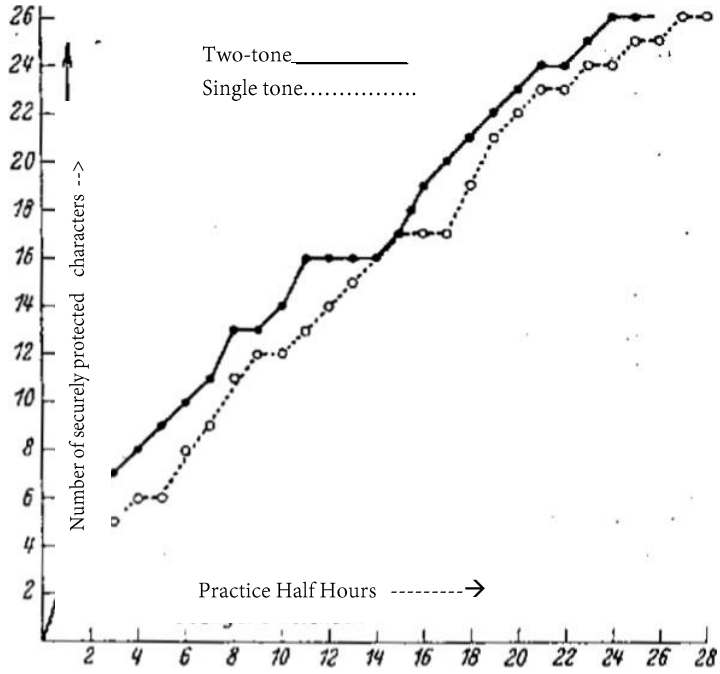


Fig. 11 . Performance curves of second training courses according to the tempo method (60 Char/Min).

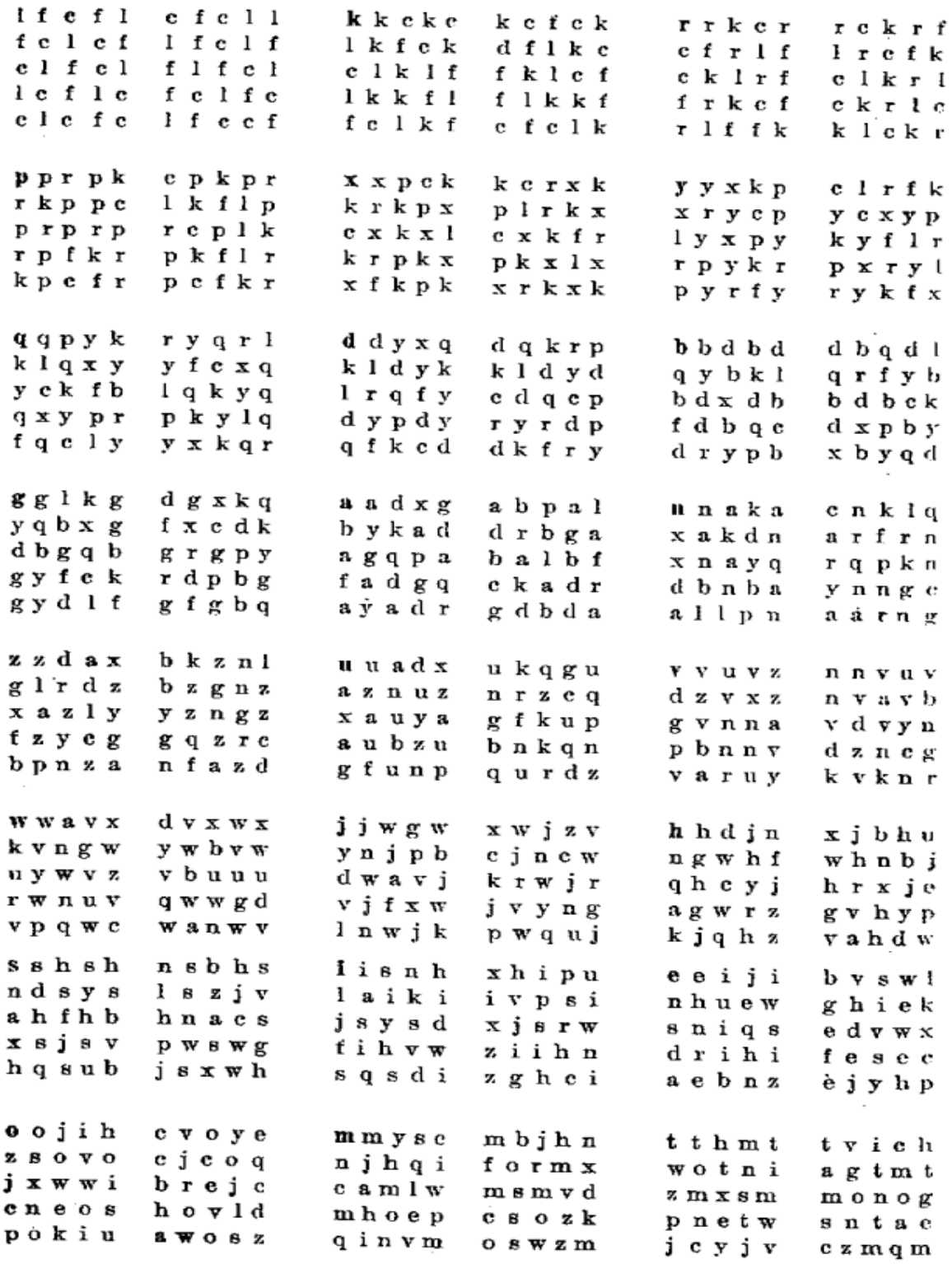
the entire training, given by the number of training half-hours required for the training.

On the ordinate is indicated the number of characters mastered in each case, the speed of progress being determined by the provisions just given for the controls. The arrangement of these 26 characters in the two is given on p. 57.

From the course of the curves it can be seen that the training took 24 half hours for the two-tone procedure and 27 half hours for the parallel single-tone procedure. The subjects were approximately equal in terms of aptitude.

If one compares the performance curves of both parallel-running courses, it can be seen that the curve for the two-tone training rises more steeply than that for the single-tone procedure, especially in the beginning. This increase can be explained by the relief of the learner's concentration due to the increased sound image effect of Morse code after the two-tone procedure, which also had a particular effect at the beginning of the training.

Letter sequence in teach-in attempt



Letter sequence

at the training course I (see Fig.11)

h f h h f	a a h f h	**b** b a f h	**g** g b a f
f h f h f	f a h f h	b h a f a	g h f a h
c c g a f	**d** d a g a	**e** e f g h	**ch** ch e g f
g c a f h	a g h f g	c g d a h	a h f g b
l l ch e d	**k** k f e ch	**i** i k l i	**o** o g o ch
c g b f h	l d c h b	k f h b d	k l f g c
t t o k l	**m** m o i g	**p** p n o g	**q** q p m o
g e a b h	k l m t l	k l e f c	k l c g b
r r g d c	**s** s g l k	**n** n o g c	**u** u r u g
g l k g a	o t m p q	q p r s n	t o n d b
w w g i k	**v** v w n u	**y** p r s n	**x** x w v q
l c r p g	s r n w p	p v w u c	u t s r g
z z w v q			
y p x w c			

The scheme shows how the individual letters are added; the newly introduced letter in each case is printed in bold.

According to the scheme established in this way, further series of exercises are formed for each exercise.

As mentioned earlier, it is not necessary to perform the training up to the endo with the two-tone method. The amplified sound image effect is only intended to facilitate the beginner's introduction to the work of auditory recording. We have made the switching of the two-tone to one-tone in our courses at different advanced levels of practice. It does not matter whether one switches to one tone after the 15th or after the 20th letter, since after sufficient training the subjective listening to the characteristic sound sequence of the character takes place anyway. These two curves show smaller plateau formations, which, however, are not based on fundamental difficulties of the learner's changeover in the case of the previous methods. As mentioned earlier (p. 47), the plateau. The plateau in the course of the curve is due to the individual difficulties in grasping certain, more difficult characters, which cannot be avoided (p x v y q z).

We have examined the effect of the letter difficulty on another training course. In accordance with the theoretical considerations given above, we set the

According to our experience, the more difficult letters p, x, y, q are included in the first third of the training. The performance curve recorded for this course (Fig. 12) shows the plateau formation at the point where the more difficult letters appear - namely at the 10th to 13th half hour of practice.
In addition, this course showed that these difficult letters were mastered with sufficient confidence at the end of the course as a result of the practice to which they were subjected during their introduction in the first third of the course.
were mastered.
The present method can be applied with the same success to adolescents as well.

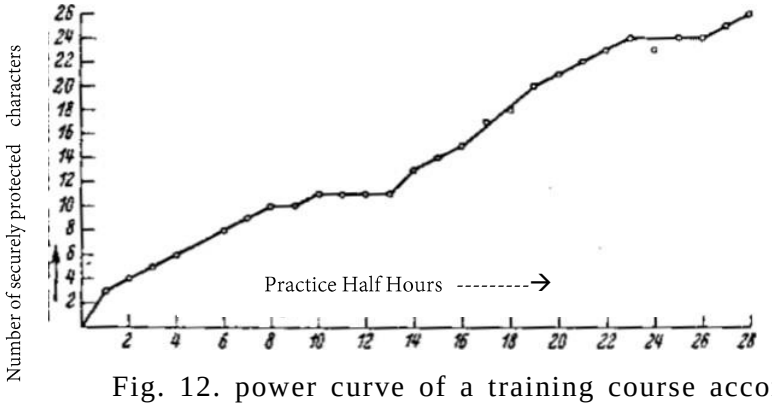


Fig. 12. power curve of a training course according to the tempo method (60 Zu/min).

This was demonstrated in a course with 13 to 14 year-old students, where the training showed the same course as in the training of adults.
If one summarizes the overall practical results of the new training method, the most striking feature is the extraordinarily large time saving compared to the previous methods.
It had already been noted earlier that the most difficult, time-consuming and basically the most important part of the training is up to the speed of 60 ppm. According to the new method, the mastery of all signs is reached in 28 half hours, while in the performance curves given in Fig. 10 from the older training methods, this tempo is reached with all signs after a training time of 7-10 weeks.
If one also takes into account that the training from which the curves in Fig. 10 originate, was carried out in quite regular school-like
operation, i.e. under much more favorable conditions than in the case of

The new method has a considerable superiority when compared with the time required for training in our courses.

The same becomes apparent when the time required for this procedure is compared with the training times specified in training regulations for radio operators in various fields on the basis of long experience, since these also provide for considerably longer practice times 1.

It should be emphasized that this superiority is not achieved by placing particularly heavy demands on the student radio operator, but on the contrary by the fact that, as a result of the adaptation of the training method to the psychic structure of the human being, all unnecessary inhibitions are eliminated, which, as has been established, lie primarily in the various changeover procedures at the speed of 60 Char/Min.

It should be noted, of course, that after the end of the 28 hours of training, further exercises must be carried out in order to maintain absolute practical reliability in the long run. However, this also applies to the other procedures, so that the comparison of the procedures and the significance of the time gain are not weakened.

E. Suitability question

In our previous investigations, we have deliberately focused on the generally valid conditions and touched upon individual differences only where they were of importance for the general consideration.

Even if the essential aim of the present work lies in this generally valid problem, we still want to direct at least a brief glance at the significance of the individual dispositions, especially since our investigation has also yielded some new points of view here.

The consideration of the individual facilities now leads naturally to the question of the individual suitability of the radio operator activity and thus to the problem of the suitability examinations for radio operators.

The aptitude tests often proceed in such a way - in former times even more than today that the different directions of attachment

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[1] Cf. statement by GIESE, Methoden of Economic Psychology in the Handbook of Biological methods of work, Berlin-Wien 1927, about the investigations of BRYAN and HARTER.

the individual abilities are examined separately with tasks especially adjusted to these abilities, and these are then brought into connection with the overall development of the personality.

If, in spite of the always existing unity of the personality, one nevertheless examines such individual dispositions, this has its reason in the fact that in general the necessary basic dispositions can occur in the most diverse interrelationships in the various professional activities of the same profession. If, for example, a carpenter is to work on a part of an object, the performance is essentially conditioned by his manual dexterity. If, on the other hand, the carpenter is making a design for an object to be manufactured, then other abilities come into play, above all spatial imagination and technical-constructive thinking. However, both groups of assets, i.e., manual dexterity and technical thinking, are interrelated when assembling a manufactured object.

In contrast to such a professional activity, which is varied in the individual activities of the profession, we see in the main activity of the radio operator, which consists in picking up and giving Morse signals, always the same sequence of work. This main activity is characterized by the fact that a number of individual systems must always be present in the same particular complex of effects, whereby it is not only important that the individual systems are present in themselves, but that they occur in this overall complex typical of the professional activity of the radio operator. This is why the basic idea is not to determine the individual systems in an aptitude test, but to test the ability to adjust to this overall complex in a realistic complex test. If one considers the previous procedures of the aptitude test from this basic idea, the following results are obtained.

The older papers published in the literature on "radio operator proficiency testing" 1 separately examine individual equipment required for radio operator activity. These works do not take into account, or take too little account, that the existing

[1] KLUTKE, Psychotechnical aptitude test for radio operators, ZPraktigcherP8 4. 1923. LIPMANN, The mental fitness of the radio telegraph operator. SchP8Beruf, H. 9. 1919.

fundamentals can only be of importance if they can enter into the required effect context. The certainty of the diagnosis will therefore be impaired with such a method.

A work, which already chooses an investigation of the wholeness of the mental phenomena during hearing reception as a basis, is the aptitude test for radio operators by BIEGEL 1.

This paper will therefore be discussed in more detail below. First of all, the points of view for an aptitude test shall be developed, which have resulted from the present investigations. The previous theoretical considerations already make it understandable that in the present training procedure it was possible to conclude with a high degree of certainty from the result of the training and the overall behavior of the radio trainee shown here, whether the training would be promising or not, approximately in the first two half hours. The last reason for this is that by moving the learning speed above the plateau of the learning curve (Fig. 10), we immediately require the learning to be complex in the context that is necessary in the practical work of the radio operator. In the case of the older proficiency tests, which examine the individual systems, it is quite probable that in the presence of these individual systems the learning will be successful at a low speed. It is not said, however, that these persons will succeed in the conversion to a higher speed at the difficulties of the learning process described above. this conversion will be possible only for those persons for whom the fundamentals can enter into -the necessary complex of effects. In fact, even in older type of training procedures, one observes that some people cannot be trained to a higher speed despite all efforts. These are the cases where even such an analytical aptitude test can lead to misdiagnosis.

It is therefore no coincidence that, without even intending to develop an aptitude test, we are inevitably led to the aptitude problem from the practical course of learning in the first hours of practice.

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[1] BIEGEL, An Attitude Test for spark telegraphy PsychotechnZ, Jg. 6. H. 2. 1931.

We were able to determine that those persons who did not learn the recording of 4 characters at a speed of 60 Char/Min. in the first 2 half hours, despite all efforts they were even grouped in a small special course to meet all their difficulties, could never be brought to a mastery of the auditory recording.

So we came to the conclusion that we can consider the first 2 half hours of the learning (learning of 4-5 characters) at a speed of 60 Char/Min) as a proficiency test. The practical possibility of using the learning procedure as a proficiency test lies in the fact that the initial learning of two characters and their differentiation is possible without any previous knowledge, and that also experience shows that the switching on of the 3rd and 4th letter is achieved in every suitable person in 2 half hours.

The practical usefulness and proof of the procedure as an aptitude test results from the fact that no success could be achieved with those persons who were identified as unsuitable on the basis of these first two exercises, even after weeks of the most detailed training. This procedure initially results only in the clear elimination of the unsuitable. All the others prove to be suitable and the training can be carried out with them. However, the separation of these suitable persons into groups with good or only average aptitude is not yet given. However, since all these persons can carry out the training, no fundamental defect is to be found in this fact. The separation into persons with good or average aptitude will clearly be made in the next 1-2 hours of training. Depending on the degree of aptitude, the persons can then be grouped together in separate training courses, which is recommended so that the good ones are not unnecessarily inhibited by the others, who progress somewhat more slowly.

In the totality of the mental phenomena in hearing reception, different partial talents occur which must necessarily be present, but which do not give sufficiently sure information about the individual aptitude by an examination of the individual functions, because these partial talents are of importance only in the totality of the effect context.

Nevertheless, they must be taken into account in the overall context in order to avoid possible false conclusions.

Thus, our investigations revealed a phenomenon that can easily lead to a wrong evaluation of the test object. There are persons who are able to follow the acoustic rhythm of the dictation and to distinguish the acoustic figures, but who are not able to write down the letters, because they lack the necessary writing skills for a higher tempo. This deficiency, if it is not due to an unchangeable bad disposition of manual dexterity, to "heavy hand", can be remedied in some persons by appropriate practice. We convinced ourselves of this fact with one examinee, who later actually proved to be well suited for the training. This phenomenon must therefore be taken into account at the beginning of the training, especially when deciding on the suitability of the student..

The most important partial talent for hearing reception is the ability to concentrate. People who are accustomed to concentration by disposition or by any mental activity are well suited for recording. Of course, this ability to concentrate does not depend on the intelligence of the person. There are very intelligent persons who are not suitable for listening at all. Particularly good predispositions for receiving have those persons, who belong to the acoustic imagination type, as was already determined in the preceding investigations (p. 21).

A more detailed treatment of partial aptitudes 8011 cannot be made here because of the preceding considerations, especially since the purpose of the present work was not to develop an aptitude test.

The advantages of aptitude testing according to the present method are based primarily in the great certainty of the procedure, which is shown by the fact that with the many persons trained (about 100) none of the diagnoses made on the basis of the first two half-hours led to an erroneous judgment. Another advantage is the simplicity of the examination and its tools, since no equipment is required except for the hearing aid, which is already available for the training. According to

development of this method, however, it still seems necessary,

to go into more detail on the BIEGEL aptitude test mentioned at the beginning, because Bier already presents an investigation of the totality of the mental processes during hearing reception.

BIEGEL 1 starts the aptitude test with the presentation of three sound images at a listening speed of about 40 Char/Min. The tempo is then increased in 5 different steps up to a tempo of 90 Z./min. The signs are given immediately as sound images, which is quite correct in our opinion. At the initial tempo there are no great difficulties in recording the auditory sequence, because the pause d between 2 sound images is 1 sec. and the examinee can correctly grasp the sign during this time by thinking. However, as the speed increases, thinking during the pause d becomes less and less possible. We had previously developed that, for these reasons, a fundamental, protracted conversion must take place in the learner in a certain tempo range (around tempo 50 Char/Min) in the training procedures still usual today (p. 32). Yes, this conversion phase of the training means insurmountable difficulties for some just ultimately unsuitable persons. After a training period that has already lasted weeks up to this conversion speed, the trainee must finally recognize that he does not meet the requirements of practical radio traffic. In so far as in radio traffic speeds in hearing and transmitting are expected which lie above the plateau formation of the hearing curve, the psychological conditions of this high speed alone can and must in principle be decisive as a prerequisite for suitability.

However, it is precisely these fundamental and decisive aspects which are overlooked by the BIEGEL method, despite some correct approaches. This may be due to the fact that BIEGEL did not base his aptitude tests on such detailed studies of all processes during auditory reception as it was done in the present investigation. First of all, it must be stated that a useful performance in BIEGE%S suitability tests at low tempo does not allow a clear prediction for the performance at higher tempo required in practice.

[L] BIEGEL, A proficiency test for spark telegraphists. PsychotechnZ, J. 6, H. 2. 1931.

Even more decisive, however, is probably another error. By increasing the listening speed in 5 steps from 40 (50, 60, 70) to 90 Char/Min, BIEGEL creates the necessity of a changeover (at a speed of about 50 Char/Min), which has proven to be particularly difficult and inhibiting in all our investigations. Now, however, this changeover, which, even with all the signs, still takes weeks in radio students after long training (see hearing curves Fig. 10), is supposed to take place in the BIEGEL aptitude tests during this very short period of the examination. This is certainly a source of misdiagnosis, which also occurs in BIEGEL's publication.

BIEGEL also examines the factors of rhythm and presence of mind, but this also points to an insufficiently deep penetration of the psychic processes during the reception of Morse signals. BIEGEL, understands by rhythm the typical sound pattern of the Morse code. She wants to investigate the ability to perceive such sound images by presenting 2 signs - again in the same speed steps as in the first experiments - whose optical symbols represent mirror images. She completely overlooks that such signs as was already explained earlier, even differ quite characteristically in the sound effect and show nothing of the similarity which is present with the optical symbol in the mirror image. Incidentally, the use of the term rhythm seems to have been made in the wrong place, since the actual rhythmic phenomenon when listening to Morse code is given in the sequence of Morse codes determined by tempo, as already developed in the section on rhythm (p. 37).

BIEGEL attributes the phenomenon, which is also discussed here, that the student gets out of the rhythm because he does not immediately grasp a character, and now perhaps has to omit several characters at once, to a lack of presence of mind. However, we have previously been able to prove that this is due to the student's not yet being correctly attuned to the rhythm and to certain techniques (substituting a dot for the misunderstood sign) and can be overcome by systematic training.

Thus, even if BIEGEL's aptitude study already shows a certain progress in comparison with the older analyzing

method, however, it contains various errors, which are probably mainly due to the lack of sufficiently detailed investigations on the mental processes during the recording of Morse signals.
recording of Morse code.
However, the suggestions made here for an aptitude test for radio operators can be based on such studies, so that they probably represent an even more useful procedure, especially as the practically performed predictions have also proven their usefulness.

F. Implementation technique

The two tones of the sound image required for the new training procedure (two-tone procedure) are generated according to a circuit type developed for this purpose. Two electron tubes (R.E. 134) as oscillation generators with different correspondingly close frequencies are switched to headphones or loudspeakers by an automatically working contacting. The regulation of the pitches is done by the variable heating resistances of the used electron tubes.
We solved the automatic contacting in the following way. Film tape (narrow film 16 mm), which has become unusable, was used as a transmission strip. In this film strip recesses are punched with appropriate distance in two rows lying next to each other. One row contains the recesses for the line lengths and the other row contains the recesses for the dot lengths of the Morse code. We made a simple punching device for punching the sequences of prayers compiled for the training course.
The thus prepared transmitting strip is moved along over a contact roller made of copper. Two slightly springy contact tips (nickel silver) engage in the recesses of the dot and dash lengths on the insulating film strip, and this opens one or the other circuit (corresponding to dash or dot) each time, according to the sequence of the elements of a Morse code, thus creating the two-tone sound pattern. The transmitting strip is moved by means of a toothed transport wheel and is secured against slipping by a pressure roller. The Drive of the transport wheel er-

is followed by a small electric motor via a coupling (small rubber disc), which is slidably arranged on the drive point. The electric motor is equipped with centrifugal governor to regulate the transport speed of the transmission strip. By means of the sliding coupling on the drive shaft and the centrifugal governor of the electric motor, the speed of giving can be regulated within the desired limits (60-100 Char/Min). Giving with "two-tone" is also possible by hand without difficulty after some practice.

G. Summary of the main results

In the present work, investigations have been carried out into the psychological phenomena involved in picking up Morse code (audible reception). Based on the findings of these investigations, a training procedure for radio operators has been developed and conclusions drawn about the aptitude problem.

l. The recording of the acoustic Morse signal

The reception of the acoustic Morse code is bound to the general psychic appearance of the wholeness and Gestalt perception (sound image of the Morse code).

The Morse code must therefore always possess Gestalt character independently of the tempo, if it is to correspond to the psychic disposition. The temporal proportions of the Morse code established by international agreement are therefore suitable for audio recording only for speeds (Char/Min) that lie above the tempo range of about 50 Char/Min, since only from these speeds onwards does the Morse code become an acoustic unit (Gestalt).

at lower speed, with the observance of the proportions according to the international agreement, shape decay of Morse code occurs.

When Morse code is transmitted at a higher tempo, the radio operator who is accustomed to recording "shaped" Morse code generally observes the international proportions. However, individual differences appear in the sound pattern (appearance of partial shapes, etc.), which are based only on the smallest temporal differences, but nevertheless characterize the overall sound pattern individually,

II. The psychological learning process

1. With the past procedures for the learning of the hearing reception in the tempo range 50 Char/Min. with the learner conversion inhibitions arise. The reason for this lies in the fact that the grasping of the heard Morse code takes place first over thinking and must be replaced with higher speed by gradual forming of an immediate unit of meaning between the heard Morse code and the letter. This changeover requires longer time and therefore manifests itself in a plateauing of the performance curve, i.e. in a prolongation of the learning time.
2. To avoid these time-consuming changeover inhibitions, the new learning procedure proposed here begins training immediately at a speed of 60 Char/Min.
3. Starting the training at an even higher speed (100 Char/Min) is not advisable because of the high demands on concentration and is also unnecessary, since after mastering the recording at a speed of 60 Char/Min, the further increase in speed no longer offers any fundamental difficulties.
4. Whereas the previous methods first teach all characters at a low speed and then increase the speed, the new method starts immediately at a speed of 60 Char/Min, but first teaches two characters and then gradually switches on the remaining characters one by one.
5. The purpose of this method is that from the first exercise the student is trained to the immediate unity of meaning between sound image and letter (automation). However, a new letter may only be added when this automation has been fully achieved.
6. In order not to disturb the formation of this automated unit of meaning sound-image-letter, the optical symbols for Morse code must not be introduced in the beginning of the training.
7. The acoustic effect of a sequence of characters is a rhythm determined by the tempo, which is important for safe recording. In order to accustom the student radio operator to the rhythm of the 60 Char/Min. tempo, training in the rhythm is already combined with learning the first two signs.

8. The shape effect of the Morse code, which is already given by the choice of the tempo of 60 Char/Min, can be further intensified to relieve the concentration by giving the dot and stroke lengths of the code in two different, but closely spaced pitches (melody effect). In the further course of learning, the tones are brought closer to each other again; the recorder then hears this characteristic tone sequence in the sound image of the character.
9. The course of training is influenced by other peculiarities, e.g. differentiation of similar letters, different difficulty in picking up individual letters, way of time distribution of exercises etc. The correct design of the entire learning process must take these aspects into account.
10. The practical success of this new method, which was developed taking into account all mental conditions, is shown above all in the fact that the learning time was considerably shortened. At a speed of 60 Char/Min, mastery of all letters was achieved in 24 to 28 hours, taking into account that the practice hours were usually not favorable for external reasons.

III Aptitude test for radio operators

1. Although the task of the present investigations was not the development of a suitability test, some aspects for the suitability test resulted from the experiences made during the training.
2. The aptitude test for radio operators seems to lead to more reliable results, if not single functions are examined separately, but in the effect complex, which occurs when recording at higher speeds.
3. Therefore, the behavior during the learning of the first 3 to 4 characters (1st to 2nd half hour) at the pace of 60 Char/Min. already gives a safe judgment about which students are unsuitable Bind.
4. The separation of the remaining students into average and good is generally possible in the 3rd to 4th half hour of practice.
5. The new training procedure therefore has the further advantage of including the aptitude test at the same time.

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