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ABSTRACT

Nine studies are summarized which investigated the relation between attributes of performance as perceived by the subject and corresponding objective measurements. The attributes studied were: (1) intellectual activity perceived to be involved when dealing with a task (Studies 1 and 2), and (2) perceived difficulty (Studies 4 to 9). Study 3 combined both features. In Study 1, subjects with 9 years of schooling were asked to estimate the degree of qualitative similarity between sample items of 10 tests. Study 2 was basically a replication of Study 1 with high school students in another country. Study 3 investigated the extent to which the perceived difficulty of intelligence tests would covary with the estimates of qualitative similarity. Results on perceived difficulty were summarized in Study 4. In Study 5, involving a simple motor skill task called "wire labyrinth," perceived difficulty was found to be linearly related to performance, with time the only possible objective measurement. Study 6 involved the perceived difficulty of an immediate memory task in which successive messages of 4 to 10 digits were presented acoustically at two digits per second. Ss were to recall them immediately in their original order. Study 7 dealt with the perceived difficulty of a search activity in a visual attention task involving 7 complex stimulus matrices consisting of pairs of consonants. Studies 8 and 9 investigated the perceived difficulty of individual items in 4 tests of intellectual performance. (For related documents, see TM 003 055-061.) (KM)

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PERCEPTUAL CORRELATES OF MENTAL PERFORMANCE: PERCEIVED DIFFICULTY AND EXPERIENCED INTELLECTUAL ACTIVITY

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by

Oswald Bratfisch

Stockholm 1972

CONTENTS

The following studies are discussed and summarized in this paper:

(1) Bratfisch, O. and Ekman, G. Subjective and objective intelligence factors. Psychological Reports, 1969, 25. 607-620.

(2) Bratfisch, O. A further study on subjective and objective intelligence factors. Reports from the Institute of Applied Psychology, the University of Stockholm, No. 20, 1971.

(3) Bratfisch, O. Experienced intellectual activity and perceived difficulty of intelligence tests. Reports from the Institute of Applied Psychology, the University of Stockholm, No. 30, 1972.

(4) Borg, G., Bratfisch, O. & Dornić, S. On the problems of perceived difficulty. Scandinavian Journal of Psychology, 1971, 12. 249-260.

(5) Bratfisch, O., Dornić, S. and Borg, G. Perceived difficulty of a motor-skill task as a function of training. Reports from the Institute of Applied Psychology, the University of Stockholm, No. 11, 1970.

(6) Borg, G., Bratfisch, O. and Dornić, S. Perceived difficulty of an immediate memory task. Reports from the Institute of Applied Psychology, the University of Stockholm, No. 15, 1971.

(7) Borg, G., Bratfisch, O. and Dornić, S. Perceived difficulty of a visual search task. Reports from the Institute of Applied Psychology, the University of Stockholm, No. 16, 1971.

(8) Bratfisch, O., Dornić, S and Borg, G. Perceived difficulty of items in a test of reasoning ability. Reports from the Institute of Applied Psychology, the University of Stockholm, No. 28, 1972.

(9) Bratfisch, O., Borg, G. and Dornić, S. Perceived item-difficulty in three tests of intellectual performance capacity. Reports from the Institute of Applied Psychology, the University of Stockholm, No. 29, 1972.

Reference to the investigations will be made using the arabic numerals given above.

INTRODUCTION

The term performance may have various meanings. In physical terms performance might be defined as work per time unit and is usually expressed in WATT. In general English language usage, however, it has a number of different connotations. It is derived from the verb "to perform" which means in its transitive form to begin and carry through to completion, to take action in accordance with the requirements of, to enact (a feat or role) before an audience, to give a public presentation of, etc., and, in its intransitive form, to carry on, to function, to fulfill an obligation or requirement, to accomplish something as promised or expected, to portray a role or demonstrate some skill before an audience, etc. (Morris, 1969). The substantive "performance" refers then to the "act of performing" as outlined above. There are many synonyms for "perform", e.g. execute, accomplish, achieve, effect, fulfill, discharge, render. These synonyms seem more to stress the action and/or completion of a task while "perform" appears to be more connected with the skill involved in carrying something out.

In psychology "performance" appears also to be closely connected with the skill involved in carrying out a task, i.e. it refers to the degree to which the abilities an individual has at his disposal are employed in connection with a given task and is thus related to functional aspects of behaviour. Measurements of performance capacity are, as far as possible, taken in objective terms and usually with reference to some sort of maximal capacity. These objective measurements, however, provide us with but little information about the subjective costs of a reached performance level, the level of performance an individual prefers to work at, the individually most suitable level for longtime performance, problem solving strategies or the cognitive processes underlying problem solving. Even without deeper analysis it appears clear enough that these kinds of questions might fruitfully be enlightened by the study of perceptual correlates of performance.

The general purpose of the studies referred to in the present paper was to investigate the relation between some attributes of different performance activities as perceived by the performing subject himself on the one hand, and corresponding objective measurements on the other hand. The measurement tools to study perceptual correlates of performance quantitatively are to be found within the framework of modern psychophysics.

A major problem within unidimensional psychophysics is to examine the relation between objective or stimulus variables, such as weight or luminance, and subjective or perceptual variables like heaviness and brightness. Similar problems are met with in multidimensional psychophysics, where the purpose of an investigation may be, for instance, to isolate the perceptual factors of colour vision and to study these factors as functions of the physical stimulus dimension of wave length. Basically, the psychophysics of performance

do not differ from the above outlined situation. Performance may enter a psychophysical experiment as a stimulus variable to be scaled by an observer in respect to some defined attribute. The observer may be either a different subject or the performing subject himself. The many extensively used rating techniques belong, in principle, to this kind of psychophysics.

Probably the first serious attempts to study perceptual correlates of performance were undertaken by Borg and Dahlström in the area of physical work (see Borg, 1962). Attention was paid to the relations between the three effort continua, viz. (1) the perceptive indicators of stress and difficulty (2) the physiological indicators and (3) the performance indicators in the form of e.g. maximal performance or preference levels. In this context the usefulness of studying performance on the perceptual level by means of psychophysical methods could clearly be demonstrated in a number of studies, where also the practical impacts of the obtained findings have become obvious (see e.g. Borg, 1971a, b; Borg & Linderholm, 1967, 1970).

In mental work, which is the major topic of the present paper, the situation is more complex than in physical work and would hence appear at first glance to be more difficult to study. However, physically simple stimuli are not necessarily perceived as simple by the subjects, nor are complex stimuli necessarily perceived as complex. Estimating e.g. the degree of brightness may be regarded by the subjects as an unnatural and complex task, while estimating the intensity of emotional involvement may be considered a more natural and, hence, simpler task (Lundberg, 1972).

The attributes of performance studied on the perceptual level in the investigations summarized in the present paper are (a) intellectual activity perceived to be involved when dealing with a task (Studies 1 and 2) and (b) perceived difficulty (Studies 4 to 9). Study 3 combined both features (a) and (b).

METHODS

The scaling methods developed within the framework of modern psychophysics have come to be indispensable measurement tools in an increasing number of research topics even outside the area of the ordinary sense modalities, which can be said to be the classical psychophysical domain. The development of modern psychophysics and the various fields in which its methods nowadays are applicated with considerable success have been described by e.g. Stevens (1960, 1971), Ekman & Sjöberg (1965), Ekman (1968) and Zinnes (1969). The interested reader is referred to these surveys; in the present context it may be sufficient to outline briefly the psychophysical methods actually used in our investigations and to refer to studies of particular interest for the problems proper in the following.

A common distinction within psychophysics is that between unidimensional and multidimensional scaling. Unidimensional scaling refers to judgements with respect to a particular defined stimulus attribute, presumed to vary in one dimension only, while multi-

dimensional scaling refers to techniques aiming at revealing the underlying dimensionality of a perceptual, emotional or otherwise subjective nature (Ekman, 1970).

Unidimensional scaling methods may be considered to fall into two distinct groups: (1) the variability methods and (2) the quantitative judgement methods or, as they are often called, the indirect and direct methods, respectively. The distinction between these two groups of methods lies in the rationale that is adopted for obtaining the unit of measurement in constructing a scale with interval of ratio properties.

When using the variability approach, originated by Thurstone (1927a, 1927b, 1959), rather strong assumptions are needed to establish a metric scale, as the information directly obtained from the subjects is limited to a rank order of stimuli. A typical task for the subject is merely to differentiate stimuli on the basis of order, e.g. to report which of two stimuli is perceived to have a greater magnitude with respect to some defined attribute. On the basis of different assumptions concerning inter- and intraindividual discriminal processes interval scales are then established from the rank order information available. The most frequently used indirect scaling procedure, Thurstone's Case V of the Law of Comparative Judgement (see e.g. Guilford, 1954; Torgersson, 1958; Gulliksen & Messick, 1960) rests on the assumptions that the discriminal dispersions are all equally variable, that the distribution of differences is normal and that the correlations between momentary responses are zero. Indirect methods are nowadays by and large only used when direct methods are not applicable (such as in experiments concerning nonconscious processes in human subjects or in studies with animals including lower organisms or in comparative methodological studies; see e.g. Goude, 1962). In the present paper only one scale was erected using Thurstone's Case V as outlined above, for comparative reasons, in Study 3.

The quantitative judgement and production methods, originated by Stevens (e.g. 1936, 1957) are called "direct" as they yield metric scales which do not rest on such particular assumptions, as is the case with indirect scaling. It is believed that the stimuli vary along some discriminable dimension and that the observer is capable of making direct quantitative judgements in accordance with the instructions. A typical task for the observer is to express the relationship between stimuli in ratios, e.g. percept A appears to have 50 per cent of the magnitude of percept B. The specific scale values are then usually obtained through a straightforward averaging procedure.

There are a variety of estimation procedures falling under the heading "direct methods". Only the methods actually used in our studies will be outlined. The method of magnitude estimation in its conventional form has been applied in Studies 5, 6, 7, and 8. Usually a stimulus which is expected to lie approximately in the middle of the response continuum is assigned a number, the denotion often being "10", and used as a standard in relation to which all the other stimuli are estimated in ratio terms. A modified form of the outlined conventional procedure was applied in Study 8. The modification consisted in each subject being asked to point out the stimulus which he experienced as the most difficult. This item was then used

as an individual standard and denoted "100". The estimates of all the other stimuli were to be given as fractions in relation to this standard. Category ratings were applied in Studies 3 a d 9. The estimates were to be given on a nine-grade symmetrical cat.gory scale and the categories were also assigned verbal labels.

As far as multidimensional scaling is concerned a commonly accepted distinction is made between (a) distance models and (b) content models (Ekman & Sjöberg, 1965). The distinction lies in the analysis of data rather than in the estimation technique as such. which also in multidimensional psychophysics consist of direct and indirect methods. With regard to "distance models" the interested reader is referred to works by Coombs (1964), Shepard (1962, 1964) and Kruskal (1964) and with regard to "content models" to works by Ekman (1963, 1965). The relations between these different approaches have recently been investigated in comparative research, and it has been demonstrated that the content models tend to be superior when the primary purpose is to isolate dimensions of psychological significance rather than to map a variation in the most parsimonious way (Ekman, 1970).

The method of similarity analysis, developed by Ekman (1954) and revised by the same author (Ekman, 1965) is one of the content methods. Similarity estimates were used in Studies 1, 2, and 3 for the analysis of subjective dimensionality. In similarity estimation the subject is instructed to compare two percepts at a time and to estimate which proportion of one percept is contained in the other. In our studies the estimates were to be given on a percentage scale, 100 representing identity and 0 denoting no similarity at all.

EXPERIENCED INTELLECTUAL ACTIVITY

Background

There is hardly any comprehensive psychological theory which does not take into account, either explicitly or implicity, what has been called "intelligence", whether this term or a substitute is used as a denotion. Depending on their theoretical and methodological orientation, researchers attain partly strongly divergent conceptions about the notion. In the present connection such comprehensive psychological theories may be disregarded. The studies on experienced intellectual activity to be related in this paper have been carried out with reference to the type of research on intelligence that is to be found within the framework of differential psychology, i.e. the type of research that aims at revealing the underlying dimensionality of inteiligent behaviour.

Most contemporary research on intelligence of the dimensionality-approach character has its starting point in the results of intelligent behaviour, i.e. it is based on people's performance on different kinds of intellectual tasks. Performance scores are used for obtaining a matrix of intertest correlations; multivariate methods, mainly factor analysis, are then applied to such a matrix in order to reveal the underlying dimensionality of the intellectual performance in question.

However, though performance is the common basis for researchers seeking the structural components of intelligence, considerable differences concerning the number and significance of intelligence factors can be noticed. According to the so-called English school (Burt, 1949, 1955; Vernon, 1950) intelligence has a hierarchical structure; a general intelligence factor assumed to be involved in all kinds of intelligent behaviour is emphasized. Thurstone (1938) considers intelligence to be built up mainly by seven uncorrelated "primary" mental abilities. Guilford (1967) ends up with 120 hypothetical factors by means of a three-dimensional "structure of intellect-model"; each of his factors is defined through specific properties of the three dimensions "operation", "product", and "content". These examples of differences between dimensionality-researchers within the area of intelligence may be sufficient in the present context; a more detailed discussion is given by Jaeger (1967).

Probably the main disadvantage of research on the structural components of intelligence is the fact that it reveals but little about the dynamics of the performance processes; i.e. about the cognitive processes of intelligent behaviour. Our primary aim in Studies 1 to 3 was to investigate if a psychophysical approach to this problem would be suitable for illuminating these processes. Our objective frame of reference was Thurstone's system of structional units (Thurstone, op.cit.).

Studies 1 to 3

In Study 1 subjects were asked to estimate the degree of qualitative similarity between sample items of 10 tests, i.e. to estimate the degree of similarity between the kinds of intellectual activities experienced to be involved when dealing with the tasks of the tests. The sample items had about equal solution frequencies ($p \approx 0.80$) and were assumed to be representative for the tests in question.

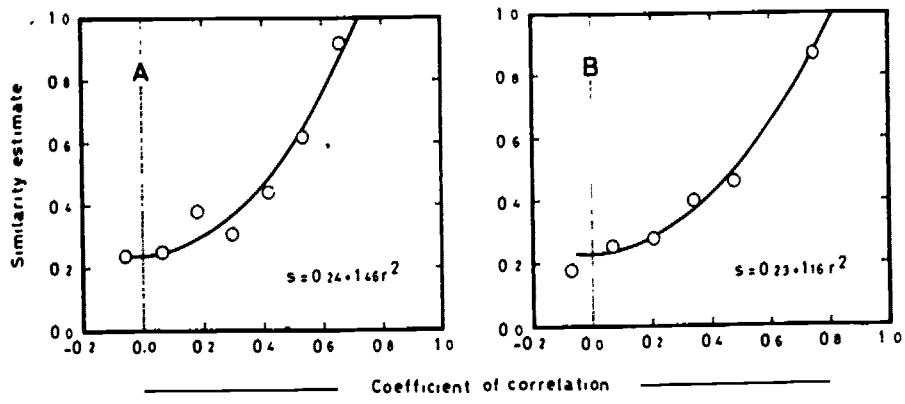

Fig. 1. Similarity estimates as a function of coefficient of correlation in Study 1. The curves drawn in the graphs represent Equation (1). Diagrams A and B refer to two different comparison groups for which correlation coefficients were available.(Bratfisch & Ekman, 1969)

When relating the averaged estimates of similarity to the corresponding intertest correlations, obtained by two groups of subjects different from the experimental one, a function of the form

$$s = a + br^2 \qquad (1)$$

where s refers to similarity and r to correlation (a and b are empirical constants), was found to be descriptive for the data. This function is represented by the curves drawn in Fig. 1.

When treating the similarity matrix as in multidimensional psychophysics, test items being regarded as stimuli, 5 "subjective" factors were found, completely corresponding to the "objective" performance factors extracted from the analyses of the correlational data. Samples of factor plots, shown in Fig. 2, illustrate the far-reaching agreement among the different sets of data, which actually was obtained for all 10 possible configurations of factors. The two points representing the highest loadings of a factor are represented by circles, at which identical tests are indicated by numbers.

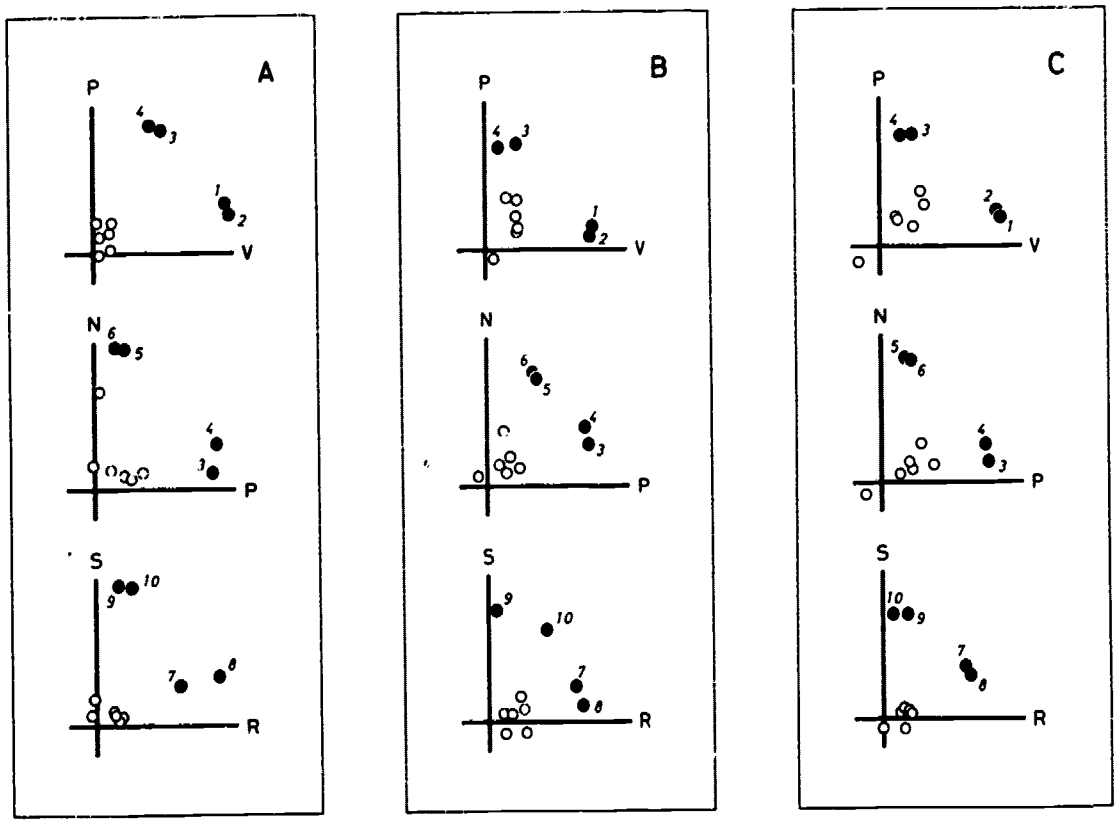

Fig. 2. Samples of factor plots obtained in Study 1. Diagram A illustrates the results obtained by similarity analysis. Diagrams B and C represent results obtained by factor analysis of correlation matrices from two groups of subjects. The denotion of factors refers to Thurstone's system of primary mental abilities, i.e. P = Perceptual speed, V = Verbal comprehension, N = Numerical facility, S = Spatial ability, R = Reasoning ability. (Bratfisch & Ekman, 1969)

Study 2 was, in a way, a replication of Study 1 with a different group of subjects who had a higher level of education (high school students) than subjects of Study 1, who had elementary (9 years) schooling only. At the same time Study 2 can be said to be a cross-national experiment, as it was conducted in Vienna, Austria, whereas Study 1 was carried out in Stockholm, Sweden. The results of Study 2 were practically identical with those of Study 1; thus Figs. 1 and 2 are illustrative for the results of both studies.

Study 3 aimed at investigating to what extent the perceived difficulty of intelligence tests would covary with the estimates of qualitative similarity. A coefficient of correlation between estimated qualitative similarity and estimates of similarity with regard to perceived difficulty of 0.48 was found and one of 0.40 between the latter similarity variable and intertest correlation. The relation between qualitative similarity and intertest correlation could again tentatively be described by equation (1), but was expressed in correlational terms ($r = 0.79$). Knowing the correlations between all these 3 variables (V_1 = Qualitative similarity, V_2 = intertest correlation, V_3 = similarity with regard to perceived difficulty) the effect of V_3 on $r_{1,2} = 0.79$ could be found out. When computing the partial coefficient of correlation $r_{12.3}$ it turned out to be 0.74. Hence it could be concluded that perceived difficulty accounted only for 12 per cent of the association between qualitative similarity and intertest correlation obtained in Study 3.

Comments

Qualitative similarity, expressed by averaged estimates of similarity between the intellectual activities experienced to be involved when dealing with various kinds of intellectual tasks, was found to be monotonically increasing with increasing intertest correlation, based on performance scores, in all three studies related above. The pattern is consistent and, thus, this result does not lack conviction. Moreover, our finding is supported by the outcome of a partly analogous study by Magnusson & Ekman (1970). Whether or not the general form of the relation between these two variables is psychologically most adequately described by the particular mathematical function chosen (Equation 1) cannot be answered as yet, as no theoretical interpretation is available. However, in general terms it may be stated that such common elements that produce positive performance correlations, also constitute the kind of qualitative overlap indicated by perceived qualitative similarity. These common elements seem practically neither to be related to individual performance (as demonstrated in all three studies) nor to perceived similarity with regard to test difficulty (cf Study 3).

From factor analyses of averaged estimates of qualitative similarity the same factors emerged as did from factor analyses of intertest correlation. This is not surprising in view of the close relationship between qualitative similarity and intertest correlation obtained. In other words, qualitative similarity estimates seem on an average to closely express the degree at which the abilities underlying performance tend to covary over the population to which the estimating subjects belong. The reason for this phenomenon is as yet psychologically not rational. To what extent it reflects an averaging effect is worth a closer examination in future research.

PERCEIVED DIFFICULTY

Background

It appears clear enough that perceived difficulty of various human activities plays an important role in many everyday situations. Even without deeper analysis it is obvious that an objective measurable ability to perform any task need not be in line with the perceived difficulty of the given task; perceived difficulty of any given activity rather than a corresponding "objective" measurement is likely to be decisive for a person's feelings, attitudes, motivations, etc., concerning that activity.

Researchers do not appear earlier to have paid much attention to this problem area. Apart from a study by Guilford & Cotzin (1941) on perceived difficulty of judgement tasks, no such investigations could be traced before the end of the fifties. At that time an extensive research program concerning the perceived difficulty of physical work was initiated by Borg (Borg & Dahlström, 1959, 1960; Borg, 1961, 1962). Among other things, it could be shown that the growth of perceived difficulty with the increase in physical work load was positively accelerated and could be described by a power function with an exponent of about 1.6.

A survey of the interesting outcomes of succeeding studies can be found in Borg (1971 a, b). The step from the area of physical work to the area of mental work was not a long one, the pilot study being carried out by Borg & Forsling in 1964. In their study a close and by and large linear relationship between estimated item difficulty and z-values corresponding to solution frequencies in a test of reasoning ability was found. Succeeding studies concerning e.g. the perceived difficulty of a test of verbal comprehension (Borg & Forsling, 1965) and another test of reasoning ability (Borg, 1966, 1969) showed on the whole the same results as the pilot study: perceived difficulty of individual test items increasing monotonically and by and large linearly with increasing objective difficulty.

The results of the above cited and other studies (e.g. Backman & Wedman, 1971, Munz & Jacobs, 1971) formed an encouraging basis for Studies 4 to 9 to be related in this paper. Our aim was, after summing up previous results on the topic and discussing various problems in connection with perceived difficulty in Study 4, to cover a bigger variety of performance activities than had been done so far, including performance on a motor skill task (Study 5), on an immediate memory task (Study 6), and on a visual search task (Study 7). Moreover, a more detailed study of four different tests of intellectual performance was undertaken (Studies 8 and 9). Thus, our main interest was in the perceived difficulty of different kinds of mental performances.

Studies 4 to 9

The results of previous studies on perceived difficulty were summarized, as mentioned, in Study 4; moreover theoretical and methodological considerations were put on the subject matter. Among other things it was pointed out that the perception of difficulty might

depend on a number of secondary factors being different for different performance activities. To learn more about such factors and in order to approach a definition of the phenomenon it was suggested that some of the main areas of human activities in the form of simplified models, starting with e.g. a simple motor skill task and ending with complicated problem solving activities should be mapped. Thereby a frame was given for the succeeding investigations.

In Study 5, concerning a simple motor skill task called "wire labyrinth" (cf. Bratfisch & Lundgren, 1967), perceived difficulty was found to be linearly related to performance time being the only possible objective measurement of performance. It was concluded that the subjects' estimates of difficulty of the simple, neutral and repetitive task employed were probably mainly based on their perception of time.

The purpose of Study 6 was to study the perceived difficulty of an immediate memory task. Successive numerical messages consisting of 4 to 10 digits were presented acoustically at a rate of two digits per second. The subjects' task was to recall them immediately in their original order. Perceived difficulty was found to grow exponentially with message length, the exponential trend becoming obvious first at messages consisting of 8 or more digits. The interpretation of this result was: with shorter messages, estimates of difficulty are probably affected by the stimulus variable, i.e. estimates are given in accordance with the number of digits of a message, whereas with longer messages, the response variable, i.e. the recall of a message, is probably decisive for the perception of difficulty.

Study 7 was concerned with the perceived difficulty of a simple search activity in a visual attention task. Seven complex stimulus matrices were used, consisting of 25, 36, 49, 64, 81, 100, and 121 pairs of consonants, respectively. The subjects' task was to search for targets determined by the experimenter one by one. The performance criterion was search time. Perceived difficulty was by and large found to be a negatively accelerated function, probably of logarithmic character, of both stimulus and response variables involved. It was concluded that the estimates of difficulty of the tasks in question are probably contaminated by the structure and size of the visual field, particularly by the estimation of numerousness.

Studies 8 and 9 aimed at investigating the perceived difficulty of individual test items of, altogehter, four different tests of intellectual performance. The tests were samples from a standardized intelligence battery (Delta Battery, 1971) and represented the factors "verbal comprehension", "spatial ability", and "reasoning ability" (two tests), respectively. A close and by and large linear relationship between estimated item difficulty and standard scores (z-values) corresponding to solution frequencies was found in all cases. Once, in Study 8 which concerned a test of reasoning ability, the relation between the two variables was also described by a slightly positively accelerated exponential function, but a linear trend would have been equally well descriptive for data. A close correspondence was noticed between the width and the levels of the ranges of the estimates on the one hand and the corresponding widths and levels of the standard scores on the other hand. An illustration of this is given in Fig. 3, representing results from Study 9.

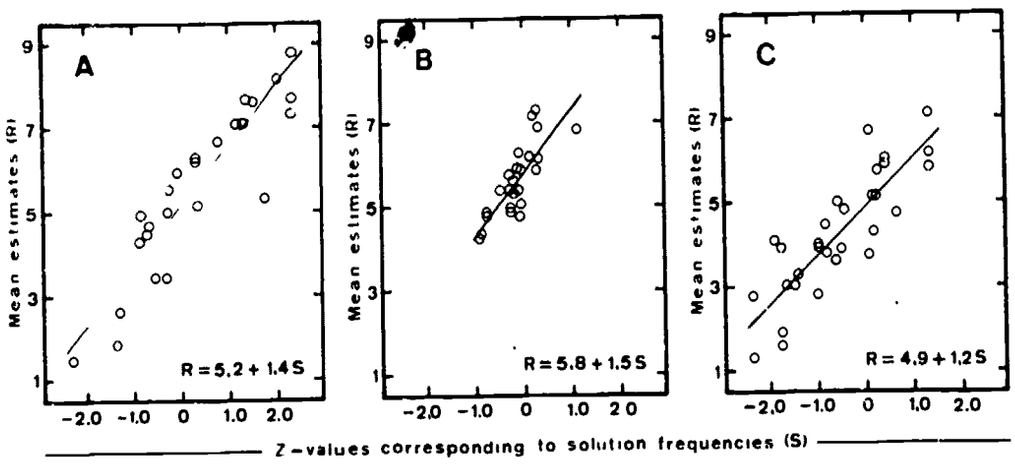

Fig. 3. Means of estimated item difficulty as related to standard scores (z-values). Diagram A shows data from the test "Number series" (reasoning ability), Diagram B those from the test "Levers" (spatial ability) and Diagram C those from the test "Synonyms" (verbal comprehension). (Bratfisch, Borg & Dornic, 1972.)

Comments

At the present stage of the work on perceived difficulty of various performance activities the probably most significant statement that can be made is, that perceived difficulty is monotonically related to objective measurements of performance regardless of the activity in question. In most studies a linear relationship was obtained. In studies where an exponential or logarithmic function was applied to data, the application of such functions was tentative; linear functions would by and large have been equally adequate. When interpreting the obtained results psychologically, the main issue is: what makes an activity difficult, or, in other words, what is estimated?

The simple, repetitive tasks of Study 5 did not vary in qualitative output. Every single task was performed correctly and the subjects had, of course, an immediate information feedback about correctness. Hence it would not have been surprising if the tasks would have been regarded as equally difficult to perform. However, differences in the estimates of difficulty were actually obtained. Other factors than correctness must then have been decisive for the estimations given. One of these factors might be the subjective costs behind a single performance, i.e. the perceived effort involved, and another is probably the perception of the time it takes to carry out a given task. To what degree perceived effort or the perception of time is expressed by the estimates cannot be stated on the basis of the experimental evidence, but it is near at hand that time was the dominant variable.

When estimating the difficulty of the immediate memory task in Study 6, the main cue seems to be the number of digits a task contains if the task is below the immediate memory span, i.e. as long as messages are so simple that they can be recalled correctly: the more

digits, the more difficult the task is, subjects probably argue. Time is probably too short to be a relevant cue. However, when the number of digits of a task grows too big to be registered in one's mind with regard to numerousness and to be recalled correctly simultaneously, probably more immediate estimates are given, i.e. estimates of difficulty which are based on the perceived mental effort behind a performance.

When estimating the difficulty of a visual search task in Study 7 subjects seem to have a number of different cues (time, visual field, numerousness) on which they base their estimates, these cues probably being closely related to each other. In a way the tasks of this study can also be regarded as simple, as every single task was solved correctly. Thus the genuineness of the estimates of difficulty was probably strongly contaminated by the variables mentioned.

The situation is, of course, even more complicated when looking at Studies 8 and 9, where the perceived difficulty of intelligence test tasks was to be judged. However, even in connection with such tasks we may distinguish between simple tasks, which are easily solved correctly, and more complex tasks which require a high degree of mental effort to be solved correctly. The estimates of difficulty of more simple tasks are probably again based on factors like time and perceptual complexity, whereas more immediate estimates of difficulty are given in connection with complex tasks. This, in a way, could be demonstrated in Study 9.

According to the reasoning above (and provided that the methods used produced reliable and valid measurements) "perceived difficulty" seems to be a function of variables which are different for different activities. Simple performance activities, i.e. activities which can be performed easily, seem mainly to be differentiated by means of variables which the subjects through learning know to be important for the performance in question. Many of these "learned determinants" are likely to be closely related to each other in connection with performance (time, numerousness, visual field, perceptual complexity). Complex mental performance activities, however, seem to produce more immediate estimates of difficulty which are related to the degree of mental effort behind the performance.

CONCLUDING REMARKS - PROSPECTIVE RESEARCH

Only results concerning the main questions dealt with in the nine studies of the present thesis have been taken up in this paper. Methodological problems, problems concerning differences between high and low performing subjects as well as the possible practical impacts of the obtained results (above all in connection with test construction) are, however, also reported and discussed in the original works.

The study of various perceptual correlates of mental performance is an almost untouched area of potential research. It implies the integration of two widely different methodological approaches: the psychophysical approach and the psychometrical approach. From a general point of view, the most interesting outcome of the studies

presented is that these different approaches to the psychological problems in question yield so closely corresponding results. Thus we feel that our studies have produced encouraging results for future research.

As far as "experienced intellectual activity" is concerned future research should, in our opinion, above all aim at isolating the "subjective" factors which produce the kind of qualitative overlap expressed by an estimate of similarity between tests. Maybe this could be done by having subjects estimate the qualitative similarity between individual items of a factor test. The dimensionality of "perceived difficulty" should be investigated in the same way as has been done with regard to estimates of qualitative similarity. The possible practical impacts of the results of the studies on perceived difficulty should be tested: estimates of difficulty might turn out to be useful complements to the ordinary psychometrical measurements and may even be suitable to obtain a fast, time-saving measurement of a person's performance level on a test. Another question of interest to be illuminated in future research is the relation of perceived difficulty to other perceptual correlates of performance like a person's preference level.

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