The Nature of Skill.[1]

By Prof. T. H. PEAR.

THE CONCEPT OF SKILL.

THE word 'skill' is used in many ways. It is therefore reasonable that for scientific purposes its connotation shall be slightly limited. The following is proposed as a definition: *Skill is an integration of well-adjusted performances.* In such a terse statement all the words need explanation and illustration. First, it is useful to contrast skills which come within the range of this definition with that type of adjustment which is a collection of mere habits. I would suggest that the outstanding feature of habit is *specificity*. The experimental work upon transfer of training has made a belief in general habits untenable.

A habit may be defined as an acquired specific response to a specific situation. As soon as we cease to respond specifically, or the situation loses its specific character, our behaviour ceases to be habitual. Skill is dependent upon habit, but not completely. The present suggestion is that, treating the term skill with respect, we should apply it only to the higher types of well-adjusted performance.

Some so-called skills are a fortuitous concourse of habits; and many of these are bad. Often no single habit in the number is well adapted to the task, and the whole collection is only a makeshift, though a makeshift for the whole life of its possessor. Contrast this with the higher skills; integrations, not mere collections of responses, and not necessarily of habits only. Then to describe as skill some industrial occupations, and some forms of domestic service in England, would be flattery.

One of the first analyses of skill was made by Mr. Frank B. Gilbreth. Studying a bricklayer, he found that his eighteen movements in laying a brick could be reduced to five. One may conclude, therefore, that the original performance which he analysed could be called skilled only in the popular sense.

SKILL, CAPACITY, AND ABILITY.

Skill must be distinguished from *capacity* and *ability*. To possess a delicately discriminative inner ear and muscles under perfect control is to have capacity for musical performance. Obviously, such gifts may exist in a person who as yet has shown no musical ability. For he proves his ability to do a thing by doing it. Even by failing he does not necessarily demonstrate his lack of capacity. For if untaught he usually will have tried to do it in the wrong way.

Skill is clearly ability, but ability to do a relatively complicated series of actions easily and well. A man who can run need not be skilled in running. But if he has learnt to move his legs well, to regulate his breathing, to sprint at a particular point or moment, to estimate the time in which it is wise to run a particular lap, to adapt himself to different tracks, different lengths of race, different classes of competition, and different competitors, he possesses skill in running races.

Skill, therefore, implies discrimination of the situation and graduation of the response. But to this should be added what I suggest as the essential characteristic of skill—the ability to *integrate* responses, and in the highest skills to substitute, instantaneously if necessary, one type of integrated response for another. In man, this integration of well-adjusted performances is acquired and fused with natural aptitude, the nature of which will be discussed in a moment.

Those reflex mechanisms which contribute to balance, to the maintenance of posture, and to the efficient co-ordination of action are an important basis of skill. In this sphere we honour the famous contributions of Sherrington, Head, Magnus, and Pavlov, to whose great work, "Conditioned Reflexes," we stand too near to see it in perspective.

Can the physiologist regard skill as entirely an integration of conditioned reflexes? Eventually, perhaps. More than that we cannot say. We are warned not to exaggerate their interpretation. An impressive fact is that to ensure the certain conditioning of a reflex the control of external surroundings must be complete. The necessity, for example, of a sound-proof laboratory, of the absence of the experimenter, to say nothing of spectators, emphasises the specificity both of situation and response. Skill, on the other hand, typically shows itself in the rapid adjustment to a changing environment and to unforeseen conditions.

Comparison of human and animal behaviour has always offered great attractions—and risks—to members of the British Association. Yet I believe that the present comparison is not difficult. While many animals inherit high-grade skills, man does not. Birds inherit skill in nest-building, the kingfisher making one type, the swallow another, and, moreover, selecting different materials.

At birth, man is spectacularly unskilled. The skills which he afterwards acquires are almost entirely determined by his social and material environment. But he compensates for his start from scratch by the number and complexity of the skills which he soon acquires; and of these, language, the raw material of which is speech-habits, is an amazing example.

PATTERNING A CHARACTERISTIC OF SKILL.

The term 'pattern' has appeared frequently in recent psychological writings. But its meanings have been different and not easy to equate. It will be used here simply and objectively to mean an arrangement of human movements in time and space which shows *integrated order*.

Always in theory, and often in practice, such a pattern could be recorded, for example, by Gilbreth's moving, interrupted light fastened to any salient part of the body. Such a pattern could be

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left by the shoes of a dancer, if they were suitably treated. The ice and the snow record beautifully some movements of the skater and the ski-runner. But they receive a trace only of one part of the body. Usually, however, many other parts are simultaneously moving in unison, in harmony, perhaps even in counterpoint. All these spatial and temporal characteristics of pattern could be recorded. But equally important would be the delicate variations in force, corresponding to accent. This integration of the part-actions into wholes usually expresses the individuality of the performer. It is unlikely, for example, that the separate steps of a dance are ever fused into a whole without being changed.

SKILL AND AWARENESS.

Unless and until a highly skilled action has become really automatic, the performer is aware of its integral character. This awareness, unclear though it may be, determines the character of the part-actions. Examples are stress, accent, and intonation in speech. As the sentence is initiated the whole, of which the speaker is aware, determines the parts. To speak a foreign language well, one must raise and lower the voice at points quite different from those which would receive the stress in one's own tongue. To acquire such skill, the learner must attend not so much to the single words as to the whole sentence. This patterning, which dominates corresponding bodily and mental events, acts upon reflex, instinctive and habitual mechanisms. When it employs habits it usually transmutes them into actions less fixed and more adapted to the situation.

'PROPRIA' AND 'ACCIDENTS' OF SKILL.

(*a*) *In Sport*.—One may pertinently inquire if some of the features of ordinary sport-skills are essential or accidental. Borrowing terms from logic, we may inquire if skill has its *propria* and its *accidents*. He who would answer this should purge himself of local and topical prejudices. Many persons assume that skill must consist in the delicate co-ordination of hand and eye and in the timing of complex actions to coincide with a momentary combination of external events. Both these gifts are often indispensable in dealing with a moving ball. But the hurling of missiles is not the only skill to which man aspires. Certain skills are proudly possessed by the blind. Delicate timing enters scarcely at all into many kinds of postural skill, and is seldom necessary for industrial tasks. So probably those subjects which an Englishman would naturally want to study, moving-ball games, should be put late in the programme. More may be hoped at present from the study of postural skills, depending little upon the athlete's 'eye.' Such are swimming, gymnastics, ski-ing, skating, dancing, and eurhythmics.

Sometimes competition in skill is a proprium, sometimes not. The most obvious kind of competition is *destructive*, where A tries to spoil the effect of B's skill, or to prevent it, as in boxing, fencing, football, and hockey. Cricket and tennis involve semi-destructive competition, through prohibitions of space. Your cross-court shot may merely amuse your opponent, but at least it lived from your racket to the net.

In many sports the competition is non-destructive. The performances may even be successive, with every chance for the competitor to do his best; and for this reason I believe they will the sooner repay study. Smith's six-foot high-jump can never be spoiled by Jones collaring him low at the take-off.

These distinctions may be obvious. But I have never seen them made in scientific discussions of skill. A little less obvious, perhaps, is the thought that different types of competition are excelled in by persons of different temperaments. Too much of the fighter's spirit and too little of the artist's and thinker's may lose many games.

In many skills emotion is an 'accident.' Obviously a player should keep his head. But coolness may be but indirectly related to skill. Some play better when keyed up, fearing nerves less than stodginess; some wilt at the thought of spectators; others admit, even seek, the inspiration of a friendly and understanding crowd. Though emotion as an accidental factor may help or hinder the expression of skill, yet in music and acting it may blend with and form an integral part of the expression. Actors, for example, sometimes genuinely feel the emotion which they are portraying.

(*b*) *In Work*.—Thus far an attempt has been made to filter the general concept of skill and to reject irrelevant meanings. In dealing with industrial skill I am indebted to an article by Miss Anna Bezanson. She writes (*Quarterly Journal of Economics*, vol. 36, pp. 626-645; 1921–22): "Considering the glibness with which workmen are pigeon-holed as 'skilled,' 'semi-skilled,' and 'labourers' in many industries, it is surprising to find little definition of what constitutes skill or lack of skill. Everyone takes it for granted that precisely what he means is understood by referring to a workman as possessed of 'skill.'"

We may utilise Miss Bezanson's collection of 'accidental' factors in industrial skill.

(1) *Accepting Responsibility for many Independent Decisions*.—Though arriving at these decisions may involve skill, the acceptance of responsibility is due to other factors.

(2) *Learning about the Capabilities of Materials*.—This involves the ordinary processes of acquiring knowledge. Muscular or kinæsthetic knowledge can only be obtained by doing. But with the progress of science it is every day easier to get from books knowledge which was formerly locked up in the skill, real or alleged, of the professional.

(3) *The possession of judgment and knowledge concerning apparently 'outside' jobs* may rank a person as skilled in the primary occupation. In practice this may be important. Its theoretical meaning is simply that other things, including intensity, being equal, the greater the extensity of skill the better.

(4) *The Ability to transfer Knowledge and Skill to a Different Industry and to Different Material*.—This

raises the question of the relation between general and specific training in a pleasingly concrete and useful form. Actually it does so twice, once in the realm of knowledge and once in the realm of power.

A special instance of the interrelations between mental abilities (and bodily ones) is raised in the consideration of

(5) *Keenness of Perception.*—In theory, keenness of perception, which means fine sensory discrimination, for example, of colours and tones, or perceptual discrimination, for example, of shapes or patterns (not, of course, visual only), might or might not be linked to superlative skill. The method of correlation makes it possible to investigate this relationship. Pioneer work has already been done by Prof. Carl E. Seashore in the investigation of musical talent. But, while it is unlikely that superlative skill will ever be found linked to subnormal discrimination, a high correlation between them cannot be assumed; and the correlation between sensory discrimination and general intelligence, though usually positive, is very low.

(6) *Appreciation of the Interrelation of Factory Processes.*—This involves intelligence rather than skill. But success in appreciating any relations may depend upon the way in which the data have been vouchsafed, and the extent to which they are obscured or illuminated by well-meant and enthusiastic 'explanation.' Explaining complex matters usually requires a skilled explainer. The skilled performer often does it especially badly.

A General Classification of Skills.

We may now attempt to classify skills, working upwards from the lowest type.

(1) *Collections of imperfectly adapted Responses.*—This class includes much domestic work, the skill of most labourers and of workers in the semi-skilled trades.

(2) *Perfectly adapted Responses which do not exhibit Personality.*—Such are the movements on parade of the perfectly drilled soldier. Military skill of this kind may be compared with the skill which would result in industry if a stereotyped series of actions, however efficient, were rigidly prescribed to the worker. Its advantages and defects are clear in military organisation.

(3) *Responses resembling Habits, but less Specific and Automatic.*—The importance and distinctive nature of such responses make one doubt the wisdom of classing them with habits. For habitual actions are inadequate to the situations which these others meet so very perfectly. Such responses are exemplified in sport when rapid, delicately effective complex adjustment is made towards the surface upon which the player is moving, for example, wet and dry, hard and grass tennis courts, heavy and light football grounds, hard, soft, smooth, and bumpy ice, and different hardnesses and elevations of snow-slopes. Such adjustments appear neither to the understanding external observer to be mechanical, nor subjectively to their performer to be unconscious.

This adaptation may be effected to conditions both outside and inside the body. A performer who is feeling ill, without decreasing control, may modify his movements so that less strain is put upon his muscles. A first-class automobile driver's adaptive behaviour in traffic makes the average motorist look like the bundle of habits which some pessimists declare man to be.

(4) *Responses like those in* (3), *but exhibiting in their Totality a Pattern characteristic of the Individual.*—This pattern may be original or unoriginal. A style which appears to the spectator to be unique may have been imparted by a teacher, though to it the pupil usually adds some personal touches.

Types (3) and (4) shade into each other, though in (4) an aspect implicit in (3) is emphasised. Probably these are in the minds of the protesters against the standardisation of industrial tasks.

(5) *Creative Skill.*—In this realm two kinds of creation may be distinguished. One is unconscious, or nearly so, as when a pioneer declares that his work finds its way out of him. Perhaps we may call it the artistic kind. The other results from deliberate analysis of earlier attempts, satisfactory to the ordinary person (a host of problems are covered by the word 'complacency'), but provoking to the genius.

Such analysis may involve recall in memory (visual, muscular, and verbal) of various skilled feats, comparison and discrimination between them, selection of their relevant aspects, re-comparison with some aim in view, re-combination, and, as a result, an unanalysed — perhaps unanalysable — polish which fuses the movements into a dazzling new unity. This is inventive creation in skill resulting from analysis. It is seen and will be seen oftener in the world of play and art. It may increase in the world of industry, if industry desires and deserves it.

Relation between Different Motor Abilities.

Tests of intelligence give results which correlate highly with each other. But there is no justified single concept enabling us to explain why some persons seem generally clever with their muscles. While there seems ample evidence for the existence of general intelligence, the results of simple tests for isolated motor performances from which intelligence has been excluded, so far as possible, give extremely low or negative correlations with each other. Moreover, these results do not warrant belief in any special connexion of simple motor abilities with intelligence.

From these results far-reaching deductions have been made by some writers. One is that there is no general capacity, no 'motor type' of person. The conclusion concerning vocational tests has been drawn that tests for ability in any performance give valid results only when the test performance is identical with that for which the test is being administered. They support the 'sample' as against the 'analogous' test.

Yet an alternative explanation of Perrin's and Muscio's findings is possible, based upon a suggestion made by Sir Henry Head to the present

writer. Their tests involve the simplest muscular co-ordinations. Many of them were confined to limited parts of the body. From the tests used by Muscio, demands upon intelligence were excluded.

As a consequence, the bodily mechanisms involved may have been controlled by relatively low levels of the nervous system. The significance of the test results, therefore, would not exclude the possibility that in *skilled* performances a higher, more complex power might employ and co-ordinate the simple mechanisms.

The above tests, therefore, being concerned with simple motor abilities, are important for the study of skill, rather as suggesting lines of inquiry than as affording data.

TRANSFER OF TRAINING BETWEEN MOTOR ABILITIES.

Another method of attacking this problem is to re-set it in the well-known form of the transfer of training. Subjects are intensively trained in some skilled activity until their curves of practice have shown a marked rise over a fairly long period. One discovers then if the undoubted ability gained in the test activity has been transferred to apparently related or similar performances. Many 'controls' are needed in such an experiment.

An extensive investigation into transfer of training in a low-grade skill was recently carried out in the Manchester laboratory by J. N. Langdon and Edna M. Yates. Possibly for the first time in such experiments a number of conditions were rigidly observed. These were the domination of the learners' motives, the selection of a really skilled performance, though a simple one, as the test activity, the testing of similar control subjects in strictly comparable conditions, and the simultaneous provision of 'analytic' tests, that is, tests of simple powers which appeared to be components of the training activity.

The operation selected for intensive training was modified from one in the driving-chain industry. The subject sits before a small turntable. It carries fixed pairs of spindles upon which links have been placed. As he brings each of these in turn before him, he removes it from the turntable, dropping the link into a box at his right hand. Simultaneously he takes another link from a box at his left and places it upon the pair of spindles, reinstating the whole upon the turntable. He then rotates the turntable, bringing the next unit into position, and repeats the whole operation.

Thirty-two unemployed boys aged sixteen, paid at a high piece-rate, were thus trained, each for two weeks. These constituted the 'trained group.' Before training, each boy's performance was measured in the various tests designed to detect the presence of transfer, if any. These had been selected after a careful observational analysis of the operation with the links and spindles. Most of them were simple tests of manual dexterity, such as inserting matches in holes, filling a box with matches, slipping curtain-rings over a rod, threading links with twine, reproducing from memory the angle of an arm movement, or the force with which a recording anvil had been struck by the subject's hammer, static and dynamic steadiness, and—to discover if the training in the skilled action had affected more purely 'mental' functions—tests in mental arithmetic and tests involving the rapid and accurate cancellation of specified letters in a page of print.

This series of tests was given on three occasions: (1) before training, (2) at the end of the first week, (3) at the end of the fortnight. They may be called transfer tests, 1, 2, and 3. Identical tests were given, in the same order and at the expiration of the same three periods, to twenty-eight similar subjects who meanwhile received no training. These were the control group.

Since the trained group contained thirty-two, and the control group twenty-eight subjects, statistical treatment is justifiable. In no instance was the difference between the trained and the control group, with regard to their improvement in transfer test 3 as compared with 1, of such a magnitude as to exclude the possibility of its being due to chance factors. In some results the brief practice afforded by the test itself was definitely shown to have had more effect than the intensive training in an apparently analogous performance.

The experiment supports the view that in such conditions training in a low-grade skill is specific rather than general. These manual habits did not transfer. How may such a clear-cut result be explained? The following considerations may be suggested: Writers upon transfer of training who know the experimental evidence believe that one of the chief agents of transfer is the formation of a sentiment. In the present experiment there was no encouragement to form a general sentiment about the acquisition of skill, which might spread to other skills.

The conditions were as unsentimental as might be. The workers were never exhorted to do their best. The only encouragement was the very real one of immediate personal gain. Conversely, slack work automatically caused less pay. This was made known to the learner with little delay. The personal influence of the experimenters was as little and as unchanged as possible. The workers were paid, and highly paid, to transfer. Yet demonstrable transfer did not occur.

The evidence seems now to establish that the problem of transfer may be divided into two parts:

(*a*) Transfer resulting from and due merely to exercise of any particular function.

(*b*) Transfer resulting from extension of attitudes, sentiments, ideals, or knowledge of methods, where the particular function trained was the vehicle of these mental powers.

It now seems certain that (*a*) is rare, and that (*b*) definitely can occur. But in educational institutions, where subjects or parts of subjects are taught by different persons, the chances of transfer through common applicable methods discovered by the learner himself, or through sentiments, is much less; and the automatic occurrence of transfer can never in the future be *assumed* by anyone conversant with the facts.