CHAPTER 10
The trainee

So far in this book we have discussed two components of training design: the nature of the training content (Chapter 8) and various training methods (Chapter 9). The third component, identified in Figure 8.1, is the characteristics of the trainee(s) that have to be considered in the design of any training programme. Trainees vary in terms of past experience, knowledge, skills, attitudes, age etc., all of which can influence how new or related skills are mastered. To use the jargon term, the trainer should be aware of the characteristics of the "target population" of trainees and training should be designed to accommodate them. This raises the rather thorny question of which characteristics are sufficiently important to demand the attention of the training designer. To reiterate the point made in Chapter 1, there are three criteria that any characteristics or variables have to satisfy: robustness, generality and practical significance. Sadly, few pass this test.

The importance of the trainee's past experience, knowledge and skills is implicit in much of the discussion in this book and these threads are drawn together in Section 10.1. Traditionally, the search for important trainee characteristics began with the study of individual differences such as IQ, age, personality and ability. A great deal of effort was expended on examining the relationship of these variables to learning, although the results were disappointing, with the notable exception of the consistent effect of age (Section 10.2). In the 1960s and 1970s this search went forward under the banner of "Aptitude Treatment Interaction" (ATI) research (e.g. Cronbach and Snow, 1977). The philosophy underlying ATI research was that the effectiveness of different training variables (methods, pace, style etc.) would depend upon the aptitudes of the trainee. This approach, which was enthusiastically advocated by Cronbach (1967), has produced weak and inconsistent results which do not lead to training recommendations for practitioners. ATI research, together with the effect of the trainee's style on learning and performance, are discussed in Section 10.2.

One reason for the disappointing results of research into both individual differences and ATI, according to the more recent cognitive tradition in psychology, is that variables manipulated by these approaches are gross descriptions of a trainee's cognitive or affective state. The argument is, rather like a reductionist one, that in order to explain and predict how a person learns and reacts to variations in training, it is necessary to measure detailed cognitive processes rather than rolling these up into one global index in which the effects of component processes become submerged. As a consequence even variables such as anxiety are now being analysed in terms of the cognitive processes which they affect (Tobias, 1987). In addition, since the mid-1970s, considerable interest has focused upon *how* the trainee goes about learning and the cognitive strategies which are used, or need to be used, to master training material. This approach is known as the "learning strategy" movement, which grew out of experimental/cognitive psychology (Section 10.3). This has given an interesting twist to the search for important trainee characteristics, although most of this work is restricted to the comprehension and retention of facts and concepts in text.

Finally, some approaches to training cannot be put easily into pigeonholes because they use a variety of principles of training design. This is the case of behaviour role-modelling (discussed in Chapter 12) because it is an example of the use of simulation, although many other features contribute to its effectiveness. At the end of this chapter, the reciprocal teaching method developed by Brown and Palincsar (e.g. 1989) is discussed. This approach uses some learning strategies, and is sensitive to the trainee's needs, although it does have many other important features which make its inclusion here somewhat arbitrary.

10.1 EXPERIENCE, SKILLS AND KNOWLEDGE

Any training should take account of the experience, knowledge and skills of the trainees. Broadly, this can be achieved by suitable modifications to either the *content* or the *design* of the training programme or, indeed, both.

Put simply, the *content* of training is determined by a sort of subtraction process. Any relevant skills and knowledge possessed by a trainee are subtracted from those which are needed to perform the task or job; that which remains specifies the content of training. Occasionally, this process is built into the method of analysis itself, such as Hierarchical Task Analysis, where the extent to which tasks are analysed depends upon the trainee's lack of knowledge and skills. Other techniques analyse the job or task without reference to any potential trainee or group of trainees (e.g. McCormick's Position Analysis Questionnaire, Flanagan's Critical Incident Technique) and it is the responsibility of the trainer to ensure subsequently that the content of training is modified suitably for any trainee(s). In the subtraction process, an important question facing the developer of training is whether or not the target population of trainees is sufficiently homogeneous in terms of skills and knowledge to receive the *same* training content. If some trainees already have some of the target skills, then there is little point in them experiencing this part of the training programme. In this manner the overall content of training can be adapted to the existing knowledge and skills of trainees by ensuring that trainees only experience relevant training "modules".

Accommodation to the trainee's skills can also take place at a more micro-level *during* training, within, say, a training "module". In principle any form of individualised training can allow this to happen (see the features of a closed-loop training system, pp. 448–451). The much heralded advantage of programmed instruction, computer-based training, and intelligent tutoring systems, discussed in Chapter 11, is that training is sensitive to the needs of individual trainees. Further explanation and advice can be tailored to the level of competence and understanding of each trainee. (This is also done by a good human tutor.) In addition the sequence in which training material is presented and its level of difficulty can be made to suit the needs of individual trainees. For example in the adaptive training discussed in Section 9.6, the computer monitored how well each trainee learned items (words or key presses) and then selected and presented those items which had not yet been mastered. In this way, adaptive training is able to accommodate not only variations in the order in which items are learned by trainees, but also different learning rates.

The trainee's experience, knowledge and skills will also affect the *design* of training exercises. Ausubel stressed the importance of relating new information to existing knowledge which, according to him, enabled new information to be assimilated more easily. One method of achieving this is to provide the trainee with an advance organiser prior to training, a topic discussed in Section 9.2. Reigeluth and Stein's Elaboration theory of instruction (pp. 323–325) adopts a similar perspective and suggests that training material should be introduced progressively and elaborated in increasing detail as a training programme unfolds. Also many of the learning strategies, discussed in Section 10.3, improve learning and retention by requiring trainees to use their existing knowledge and experience to elaborate and organise new information.

Functional context training

The term "functional context training" is used occasionally in the literature (e.g. Caro, 1973; Montague, 1988), although I have to confess to being uncertain of the meaning of the term. What is certain is that it is highly desirable and beneficial to use this technique, method, set of principles or whatever "it" might be. Duncan and Gray (1975) have performed some useful detective work in tracing its origins and they have discussed various training studies, including their own, which use it. Their discussion and that by Montague (1988), confirms my suspicion that functional context training is a rather diffuse set of ideas, and can mean many things. One aspect appears to be that it is "performance-oriented", (Montague, 1988) and "contains safeguards against inclusion of topics that lack functional significance" (Shoemaker, 1960, cited by Duncan and Gray, 1975). The concern underlying these points is that training content may not be relevant to the job in question; instructors may provide a lot of abstract theory (declarative knowledge) which cannot be related to performance of the task (procedural knowledge). One message of this book is that carrying out a proper analysis before developing training should minimise such problems.

Other important aspects of functional context training can be integrated by the notion that *the trainee should develop new skills by relating them to both previous ones and to the future performance situation.* This interpretation is conveyed in the following quotations concerning features of functional context training:

> All new knowledge is acquired on the foundations of old knowledge (Sticht et al., 1986, pp. 175–176, cited by Montague, 1988, p.130).
>
> A meaningful and relevant context is provided for the learning of novel and abstract material (Shoemaker, 1960, cited by Duncan and Gray, 1975, p. 84).
>
> Aircraft manoeuvres such as descending turns are taught to undergraduate level instrument flight trainees within the functional context of a simulated instrument approach, rather than as an exercise, per se, ... (Caro, 1973, p. 505).
>
> ... establishing a need to know certain instructional material before that material is presented (Herbert, F.J., in the Appendix to Brown et al., 1959, cited by Duncan and Gray, 1975, p. 85).

Duncan and Gray (1975) identified the same ideas as being important in functional context training which they used to guide their development of training for petroleum refinery operators:

1. that the information presented in the course of instruction must mean something to the trainee in the sense that he can connect it to his previous experience, inside or outside of refineries; and

2. that the information presented in the course of instruction must be placed in the context of those operations and procedures which are necessarily performed in the control of refineries (p. 87).

Hence functional context training emphasises that the significance of new training material is established before it is encountered, one consequence of which is that trainees should proceed from whole to part training so that they can appreciate the breadth of training and how parts fit together (cf. Reigeluth and Stein's Elaboration theory, pp. 323–325). Functional context training is of benefit because of its positive cognitive and motivational effects. It is closely related to Ausubel's notion that new information is more easily assimilated when the trainee has some relevant "conceptual scaffolding" and knows where the new information fits. This is also motivating as is knowledge of the goal of training and how "lessons" relate to parts of the trainee's job.

10.2 INDIVIDUAL DIFFERENCES

The argument that individual differences are relevant to training is a simple one. Nearly all of the findings discussed in this book are generalisations based on the average score of a sample of trainees (or learners), e.g. the power law of practice discussed in Chapter 2. By definition, some scores are above average and others below average. How much of this variation can be attributed to individual differences between the persons used in these studies? Are individual difference variables of age, IQ and personality related to the rate of learning and, if so, can any handicaps be overcome? In a nutshell, the answer to the first question is that not much variation can be pinned down systematically to individual differences, and that which can occurs in the early stages of training and disappears later on. Training, it seems, has a levelling effect. This is consistent with the notion, discussed in Chapter 7, that a task-specific ability becomes more important in the later stages of skill acquisition, or in Anderson's terms, a unique rule structure is developed as procedural knowledge. The answer to the second question is that personality effects have not been demonstrated, despite a couple of exceptions (Leith, 1969, 1982), and IQ, almost by definition, has an impact for some tasks, although large variations in IQ are necessary to produce reliable differences in performance. Even then, training can be designed to cope with these difficulties. Some of the most compelling evidence of individual differences is associated with research into the effect of age. This work has built up gradually over the last 40 years and is particularly important to training for two reasons. Firstly, the longevity of the population is increasing. Secondly, the rate of technological change in society means that the nature of jobs has changed, and is continuing to do so, resulting in an increasing need for retraining. Thus maintenance personnel have been retrained to deal with electronic rather than electromechanical devices; process control operators are no longer physically involved in the manufacturing process, which is now largely automated, but are involved in more of a monitoring and supervisory role. New skills have also been developed to cope with developments in information technology which have affected daily life. Therefore an important issue concerns how well the older person or worker can be trained to cope with these changes.

Age

Is there a deterioration in basic cognitive capabilities with increasing age? If so, does this affect the efficiency of learning new skills? Can training be designed to circumvent such problems? These questions which concern retraining the older person form the focus of this section. First, let us examine whether basic capacities deteriorate with age before discussing whether training programmes can accommodate and overcome them.

Sadly, there is overwhelming evidence that basic cognitive capacities do deteriorate with age, although more recent reviews suggest that decrements in capacity are smaller and occur later than was originally thought (e.g. Birren and Schaie, 1985). Talland (1968) demonstrated that persons between 77 and 89 years old remembered less than half the number of three-letter words compared with a group between 20 and 25 years old in an immediate recall test. Older people find it more difficult to ignore irrelevant features of a task (Rabbitt, 1965), whilst those over 55 years of age find it difficult to adapt when information about a task is transformed in some manner, such as by a mirror (Welford, 1958). Older people need relatively more time to discriminate cards or weights as the number of alternatives increases (Crossman and Szafran, 1956). Salthouse, Kausler, and Saults (1988) examined the correlations between age (ranging from 20 to 79 years) and performance on eight basic cognitive tasks including verbal and spatial memory, geometric analogies, series completion and speed of matching digits and numbers. There was a negative correlation between age and level of performance on all eight measures.

These limitations with increasing age are likely to retard the older person's learning of some tasks and partly explains the "slowing of responding" that characterises the older person's performance of complex tasks (Welford, 1958). Important questions are whether the age-related deficit increases with the complexity of the task and, if so, whether it can be overcome with practice. These questions were addressed by Jordan and Rabbitt (1977) in a study of the difference in response time between 12 elderly persons (average of 69 years) and 12 young persons (average of 20 years). Three studies were conducted in which the complexity of the mappings between displayed stimuli and responses varied as indicated in Figure 10.1. Two-choice, four-choice

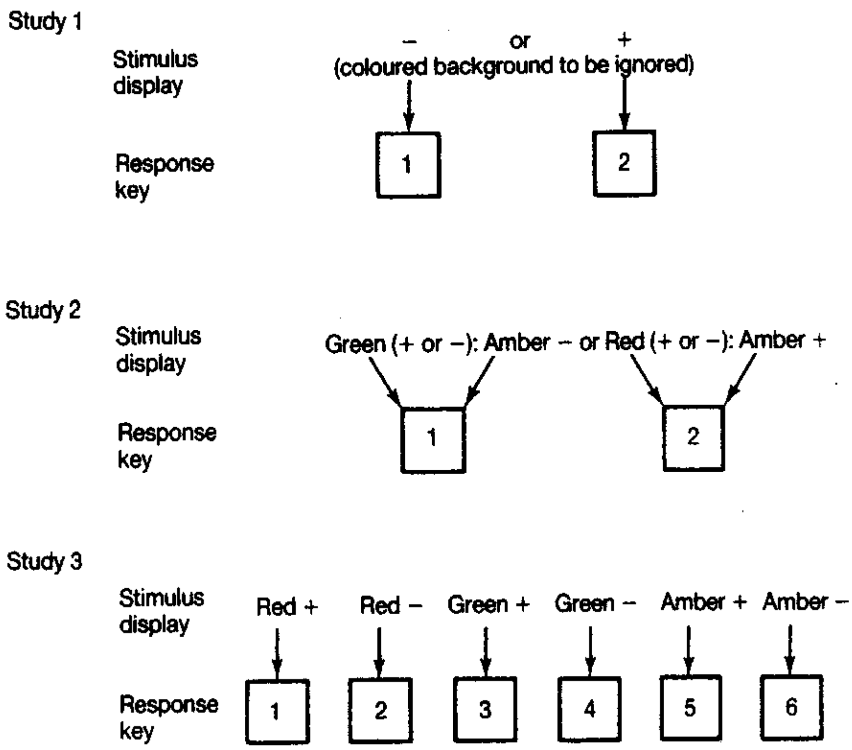


Figure 10.1 Schematic diagrams of stimulus–response mappings used in three studies by Jordan and Rabbitt (1977).

and six-choice tasks were used in Studies 1, 2 and 3 respectively. The elderly group was slower than the younger group and this difference increased with the complexity of the task used in the studies. Study 3 is particularly interesting since practice was given over four blocks of trials. Complexity was varied by changing the manner in which the stimulus–response pairing varied from one trial to the next. For example, on successive trials, the person might respond to the same stimulus display, a display in which the shape changed but the colour remained the same or a display in which both colour and shape changed. The first situation simply involves repetition and therefore no change from one trial to the next. The last situation is the most complex, since both shape and colour change and have to be "processed" by the person in order to find the correct response on the next trial. Differences in response time between the elderly and young groups over the four practice sessions are given in Figure 10.2. The initial decrement for the elderly group increases as complexity increases. It is striking, however, that the elderly group

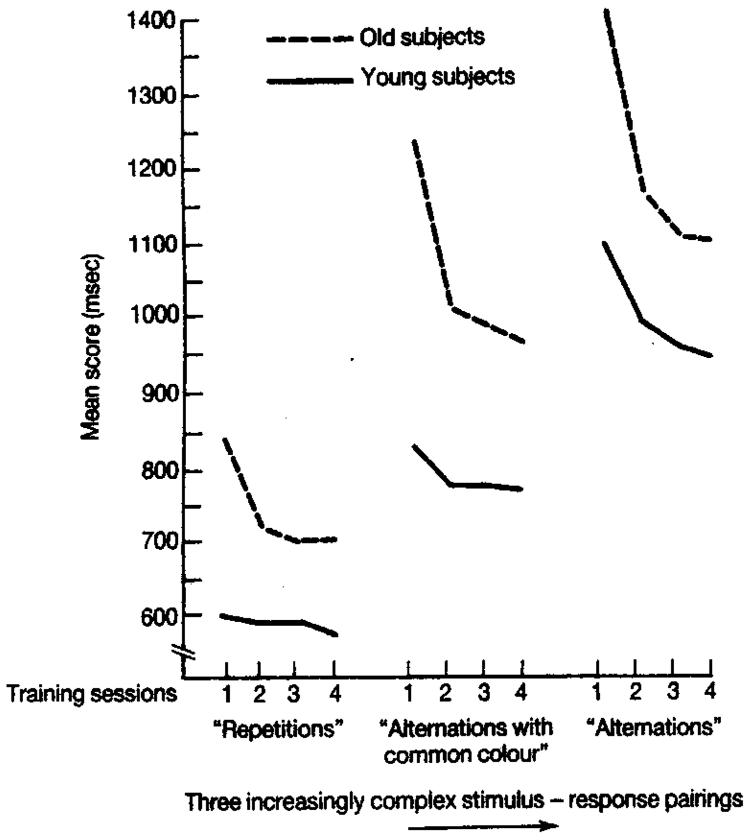


Figure 10.2 Learning curves for elderly and young persons over four training sessions (Jordan and Rabbitt, 1977, Study 3). The three sets of data refer to the complexity of the changes which occurred from one trial to the next. In "repetitions" there was no change, whereas in "alternations with common colour" shape changed and in "alternations" both shape and colour changed making it the most difficult condition.

improves more rapidly than the young group until the age decrement is approximately a constant amount after a period of practice. This suggests that whilst increasing complexity affects older persons more than younger ones, this decrement reduces with practice until it reaches a fixed amount.

So far we have established that there are reductions in the efficiency of basic psychological processes which are related to age. Therefore it should be no surprise to find age-related decrements or difficulties associated with mastering tasks which require such processes. One problem with examining this proposition is that tasks in studies have not been devised because they require such processes but because they were of applied interest. Even if tasks were used which did require such processes, age-related effects may not be found. One reason is that performance may not be sufficiently dependent upon those processes to produce differences in rate of learning. Another reason is that older persons may have compensatory strategies which, in effect, means that they are superior at other aspects of a task that compensate for their handicap in those aspects related to basic processes. Neither of these issues has received sufficient attention in the literature. Salthouse (1989) discussed the possibility that older persons use such compensatory mechanisms to maintain their level of skill at bridge, chess and typing although interpretation of the evidence is not straightforward.

Various studies have demonstrated age-related problems in training. A sustained research programme was carried out by Belbin and her colleagues on problems of training the older worker (Belbin, 1964; Belbin and Belbin, 1972; Newsham, 1969). Some of this work is discussed in detail later. Czaja and Drury (1981) were interested in age-related effects in an industrial inspection task. They used a simulated task which consisted of detecting faulty characters in a set of 74 characters displayed on a slide. They found post-training differences between three groups of persons aged 20–35 years, 36–50 years and 51–65 years. Both search time and classification errors increased with age. A review by Salthouse (1989) mentioned some lesser known studies, including two by Thorndike et al. (1928) concerned with writing and learning a language. In one study young adults (average of 22 years) were found to be faster than middle-aged adults (average of 41 years) in wrong-hand writing after 15 hours practice. The results of a second study, which was concerned with learning Esperanto, were less clearcut. The middle-aged group improved as much as the young group on all measures of language proficiency except one concerned with oral directions. Another age-related training effect, according to a study by

Smith, Kliegl and Baltes (1987), again cited by Salthouse (1989), was that young adults were better at learning a mnemonic skill.

Belbin (1964) described some, by now, famous studies of how training might be adapted to cope with the needs of older trainees. One study was concerned with problems of training letter sorters at the London Postal School. The main problem was that many trainees were not sufficiently competent after training. During the nine months preceding the study, 128 of 533 trainees had failed the training course and, significantly, the failure rate was 27% for those over 40 years in comparison with 18% for the others. The task that had to be learned involved associating the names of streets with their correct postal district in the London area and subsequently sorting letters into a 48-box frame using their postal districts such as "Battersea S.W.11", "foreign" and "W.2". In total the trainee had to know the position of 635 places in London in terms of their geographical location and their corresponding pigeon-holes in the frame. The objective of training was that the trainee was able to sort 500 incompletely addressed cards "at the rate of thirty-three a minute with fewer than fifteen errors".

Problems of training these letter sorters were examined by a mixture of observation of, and discussion with trainees, together with experimental studies and pilot training schemes. One major problem was how trainees could learn to associate the address with the correct postal district. In the traditional training method each trainee was provided with a pack of cards which had an address on one side of each card and its postal district on the reverse side. Thus trainees could refer to these "prompts" when they were unsure of the correct postal district. Belbin noted that this created a memory problem because during practice, typically, the trainee read the card, turned it over, read the prompt, searched for the postal district in the frame, and then put the card in the correct pigeon-hole. Belbin suggested that turning the card over to read the cue on the back interfered with learning the pairing between the address and its location in the frame. Hence by the time the trainee had put the card in its correct pigeon-hole in the frame, the trainee "would forget which place he was putting there". The first solution tried by Belbin was to minimise early errors by heavily prompting the trainee where to put each card (for example coloured card to same coloured box). As might be expected, this was unsuccessful, since it resulted in improved performance but little learning. Eventually, after a series of experiments on different aspects of training, a modified training programme was designed. This involved the use of six "learning" packs of cards which represented a sort of cumulative part training. For example, one pack was concerned with locations on the frame, another pack presented common postal districts whilst another pack covered districts which were easily confused. The final training programme incorporated various other changes such as longer practice sessions, a reduction in so called "extraneous" lectures and an emphasis on enabling the trainee to make a correct decision and act on it. According to Belbin the revised training programme compared favourably with the traditional one. However there was an increase in the failure rate of trainees which Belbin attributed to shortcomings in the training of instructors. It is not possible to disentangle the effects of the different modifications used in the training programme which is a criticism of most applied training studies. Belbin's account is a rich documentation of problems associated with training the older person and how they might be overcome by carefully modified training procedures.

Newsham (1969) summarised recommendations for training the older worker which emerged from Belbin's postal study and other related investigations. These are listed in Table 10.1. Overall, these recommendations emphasise that using what are essentially principles of good training design is even more important for the older trainee. Thus training should proceed cautiously, providing sufficient time to master one part before proceeding to the next and minimising the extent of any "cognitive gymnastics" which are required of the trainee. Newsham (1969) stressed the importance of the older trainee's confidence and attitudes. Generally, the older trainee is less risky in decision-making and may have considerable anxiety associated with retraining. This partly explains the reluctance of older persons to take up retraining, which is not helped by the stereotype that they are more rigid and difficult to train. Newsham (1969) found that a higher proportion of older rather than younger persons left either during training or soon afterwards. (The training study by Bartram, discussed on pp. 362–365, suggested that age was an important determinant of success during training.) However, this trend reverses at some point after training, since it is found that older trainees "survive" longer in a job than younger trainees. Newsham suggested that there were critical periods of adjustment for older trainees which occurred both during and after training, lasting several weeks.

Older people tend to be more cautious, which is why in paced tasks, they opt for accuracy rather than speed. A subsidiary finding of the Jordan and Rabbitt study, discussed earlier, was that the elderly group was generally more accurate than the young group, making fewer errors in responding to complex stimuli. Similarly Belbin and Belbin (1972) described the progress of 50-year-old Mrs Chatton in learning a high speed sewing machine skill whereby "at every stage she showed a

Table 10.1 Problems of learning for the older trainee (Newsham, 1969)

Difficulties increase with age	Suggestions as to how the training could be suitably adapted for the older learner
1. When tasks involve the need for short-term memory	(a) Avoid verbal learning and the need for conscious memorising. This may often be accomplished by making use of "cues" which guide the trainee (b) When possible, use a method which involves learning a task as a whole. If it has to be learned in parts, these parts should be learned in cumulative stages (a, a + b, a + b + c, and so on) (c) Ensure consolidation of learning before passing on to the next task or to the next part of the same task (importance of self-testing and checking)
2. When there is "interference" from other activities or from other learning	(a) Restrict the range of activities covered in the course (b) Employ longer learning sessions than is customary for younger trainees (i.e. not necessarily a longer overall time, but longer periods without interruption) (c) To provide variety, change the method of teaching rather than the content of the course. A change of subject matter may lead to confusion between the subjects
3. When there is need to translate information from one medium to another	(a) Avoid the use of visual aids which necessitate a change of logic or a change in the plane of presentation (b) If simulators or training devices are to be used, then they must be designed to enable learning to be directly related to practice

4. When learning is abstract or unrelated to realities	(a) Present new knowledge only as a solution to a problem which is already appreciated
5. When there is need to "unlearn" something for which the older learner has a predilection	(a) Ensure "correct" learning in the first place. This can be accomplished by designing the training around tasks of graduated difficulty
6. When tasks are "paced"	(a) Allow the older learner to proceed at his own pace (b) Allow him to structure his own programme within certain defined limits (c) Aim at his beating his own targets rather than those of others
7. As tasks become more complex	(a) Allow for learning by easy stages of increasing complexity
8. When the trainee lacks confidence	(a) Use written instructions (b) Avoid the use of production material too soon in the course (c) Provide longer induction periods. Introduce the trainee very gradually both to new machinery and to new jobs (d) Stagger the intake of trainees (e) If possible, recruit groups of workmates (f) Avoid formal tests (g) Don't give formal time limits for the completion of the course
9. When learning becomes mentally passive	(a) Use an open situation which admits discovery learning (b) Employ meaningful material and tasks which are sufficiently challenging to an adult (c) Avoid a blackboard and classroom situation or conditions in which trainees may in earlier years have experienced a sense of failure

disposition to pause for extra checks and inspections". The older person's predisposition towards accuracy rather than speed could be of benefit in many jobs. Another point for the training designer to consider is that an older person brings a greater range of both general and specific skills to any training situation. This may either facilitate or hinder the acquisition of new skills.

The training designer therefore has to be aware of the potential problems of the older trainee and design training to overcome these difficulties. It is likely to be an exceptional situation in which this is not possible.

Ability and intelligence

Persons with different abilities will differ in their acquisition of skill to the extent that either the training method or the task requires those abilities. This rather obvious statement follows from the definition and concept of ability which are discussed in detail in Section 7.2. Therefore persons of low verbal ability will not do well if confronted by verbal instructions concerning how to operate a piece of equipment. Also studies carried out by Fleishman and colleagues, described in Section 7.2, have identified the changing ability requirements of some tasks at different stages of training. This information has been used not only to predict differences in the rate of learning for groups varying in the level of required abilities, but also to modify the training programme to take account of these changes in ability requirements.

In learning complex tasks, less able trainees are likely to be disadvantaged by training situations which are unstructured. There are more courses of action available to trainees in performing complex tasks and the less able may be more easily distracted by irrelevant information leading to an inefficient strategy (e.g. Dale, 1958). Some interesting results concerning ability level emerged from a study by Duncan (1971) which investigated the training of a complex fault-finding task. The task involved locating a fault in a chain of components in which the probability and cost of failure of each component varied. Sixty persons were trained and split into six groups which were tested after 6, 58 or 182 days on either the original task or a transfer task which involved a different set of costs and probabilities of failure. The main finding was that whilst retention declined, transfer remained at the same low level. These results were re-examined in terms of high- versus low-ability persons, ability in this case being defined by initial, unaided performance on some fault-finding problems. It emerged that the high-ability group did not deteriorate over the three retention intervals and were better at the transfer task on each occasion in contrast to the low-ability group. Duncan interpreted these results as evidence that the high-ability group learned a general strategy concerning how to solve problems of this type, whilst the low-ability group only learned the specific algorithm for solving the training task and therefore showed poor transfer and decreasing retention.

The notion that there is a strong relationship between general measures of ability, such as intelligence, and the rate of learning was abandoned some years ago (e.g. Woodrow, 1946; Gagné, 1967). Intelligence is not a unitary concept and involves various cognitive activities. Consequently, intelligence is only a useful index of trainability when the task to be mastered imposes similar requirements on a trainee as a conventional intelligence test. From a training perspective, perhaps the most important facet of measured intelligence is the ability to tackle a task within a limited time period.

There is evidence that large differences in IQ (40 points or more) are necessary before clear differences emerge between normals and retardates in learning verbal tasks (Zeaman and House, 1967). Also Clarke (1966), in a survey of the trainability and employability of adult imbeciles (IQ, 20–50), concluded that, with special training programmes, such individuals could be trained to perform many routine perceptual-motor tasks at normal levels of competence. A study by Clarke and Hermelin (1955) demonstrated that it was possible to train imbeciles in the tasks of bicycle pump assembly, cutting insulated wire to an exact length, and soldering four coloured wires to an eight-pin television plug. Training was effective but it took much longer and performance during the initial stages was particularly slow and inaccurate. It has also been found that even with these very low IQ adults, transfer and retention does occur given an appropriately tailored training programme. Clarke (1966) proposed the following principles be used for training adult imbeciles for industrial tasks, some of which are the same as those principles discussed previously for training the older worker.

Use incentives.
Use part-task training, ensuring that parts are trained in the sequences required in the actual task.
Ensure that the correct movements are made early in training, by, for example, guidance.
Space out training sessions.
Overtrain.

Emphasise accuracy rather than speed early in training.
Ensure that the tools and materials for carrying out the task are clearly arranged.

Trainee strategies and styles

The book *A Study of Thinking* by Bruner, Goodnow and Austin (1956) was an important landmark for two reasons. Firstly, it demonstrated the importance of viewing learning as an *active* process rather than the passive one which was the dominant behaviourists' perspective at that time. Secondly, it was found that persons adopted different strategies or styles when given some choice in tackling a task.

Using a concept discovery task, Bruner et al. attempted to externalise

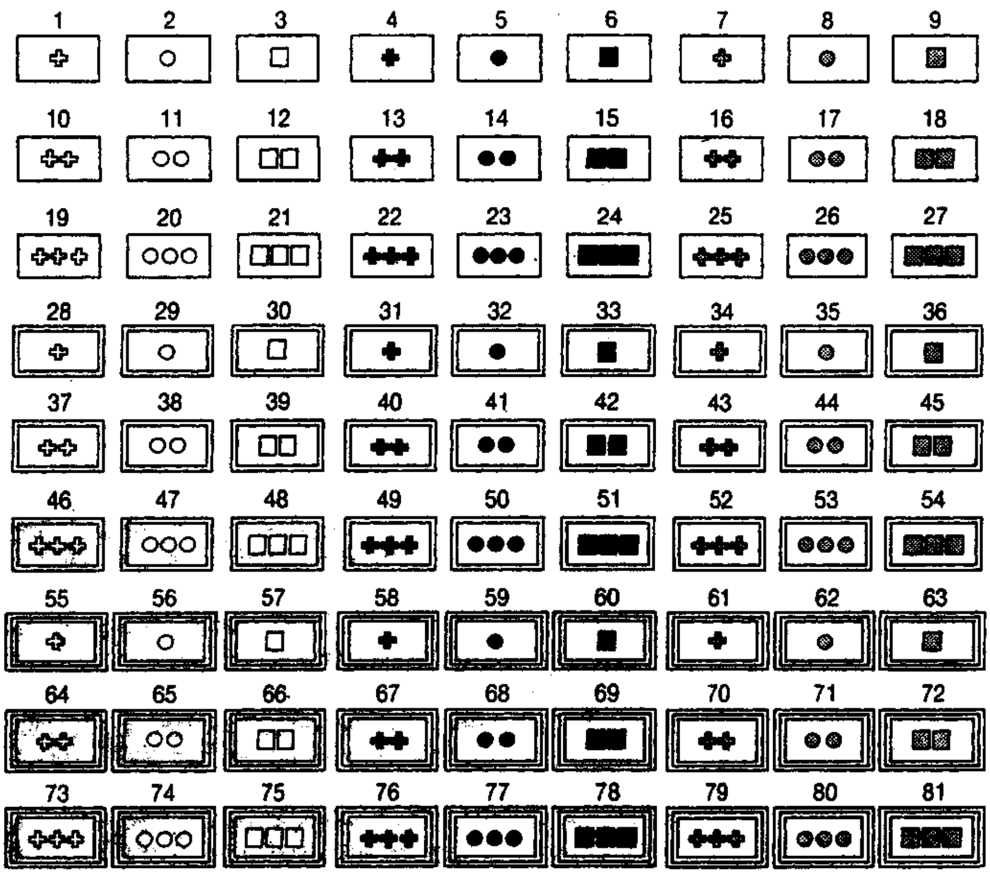


Figure 10.3 Four cards in a concept discovery task (Bruner, Goodnow and Austin, 1956). Open figures are in green, solid figures are in black, and shaded figures are in red.

the person's thinking and reasoning processes. It was termed a "selection" task because the person had to select an item, in this case a card from an array of 81 cards (Figure 10.3). The task involved the person discovering the concept which another person had defined, by selecting cards containing various attributes and being informed whether the card was a positive or negative instance of the concept. The four attributes that could be involved in the concept were number, shape, colour and number of borders, each of which had three possible values. For example consider three cards in Figure 10.3: "one green circle with one border" – card 2; "three red crosses with two borders" – card 49; and "two red crosses with two borders" – card 40. If the concept that the person is attempting to discover is "red crosses with two borders", then the cards 40 and 49 are positive instances of the concept and the card 2 is a negative instance. (In total there are three positive and 78 negative instances for this concept.) The task begins with the person being shown a positive instance of the concept and then having to discover the concept by requesting whether particular cards are positive or negative instances until sufficient information has been collected to state the concept. Bruner et al. recorded the sequence of cards examined en route to discovering the concept. From this information a person's strategy was inferred. Four basic strategies were identified made up of two main types and two subtypes:

1. *Focusing strategies*. The person focused on the attributes and changed them until the concept was found.
   (a) *Conservative focusing*. Here the person took the first positive instance as a focus and then systematically changed one attribute at a time as each card was selected. For example, given that "three green squares with two borders" is a positive instance, the person might decide to test whether the number of shapes is relevant by selecting "one green square with two borders". If this card is a negative instance then the concept must include three shapes. In this way the person need only make as many selections as there are attributes in order to discover the concept.
   (b) *Focus gambling*. This is a more risky strategy in which more than one attribute is changed at a time.
2. *Scanning strategies*. The person tests hypotheses about the concept rather than changing attributes systematically.
   (a) *Simultaneous scanning*. This is the ideal solution which is impossible psychologically. The person has to bear in mind all possible concepts and then eliminate those inconsistent with the first positive instance, and then select the next instance that eliminates

the maximum number of remaining concepts, proceeding in this fashion until only one concept is left.

(b) *Successive scanning*. This is a common strategy where the person adopts an hypothesis and then attempts to "prove" it usually by selecting positive instances. The hypothesis is only revised when a couple of negative instances are encountered. This strategy is inefficient, not only because hypotheses are tested one at a time but also because examining positive instances provides less information than examining negative ones.

The impact of Bruner et al.'s work cannot be overestimated. Even though it had a rather rough ride at the time, it gradually changed not only the nature of the questions asked by research studies, but also how they were investigated. Ironically, the focusing and scanning strategies can even be used to characterise the practice of scientific research, some scientists forming hypotheses and then attempting to substantiate them, others being more content to change variables and examine their effect. Certainly focusing and scanning represent rather different ways of approaching a problem-solving task and more recently Morrison (1985) has provided some evidence that they correlate with quality of performance of a fault-finding task. Because Bruner et al.'s work raised new possibilities, it also raised some researchers' hopes that this approach might offer a handle on individual differences, both in performance and learning. The sort of questions asked were: Are general strategies or styles adopted by different persons in performing or learning a task? Do they have implications for training?

Some research in the 1960s and 1970s was devoted to answering these questions. The simplicity of the notion that different persons have different cognitive styles or strategies which need to be identified, has had, and still does have amongst my students, great appeal. Alas the dividends of this research have been small, and it is not perhaps surprising that the complexity of human psychology cannot be captured adequately by a simple dimension of cognitive style or strategy. Nevertheless, this research did lay the foundations for examining in more detail the qualitative differences between "good" and "poor" learners and readers, a subject which has flourished in the past 10 years (e.g. Bereiter and Scardamelia, 1989).

Messick (1976) listed as many as 19 cognitive styles or strategies. Four well-known ones are:

Reflective–impulsive. This dimension was identified by Kagan (e.g. Kagan, Pearson and Welch, 1966) and refers to the extent to which persons adopt accuracy versus speed in situations which allow a trade-off.

Field dependence–independence. This is probably the most well-known cognitive style, identified by Witkin (1976). It refers to the extent to which a person organises and analyses new information (field-independent) as opposed to a more global, less analytic approach (field-dependent). It is tested by the classic embedded figures test.
Surface versus deep processors. This dimension was identified by Marton and Saljo (1976) from an analysis of what students remembered from text passages and how they reported reading them. A "deep" approach which is desirable "goes beyond" the words of the text and attempts to understand fully the intention and implications of the material. A "surface" approach, as its name suggests, fails to do this.
Holist versus serialist. These distinctions were made by Pask (e.g. Pask and Scott, 1972) and are explained below.

The last two distinctions are of particular interest, since they are concerned with *how* persons tackle the task of learning. The surface–deep distinction by Marton and Säljö gave impetus to a body of research in the educational context, summarised by Ramsden (1985). It relates to some of the learning strategies, discussed in Section 10.3, which are aimed at improving the manner in which readers process material, by, for example, providing "orienting tasks" such as answering questions.

Some of Pask's work provides a good illustration of the cognitive style approach (Pask and Scott, 1972; Pask, 1976). Few summaries of Pask's work exist, partly because of the technical complexity of some of the publications (e.g. Pask, 1975), although a useful résumé is given by Holloway (1978). Pask was interested in how persons tackled what he termed a "free learning" situation, which he created for subject matter domains that could be represented by some sort of hierarchical structure. For example, Pask and Scott (1972) devised two domains concerning fictitious Martian creatures: the Clobbits and the Gandlemullers. The Gandlemullers lived in the Martian swampland and had three subspecies: the Gandlers, the Gandleplongers and the Plongers, that were further subdivided as illustrated in Figure 10.4. A person learned about this fictitious zoological taxonomy by requesting information from a set of cards. On the front of each card was specified the type of information which could be found on the reverse (such as a picture of what a subspecies looked like; its habitat; its physical characteristics). Analysis of how persons set about learning this sort of task, and the protocols which they produced when they were asked to "teachback" what they had learned, led Pask to make his now famous distinction between holists and serialists. Holists are more interested in discovering the overall structure of the subject matter and are "global" in their

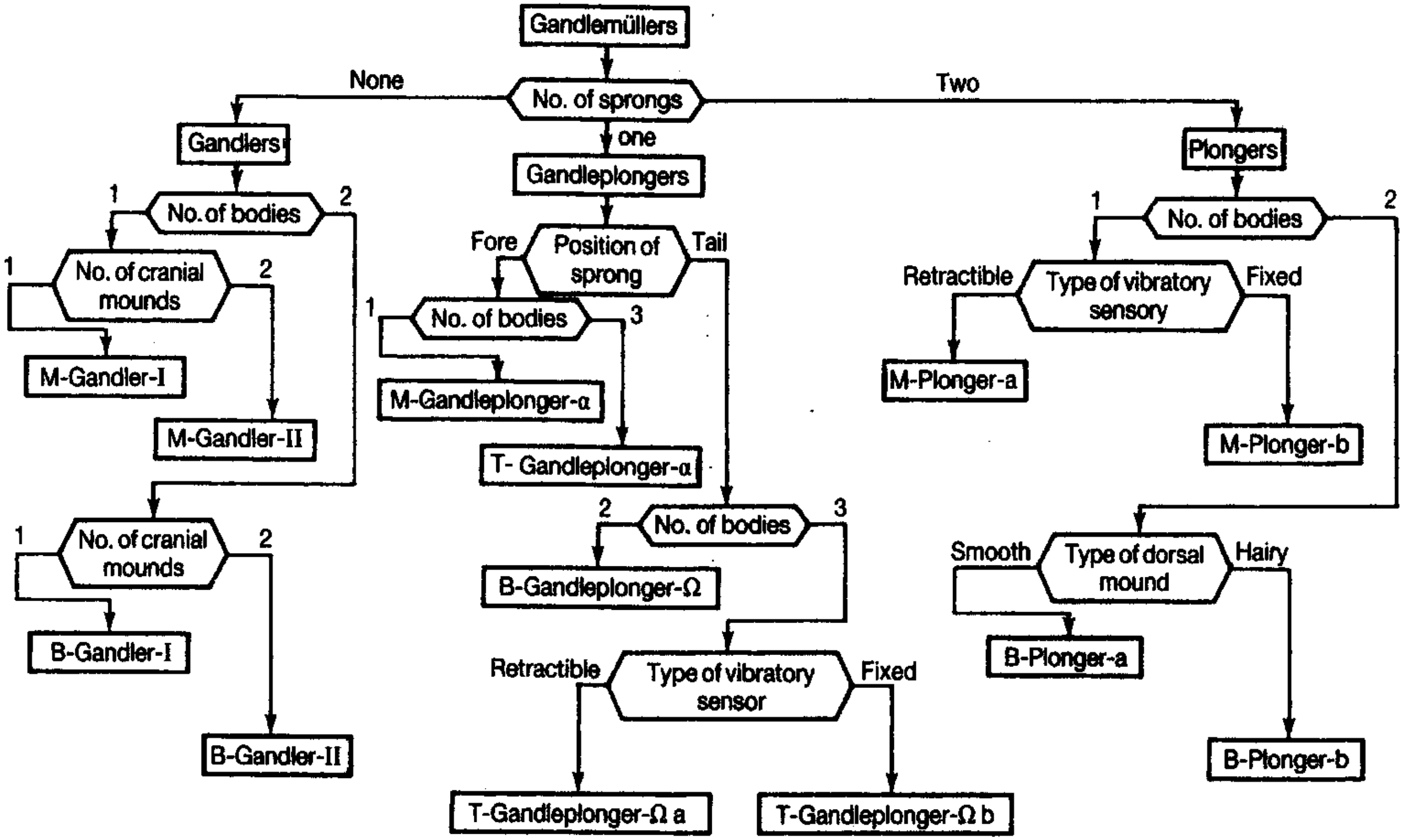


Figure 10.4 The Gandlemuller taxonomy (Pask and Scott, 1972).

approach to learning. In contrast, serialists proceed in a "step by step" fashion, accumulating a lot of detailed information in a systematic fashion, and consolidating knowledge in one area before proceeding to the next. Thus, with respect to the Gandlemullers, the holists had a good understanding of the structure and relationships between subspecies, whereas the serialists tended to focus on detail and speculate less about the relationships between the subspecies. Serialists tended to fail to see the "wood from the trees" because of the amount of information collected, whereas holists failed to recall some of the detail accurately. Pask interpreted these differences in terms of the degree of uncertainty that different persons are comfortable with whilst learning a task; serialists are only able to tolerate a low level of uncertainty, which accounts for their proceeding in a step-by-step fashion. However, as Holloway (1978) pointed out, there are different types of uncertainty: uncertainty about structure and uncertainty about detail. It may be that holists are unable to tolerate uncertainty about the structure of a domain in contrast to serialists who can. The converse applies to uncertainty about the detail of a domain.

Studies by Pask (e.g. Pask, 1975) investigated the learning of other tasks, whose structure could also be represented by relationships between nodes, termed an "entailment structure". There were more restrictions concerning how the learner could proceed than in the "free learning" situation. The learner's progress was monitored by which "nodes" in these structures were interrogated and the type of information requested. Multiple-choice tests were also given during learning to identify the current level of understanding of parts of the domain. Serialists tended to aim to master material concerning adjacent nodes in contrast to holists who were more wide-ranging in their approach.

These ideas have immense appeal, although the reliability, generalisability and potency of these effects have not been demonstrated sufficiently to make them an everyday feature of training design. A prerequisite of the holist–serialist distinction is that the subject matter can be structured and segmented in some hierarchical fashion such as a kinds-of, or parts-of hierarchy. One important finding of Pask's work from a training perspective is that there were drawbacks with both cognitive styles in terms of the extent to which the subject matter was mastered. The holist fails to master sufficient detail, whereas the serialist does not learn the overall structure of the material. Both types of learner therefore require the intervention of the trainer or training system to ensure that full mastery is accomplished.

Aptitude Treatment Interaction (ATI)

In the preceding sections we have discussed various individual differences which affect the nature and rate of learning. Ideally, training should be designed to accommodate these individual differences between trainees. The ultimate consequence of this is that different training methods may be necessary for different trainees. In this way, training can be adapted to individual differences and each trainee can experience the optimal training programme. This approach was advocated enthusiastically by Cronbach (1967), which began the search for what were known as Aptitude Treatment Interaction (ATI) effects. ATI research is reviewed by Cronbach and Snow (1969), whilst Cronbach and Snow (1977) have provided a comprehensive review of all aspects of this research.

What is meant by the term aptitude treatment interaction? Both aptitude and treatment were defined broadly by Cronbach and Snow (1977) as follows:

> ... 'aptitude' is here defined as any characteristic of a person that forecasts his probability of success under a given treatment (p. 6).
>
> We also give 'treatment' a broad meaning. It covers any manipulable variable. Instructional studies vary the pace, method, or style of instruction. Classroom environments and teacher characteristics are also treatment variables of interest. Even where a characteristic cannot be manipulated (e.g. teacher sex), the student's experience can be manipulated by an assignment policy (p. 6).

ATI can be explained by reference to Figure 10.5. In Figure 10.5a, there is no interaction between the training treatment and the trainee's characteristics. Those versed in analysis of variance will recognise this because the two lines in the graph are parallel. What this means is that, irrespective of the level of any trainee's aptitude/characteristic, training treatment A is always superior to training treatment B. Consequently, all trainees should be given treatment A. It should be noted that outcome is defined in any way which is significant to the aim of training which includes measurement of learning, costs in the widest sense, and any aggregation of the two. In Figure 10.5b there is one type of ATI effect, known as a disordinal interaction. (Disordinal interaction indicates that the lines cross over rather than just diverging or converging which is an ordinal interaction.) In this situation, training treatment A is better for some trainees, whilst training treatment B is better for others. This is represented in Figure 10.5b by the dotted cut-off line which passes through the intersection of the lines of the graph. Trainees with levels of

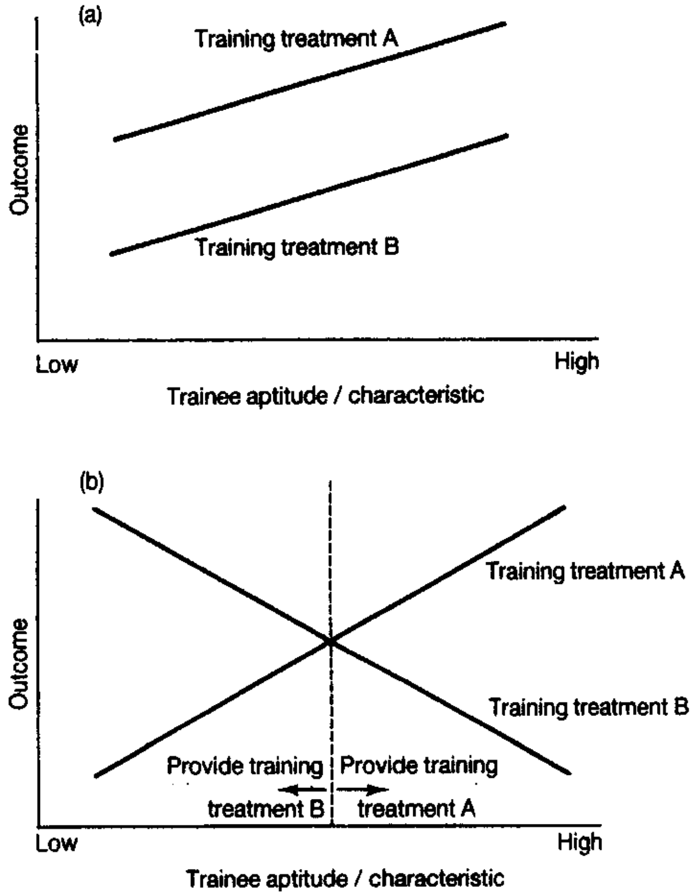


Figure 10.5 Relationships between training treatments and trainee aptitudes/characteristics.

the aptitude/characteristic which are lower than the cut-off level should receive training treatment B, whereas those with higher levels should receive training treatment A. Consequently, individual differences in aptitude are being used to determine which "type" of training a trainee should experience.

Anxiety is one aptitude which has been found to interact with different training treatments (Sieber, O'Neil and Tobias, 1977; Tobias, 1977). Generally, highly anxious trainees perform better when the training is highly organised and structured. However, evaluation itself depends upon whether trainees are subject to test anxiety and if they are, then performance is depressed. In the preceding section, Pask's distinction between holists and serialists was discussed (Pask, 1976; Pask and Scott, 1972). This work also identified an ATI effect, since learning suffered if training style was not matched to the learner's style. In the study by Pask and Scott (1972), learners were classified as holists or serialists using the Clobbit taxonomy and then were taught the Gandlemuller taxonomy by a training style that was either matched or mismatched with their own. Training style was determined by the sequence in which information was presented, so that serialists received initially low-level facts in one area, whilst holists had information concerning the overall structure of the subject matter. There was also a difference in the type of background information provided in the holist and serialist training styles, which makes interpretation of the results of this study problematic. However it was found that the "matched" groups (i.e. serialist/serialist and holist/holist) were better than the "mismatched" groups (i.e. serialist/holist and holist/serialist) not only in their test results for the Gandlemuller taxonomy but also when they were asked to "teachback" what they had learned to the experimenter. The mismatched groups produced more errors and their test results were considerably worse (Table 10.2). Further evidence that learning deteriorates when the training style and the learner's style are mismatched can be found in Pask (1976).

Table 10.2 Interaction of training and learner styles on average test score (Pask and Scott, 1972) (max. = 30)

	Type of training style	
Type of learner style	Serialist	Holist
Serialist	29	8.5
Holist	19	30

One of the main problems with ATI effects is their inconsistency. Some studies find an ATI effect whilst others do not, and generally there has been difficulty in replicating results, as noted by Cronbach and Snow (1977). These authors are widely quoted in their statement that no ATI effects "are so well confirmed that they can be used directly as guides to instruction". However, the overall conclusions of their massive review were critical of the research carried out rather than the ATI approach itself, about which they remained optimistic. However, there are no signs today that ATI research, as traditionally conceived, is improving its record and unfortunately, despite considerable research, the overall findings have been disappointing. Carroll (1967) anticipated this state of affairs in his comments on Cronbach's (1967) conference paper by stating:

> ... I predict that the study of instructional methods and individual differences is going to be extremely difficult and frustrating, even if it is "most interesting" psychologically. Cronbach has already pointed to the inconsistency and inconclusiveness of the available research literature. It is, then, possible that research will never be able to come up with a sufficiently solid set of conclusions to justify being adopted in educational practice. Or, it may turn out that even though differentiation of instructional method is possible in an actuarial sense, the net gains are not of impressive magnitude. In many cases, the cost of differentiating instruction may be too high to suit the practical school administrator, particularly if it involves elaborate and expensive equipment or extensive teacher retraining. "Reality teaching" in this field may be painful (p. 41).

10.3 LEARNING STRATEGIES

A trainee uses various cognitive strategies to learn the content of a training programme. Cognitive strategies which facilitate learning and retention are termed "learning strategies". Trainees vary in the extent to which they use these strategies and if they do, how efficiently they deploy them. Is it not possible to identify these learning strategies and either train or encourage trainees to use them? This question was posed in the 1970s and generated much excitement, since traditional training and education programmes had ignored such issues. Arguments were made that the *processes* of learning had received little attention in comparison with the *products* of learning and yet *how* the trainee goes about learning, determines the success or not of training. Evidence in support of this proposition comes from a vast number of experimental studies which demonstrated that learning and retention could be improved dramatically when the learner organised and elaborated new information rather than being a passive recipient. For example, the use of mnemonic techniques has a powerful effect on the retention of factual information. This sort of evidence gave rise to some over-optimistic hopes that training in effective learning strategies would enable students or trainees to get more from poorly designed education or training programmes. Some imagined that after being equipped with effective learning strategies, trainees might operate somewhat like vacuum cleaners in picking up new skills and knowledge. Not surprisingly, such unrealistic hopes were disappointed, although some progress was made in developing practical interventions designed to improve learning strategies for a certain type of task, namely, reading and understanding text.

The origins of the learning strategy movement can be traced back to the notion of study skills. Robinson (1946) developed what was known as the SQ3R approach which was intended to improve the understanding and retention of ideas in text passages. It was recommended that the student should: *s*urvey the content of a chapter to identify the main areas; develop *q*uestions which the text might answer; and then *r*ead the material whilst attempting to answer these questions. The last two Rs in SQ3R refer to *r*ecalling what has been read and then *r*eviewing it. A more recent version of this study technique is the PQ4R method developed by Thomas and Robinson (1972). The stages in this method are *p*review, *q*uestions, *r*ead, *r*eflect, *r*ecite and *r*eview. The main difference between PQ4R and the SQ3R method is the extra R concerned with reflection. In reflecting, the learner is encouraged to generate examples, whilst reading, in order to relate new information to previous knowledge. There is considerable experimental evidence to justify the use of the headings employed by these study skill techniques.

Learning strategies and orienting tasks

It is important to clarify the nature of learning strategies and their implications for training. One of the most penetrating accounts of learning strategies is provided by Rigney (1978). Rigney observed that the traditional approach to training has been to provide training content and hope that the appropriate cognitive (i.e. learning) strategies will be generated by the trainee. Rigney provided the following definition of cognitive strategy:

> Cognitive [i.e. learning] strategy will be used to signify operations and procedures that the student may use to acquire, retain, and retrieve different kinds of knowledge and performance. These operations and procedures may be cognitive information processing, as in mental imagery, or may be cognitively controlled, as in skimming through a textbook to identify major points. Cognitive strategies involve representational capabilities of the student (reading, imagery, speech, writing, and drawing), selectional capabilities (attention and intention) and self-directional capabilities (self-programming and self-monitoring) (Rigney, 1978, p. 165; square parentheses added).

Skilled or expert learners share the same general characteristics of experts in other domains. They are able to select what to attend to, select appropriate strategies for tackling the training materials or tasks, and monitor and regulate their cognitive processes (e.g. Glaser and Bassok, 1989). Rigney suggested that training should develop appropriate learning strategies by the provision of what he termed "orienting tasks".

As the term suggests, these tasks "orient" the trainee to adopt and develop appropriate strategies for learning the task. The distinction between learning strategies and the orienting tasks that are designed to develop them is an important one. Learning strategies are covert and not open to direct manipulation. They can only be influenced indirectly by the manipulation of what Rigney has labelled "orienting tasks". Thus activities engaged in by the trainee such as summarising, questioning, notetaking, rereading, reviewing and following the instructions of the trainer are examples of orienting tasks designed to nudge the trainee to develop appropriate learning strategies. Therefore the role of the training designer is to select and develop appropriate orienting tasks for different training materials. However, no matter how well conceived the orienting task, the possibility remains that the trainee will deliberately or unintentionally fail to develop an appropriate learning strategy.

Rigney used two dimensions to distinguish how orienting tasks might vary (Table 10.3). The first dimension concerns whether the orienting

Table 10.3 Learning strategies and orienting tasks (adapted from Rigney, 1978)

Nature of learning strategy	Control of orienting task: Trainee assigned	Training system assigned
Detached	A	B
Embedded	C	D

task is under the control of either the trainee or the training system (i.e. trainer, automatic device). In the former case the trainee might instruct himself in how to go about the task, which in turn may influence the learning strategy used. Such self-instruction is an orienting task which may or may not be successful. A trainee may be unaware of the learning strategies which he uses, and the orienting tasks which induce these strategies. This state of affairs may be less haphazard if the training system has control over the orienting task, although, again, there is no way of guaranteeing that the trainee will adopt suitable cognitive strategies.

The second dimension of orienting tasks identified by Rigney, concerns whether the learning strategy is independent of the training material (i.e. is "detached") or not (i.e. is "embedded"). The SQ3R and PQ4R study techniques, discussed previously, are orienting tasks in Rigney's terms that are designed to develop "detached" learning strategies. This is because the study techniques can be trained independent of any specific material and, in theory, can be applied to any learning from text. The same philosophy underpins the orienting tasks used in Dansereau's learning strategy training programme which is discussed later in this section. In contrast an orienting task might produce a learning strategy that is "embedded" in the training material and is not separable from it. Hence during training a trainee might be confronted with: questions interspersed in the text that are designed to encourage the information to be processed in a particular manner; instructions to use a mnemonic or some imagery in order to facilitate the encoding and retention of information; and an analogy which pinpoints the similarity between a new principle and one already known. These are all examples of orienting tasks that develop learning strategies which are closely linked to some specific training material, i.e. are "embedded". Another example, in an industrial training situation, is provided by Marshall, Duncan and Baker (1981). They were interested in training operators to diagnose plant failures. In one training condition information concerning various indicators was "withheld" until requested by the trainee. The "orienting task" of requiring trainees to request information enabled the trainer to ensure that the trainees were using the diagnostic rules provided during training and also applying them in the optimal sequence.

Evidence concerning the potential effectiveness of the learning strategy approach to training comes from two sources:

1. Laboratory studies of individual strategies in which certain treatments result in superior learning and/or retention.
2. Training or education programmes which bring together various learning strategies. These applied intervention programmes either train these learning strategies directly or embed them within the training/educational materials.

These two sources of evidence are discussed in the following two sections.

Individual learning strategies

There is a vast literature concerning how learning and retention can be improved by different orienting tasks. This discussion will necessarily be highly selective. Reviews of some of this evidence can be found in Dansereau (1978, 1985), Holley and Dansereau (1984a, b), Jonassen (1988), Weinstein (1978), and Weinstein and Mayer (1986). It has already been pointed out that the term learning strategy was first used in the 1970s. Rothkopf (1970) used the term "mathemagenic" to refer to those activities which literally "gave birth to learning". Also Wittrock (1974) pointed to the importance of "generative" activities during learning in which the learner establishes new relationships and conceptual structures between new information and previous knowledge. Undoubtedly, retention is better when the learner is active in organising and elaborating new information.

The distinction between orienting tasks and learning strategies has already been discussed although it is a distinction which is not observed in much of the literature. Below are some common orienting tasks designed to improve learning strategies, typically for prose materials and relatively straightforward comprehension tasks:

Mnemonics	Analysis of key ideas
Notetaking	Categorising
Paraphrasing	Elaborating
Analogies	Integration and differentiation
Questions	Reviewing
Summarising	Underlining
Images	Instructions
Networking	Rehearsal

These orienting tasks may produce either "detached" or "embedded" learning strategies in Rigney's terms, depending upon how they are used. The same type of orienting task can fulfil different functions depending upon the training situation. Thus embedding questions in text may direct the trainee's attention to important material and therefore have a directional function. Alternatively, questions might be designed to encourage material to be processed in a particular manner (e.g. what are the similarities and differences between materials *X* and *Y*?). This has led some writers to categorise orienting tasks in terms of their function. Weinstein and Mayer (1986) defined and contrasted eight categories of learning strategies covering rehearsal, elaboration, organisation, comprehension monitoring and motivation (Table 10.4). However, these distinctions are not clearcut and there is some overlap between categories.

Questions. Questions can be inserted in training text in order to improve how trainees process and remember new information. Reviews have considered the effect of question type, position and frequency (Prosser, 1978; Rickards and Denner, 1978). This literature is complex and difficult to summarise. Generally, it is found that the insertion of relevant questions after some text, improves comprehension and recall

Table 10.4 Eight categories of learning strategies (Weinstein and Mayer, 1986)

1. *Rehearsal strategies for basic learning tasks* – such as repeating the names of items in an ordered list. Common school tasks in this category include remembering the order of the planets from the sun and the order in which Shakespeare introduces the characters in the play *Hamlet*.
2. *Rehearsal strategies for complex learning tasks* – such as copying, underlining or shadowing the material presented in class. Common school tasks in this category include underlining the main events in a story or copying portions of a lesson about the causes of World War I.
3. *Elaboration strategies for basic learning tasks* – such as forming a mental image or sentence relating the items in each pair for a paired-associate list of words. Common school tasks in this category include forming a phrase or sentence relating the name of a state or its major agricultural product, or forming a mental image of a scene described by a poem.
4. *Elaboration strategies for complex tasks* – such as paraphrasing, summarising, or describing how new information relates to existing knowledge. Common school tasks in this category include creating an analogy between the operation of a post office and the operation of a computer, or relating the information presented about the structure of complex molecules to the information presented about the structure of simple molecules.
5. *Organisational strategies for basic learning tasks* – such as grouping or ordering to-be-learned items from a list or a section of prose. Common school tasks in this category include organising foreign vocabulary words into the categories for parts of speech, or creating a chronological listing of the events that led up to the Declaration of Independence.
6. *Organisational strategies for complex tasks* – such as outlining a passage or creating a hierarchy. Common school tasks in this category include outlining assigned chapters in the textbook, or creating a diagram to show the relationship among the stress forces in a structural design.
7. *Comprehension monitoring strategies* – such as checking for comprehension failures. Common school tasks in this category include using self-questioning to check understanding of the material presented in class and using the questions at the beginning of a section to guide one's reading behaviour while studying a textbook.
8. *Affective strategies* – such as being alert and relaxed, to help overcome text anxiety. Common school tasks in this category include reducing external distractions by studying in a quiet place, or using thought stopping to prevent thoughts of doing poorly from directing attention away from the test and towards fear of failure.

of information that is related to these questions. However, the exact nature of this effect and the reasons for it are still a matter of debate.

An alternative to the trainer embedding questions in training materials is to ask or train the trainees to generate their own questions. One of the earliest investigations of whether trainee-generated questions improved recall was a study by Frase and Schwartz (1975). Students were required to recall facts from a passage of text after either generating questions, answering questions generated by a fellow student or studying alone in the conventional manner. It was found that both generating questions and answering questions improved recall, but only of information directly related to the questions. Information not directly related to the questions was no better recalled than when studying alone. Frase and Schwartz also found that increasing the number of questions generated by students from five to 10 did not increase recall significantly, although this finding is likely to depend upon many features such as the nature and amount of the training material.

Wong (1985) reviewed 27 studies which evaluated the effectiveness of trainee-generated questions. Wong found considerable variation in the type of question which the trainee was asked to generate. Questions were aimed at clarification, constructing some high-level understanding, relating new information to prior knowledge, and monitoring one's own comprehension whilst reading or being in a tutorial. Generally all of these types of question were effective at improving scores on measures of both recall and understanding. According to Wong, studies which failed to demonstrate the benefits of self-questioning suffered from one or more methodological problems:

> insufficient training prior to administering posttraining tests, lack of explicitness or direct instruction on generation of questions, and insufficient processing time allowed students to read given passages and to generate questions (Wong, 1985, p. 250).

Analogies. An analogy points to the similarities between two experiences, ideas or devices and is potentially useful therefore in helping us to understand something "new" in terms of something "old". In the last decade, psychologists have suggested that much learning is achieved by analogical reasoning. Rumelhart and Norman (1981) argued that learning by analogy underpinned the development of new schemata. More recently, Collins and Gentner (1987) have argued that analogies can be used to construct a new "mental model" in an unfamiliar domain, although this process is difficult and can result in misconceptions and incorrect inferences. Different analogies can have powerful effects on the way in which people understand and think about new situations.

This is well illustrated by Gentner and Gentner (1983) who found that the pattern of inferences made about problems concerning electricity depended upon which analogy of electricity was adopted: either, what they termed, a "water-flow" or a "moving crowds" analogy.

Science writers have long recognised the power of providing the reader with an analogy to understand a new principle or device. Curtis and Reigeluth (1984) analysed 216 analogies which they discovered in 26 science textbooks. They found that the majority of these analogies were aimed at explaining how something functioned, for example, the principle of feedback being explained in terms of how a thermostat functions. However, the majority of analogies were not accompanied by any explicit description of how the analogy was relevant or should be used. This is risky because, by definition, an analogy is concerned with the *similarities* between something "new" and something "old". The designer intends that the *differences* between them should be ignored, although this may not be so unless the analogy is made explicit.

Like questions, analogies can be provided by the trainer or they can be self-generated by the trainee. The risk is even greater in the latter case that an inappropriate analogy might be generated or the trainee might fail to appreciate the boundaries of the analogy or when it should be used. Providing the trainee with an analogy depends upon some careful analysis of the new task or subject matter having been undertaken. An analogy needs to be selected so that it maximises the similarities between the new and old task, situation, idea, etc.

Mnemonics and associated techniques. In any training situation, we would all like to be able to learn and remember new information better and more easily. A trainee salesman has to remember different selling techniques; students have to remember information given in lectures; actors have to remember their "lines"; and some military personnel have to be fluent in Morse code or semaphore signals. It is not surprising therefore, that the study of techniques which "improve" memory have a long history. We constantly encounter advertisements promising to provide us with a "super-power" memory which will enable us to perform some amazing memory feat.

Mnemonics and similar techniques attempt to fulfil these dreams. The principles on which they are based are quite straightforward and have been known for many years. William James, as usual, was one of the first to articulate these principles when he said:

> In mental terms, the more other facts a fact is associated with in the mind, the better possession of it our memory retains. Each of its associates

> becomes a hook to which it hangs, a means to fish it up by when sunk beneath the surface. Together they form a network of attachments by which it is woven into the entire tissue of our thought. 'The secret of a good memory' is thus the secret of forming diverse and multiple associations with every fact we care to retain. But this forming of associations with a fact, what is it but *thinking about* the fact as much as possible? Briefly, then, of two men with the same outward experiences and the same amount of more native tenacity, the one who thinks over his experiences most, and weaves them into systematic relations with each other, will be the one with the best memory (James, 1908, p. 294).

Associations between facts can take many forms. Perhaps the most simple mnemonic is to associate a new fact with a familiar one which one will never forget. Evidently, when Bertrand Russell visited New York in 1951, he was reported to have told a newsreporter that he could easily remember that his room number at his hotel was 1414 because it had the same digits as the square root of 2.56 (i.e. 1.414)! Clearly the utility of this highly individual mnemonic will depend upon what the person is familiar with and finds meaningful. Alternatively, an association can embellish the item to be remembered by providing some extra mental imagery which is both vivid and points to its important aspects. For example, in order to remember a dog and a bicycle, one could evoke an image of a dog riding a bicycle, which should be quite memorable! Here one is associating two items which have to be remembered through the same imagery. Such imagery might be either provided to the trainee by a photograph, diagram etc. or the trainee might be instructed to produce his or her own imagery.

Other forms of elaboration which can be used to improve learning and retention are discussed by Weinstein (1978) and Mayer (1980). A trainee may relate new information to existing knowledge (integrative elaboration) or compare two new concepts (comparative elaboration). Just adding information which is unusual or interesting is an aid to memory. For example, pretend that you wish to remember that the boiling point of water is influenced by atmospheric pressure. One way would be to remember that it is impossible to get a decent cup of tea at the top of Mount Everest! There atmospheric pressure is low and tea boils at a low temperature; totally unsuitable for making tea.

One of the most powerful principles expounded in any psychological textbook on memory is the effect of organisation. It is perhaps stretching James' notion of association a bit far but essentially organisation is concerned with associating bits of information in some way. Thus it is easier to remember 200 words of poetry than 200 words of prose, which are in turn easier to remember than 200 nonsense syllables (Lyon, 1914). This is because of the differing degrees of meaningfulness and organisation of these materials. Organisation can be imposed on information provided during training either by the trainee or by the trainer, training text etc. Either form of organisation will improve retention dramatically which is confirmed by many laboratory studies in psychology, too numerous to cite. Even putting a list of items to be remembered into a set of categories will facilitate recall. For example a list of hazardous substances could be categorised in terms of their effects or a list of your new employees could be grouped according to their different jobs. Any *meaningful* organisation of items will improve their recall.

One class of techniques, which are orienting tasks in Rigney's terms, bring together many of these principles in order to improve the retention and comprehension of prose materials. They have been labelled "spatial learning strategies" (Holley and Dansereau, 1984a) because each one of these techniques requires the trainee or reader to represent the ideas, concepts etc. diagramatically. As we will discuss later, emphasis on the spatial nature of these learning strategies is somewhat misleading. These techniques vary in terms of both the rules and vocabulary which the reader uses to "analyse" or represent the passage and also the type of material to which they can be applied. Holley and Dansereau (1984b) described one such technique, named "networking", in which readers analysed and mapped out the relationships between the concepts and ideas in a textbook. An example of such a map which was constructed from part of a nursing textbook concerned with the discussion of wounds is given in Figure 10.6.

The relationships identified in this networking technique are: parts-of (p), and types-of (t), relationships in a hierarchy; chains (l) which include lines of reasoning, causal sequences; and clusters which involve characteristics (c), definitions and analogies. Thus in the discussion of wounds there are two parts (p), one of which breaks wounds down into four types (open, closed, accidental and intentional), each of which has its own characteristics (c) (Figure 10.6). Readers can be trained in the use of this networking technique which they can apply to analyse the structure of passages in textbooks. Assuming the relevance of such a technique to some text, it is very unlikely that it would not be of benefit since it forces the reader to organise, summarise and represent the main ideas. However, its benefit will depend on the extent to which it makes the reader attend to and analyse important parts of the materials in a way which would not have occurred spontaneously. Whilst the spatial aspect of such an orienting task may exert some influence on retention, and we know that spatial representation can be powerful, it is impossible, or at least exceedingly difficult, to separate its effect from the cognitive

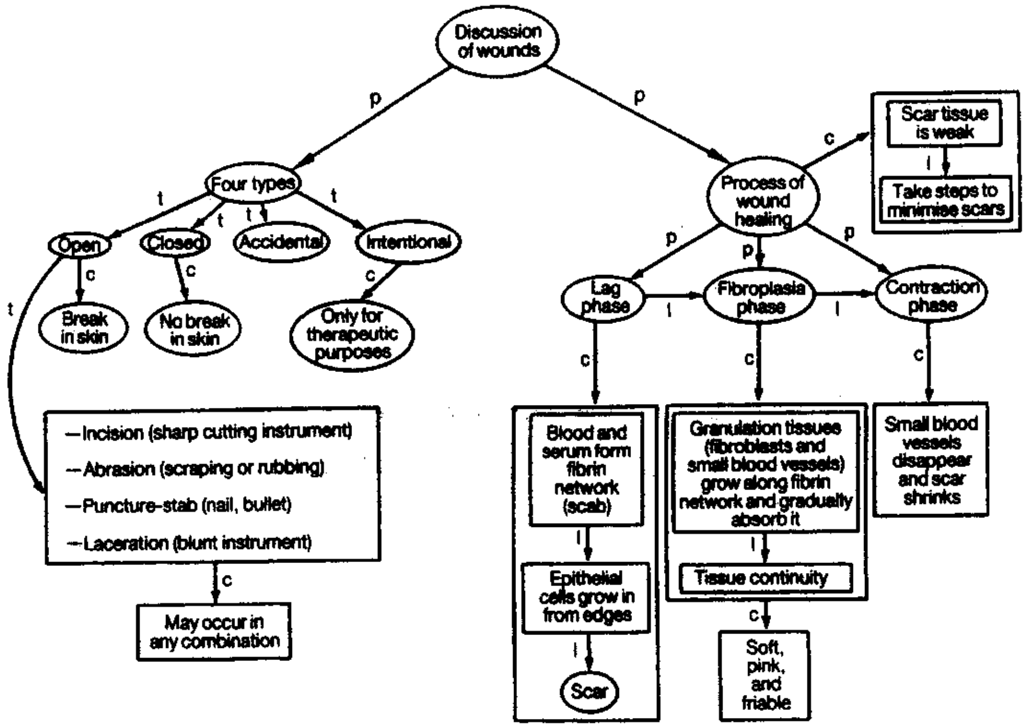


Figure 10.6 Example of the application of networking to a chapter from a nursing textbook (Holley et al., 1979).

activities of categorising, organising and summarising which the technique requires. A number of techniques sharing the same philosophy as "networking" include relational mapping between concepts (Schallert, Ulerick and Tierney, 1984) and mapping ideas in text (Armbruster and Anderson, 1984). The differences between these kinds of techniques lie in the nature of their distinctions and how these distinctions are represented. A problem which is particularly acute for this type of orienting task, is the relevance of these preset distinctions to both the goals of the reader and the nature of the materials.

It is difficult to leave this topic without mentioning some of the traditional and much-loved mnemonic techniques which inevitably creep into most student textbooks. In case some training practitioners are beginning to think that this is rather academic, it is worthwhile trying to rescue our cause by citing a report by Braby and Kincaid (1978) which was concerned with the use of mnemonics in training materials for the US Navy. Their aim was to encourage the use of mnemonics by writers of technical training materials by describing nine types of mnemonic, their potential application and how they should be developed. In their report there are many practical training situations in which mnemonics of some sort or another were helpful to the naval trainee.

In a sense the use of mnemonics should be a last resort and only used when there is little or no intrinsic organisation available in the training material. There is no sense in forming arbitrary associations in order to learn new information if the information itself can be well integrated and organised. In fact there is a danger that people might be tempted to use mnemonics in lieu of pursuing a deeper understanding or comprehension of the training material. This should be avoided, since the superficial yet successful recitation of information is no substitute for real meaning, which might take longer, but is well worth pursuing, not least because it will produce better retention in the long run. Also mnemonics are only necessary in situations in which accuracy and speed of recall is essential, and there is no possibility of using some aide memoire.

Two of Braby and Kincaid's nine types of mnemonic have already been discussed: namely the use of verbal/visual associations and visual images. Some of the remaining types of mnemonic are described below.

1. First letter. The trainee takes the first letter of each key word that has to be remembered and either forms an acronym or reorders these letters to produce a meaningful word.

Example: A trainee technician has to remember the following shutdown procedure:

(a) *S*top the main motor.
(b) *T*urn off the mains isolator.
(c) *E*nsure mould is fully closed.
(d) *P*urge the machine if necessary.

The word "STEP" might be remembered to cue the steps of this procedure. If the procedure could be executed in any sequence then other words such as "PETS" or "PEST" might be remembered depending upon which one could be more easily associated with this shutdown procedure.

2. Acrostic. An acrostic is a series of words, usually a sentence, each of which starts with the first letter of the words to be recalled.

Example: Presumably we all remember what "*R*ichard *o*f *Y*ork *g*oes *o*ut *i*n *v*ain" stands for?

3. Alliteration. The trainee uses the same letter or sound in a series of words in order to remember some key points.

Example: (from Braby and Kincaid). The following navigational rule can be remembered by the mnemonic:

Rule	*Mnemonic*
Keep the *r*ed buoy	*R*ed
on the *r*ight	*R*ight
when *r*eturning from sea	*R*eturning

4. Rhyme. This needs no explanation except to point out that most of us use a rhyme in remembering the number of days in a month.

5. Method of loci. Trainees are encouraged to visualise placing the items to be remembered in different locations (loci), perhaps along a familiar route such as from home to work. Since the locations can be recalled, so can the items.

Example: Trainees have to learn the procedure for inserting tools into an injection moulding machine. They do this by imagining their usual walk from the car park to their office and creating an image at each location which links that location with a step in the procedure. For example, at the security gate the trainee who has to remember "prepare tool for lifting and changing" might imagine a large tool being unwrapped and preventing the gate from opening. If the second step in the procedure is to "attach the tool to a hoist", then the trainee might imagine a large crane-like hook protruding from the door of the reception room! By rehearsing this imaginary walk from the security gate to the canteen with the associated actions, the trainee will be able to remember the procedure. Try it if in doubt!

6. Pattern. (from Braby and Kincaid). Any pattern or regularity in the information can be used to remember it.

Example: Navy recruits who have to remember the Morse code numbers 1–5 should notice that number 1 is one dot and four dashes, number 2 is two dots and three dashes, and so on, up to number 5 which has five dots.

7. Peg word. Various peg word or peg list mnemonic systems exist. One common peg word system uses a rhyme to link peg words and numbers:

One is a bun	Six are sticks
Two is a shoe	Seven is heaven
Three is a tree	Eight is a gate
Four is a door	Nine is a line
Five is a hive	Ten is a hen

One – Bun

1. Take charge of this post and all government property in view.

Sentry on giant bun overlooking post "taking charge" of post

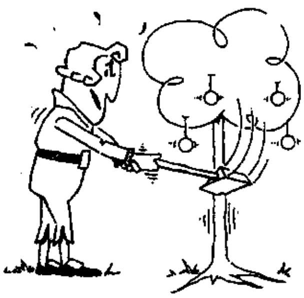
Two – Shoe

2. Walk my post in a military manner, keeping always on the alert, and observing everything that takes place within sight or hearing.

Walking past in military manner wearing well shined shoes

Three – Tree

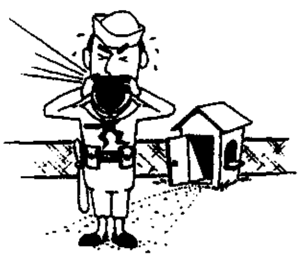
3. Report all violations of orders I am instructed to enforce



George Washington chopping down cherry tree and then reporting "violation" to his father.

Four – Door

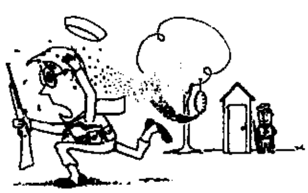
4. Repeat all calls more distant from the (guard house) quaterdeck than my own.



Sentry repeating call from guard house with door open.

Five – Hive

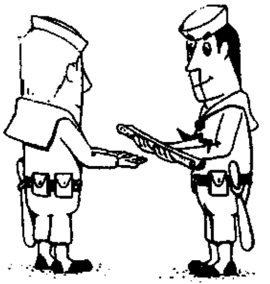
5. Quit my post only when properly relieved.



New sentry relieving old sentry who is being chased by bees from hive.

Six – Sticks

6. Receive, obey and pass on to the sentry who relieves me, all orders from the commanding officer, command duty officer, officer of the day, officers of the deck, and officers and petty officers of the watch only.



New sentry being given orders (on scrolls that look like sticks) from the sentry relieving him.

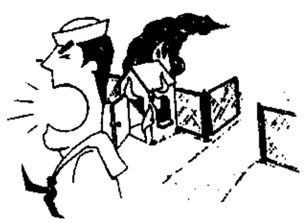
Seven – Heaven

7. Talk to no one except in line of duty.

Silent angel/sentry

Eight – Gate

8. Give the alarm in case of fire or disorder.



Sentry giving alarm with open gate behind him.

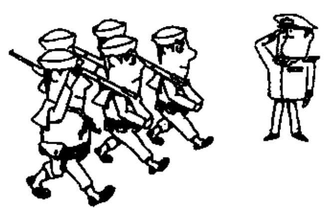
Nine – Line

9. Call the (corporal of the guard) officer of the deck in any case not covered by instructions.

Sentry calling officer of the deck.

Ten – Men

10. Salute all officers and all colors and standards not cased.



Men saluting officer.

Figure 10.7 Examples of the use of peg-word mnemonics (from Braby and Kincaid, 1978).

The rhyme is learned and each of the items to be remembered is "hooked" onto a peg word, for example, by forming a strong image between the item and the peg word.

Example: (from Braby and Kincaid). Naval recruits have to remember the duties of a sentry. How some of these duties are "hooked" onto the peg word in an imaginative manner are illustrated in Figure 10.7.

Learning strategy training programmes

The common aim of learning strategy training programmes is to improve *how* trainees learn. However, they vary enormously in terms of their specific objectives, training methods, theoretical basis, skills taught and the type of evaluation carried out. For a full discussion of these issues the reader should consult a useful review of four programmes by Campione and Armbruster (1985). Most learning strategy training programmes are restricted to the acquisition of information from text. They all raise the same fundamental training and transfer issues which are discussed in Chapters 2 and 3. What is the expertise of skilled learners? To what extent is this expertise domain-dependent? How can this expertise be taught in order to maximise its transfer potential? In this section Dansereau's learning strategy training programme, which was one of the first to be developed and evaluated, will be discussed (Dansereau, 1978; Dansereau et al., 1979; Dansereau, 1985). Its philosophy is similar to Weinstein's elaboration training programme (Weinstein, 1978; Weinstein and Underwood, 1985) in that learning strategies are taught in a "detached" fashion (in Rigney's terms) by a training programme devoted exclusively to teaching them.

Much of Dansereau's work is published in technical reports and a good summary is available in Dansereau (1985). Learning strategies are divided into two types: *primary* strategies which operate directly on the materials to be remembered and *support* strategies which maintain the trainee's concentration, mood etc., which are prerequisites for learning (Figure 10.8). The primary strategies are similar to those advocated by the SQ3R study technique (p. 410), although Dansereau argued that the problem with SQ3R is that no training is given in how to develop and implement these strategies. As can be seen from Figure 10.8, primary strategies are either concerned with comprehension/retention or retrieval/utilisation. Both of these primary strategies involve the trainee proceeding through five steps: *u*nderstanding the text, *r*ecalling the information, *d*igesting it, *e*xpanding upon it and finally *r*eviewing misconceptions about it. These five stages when linked with one of the

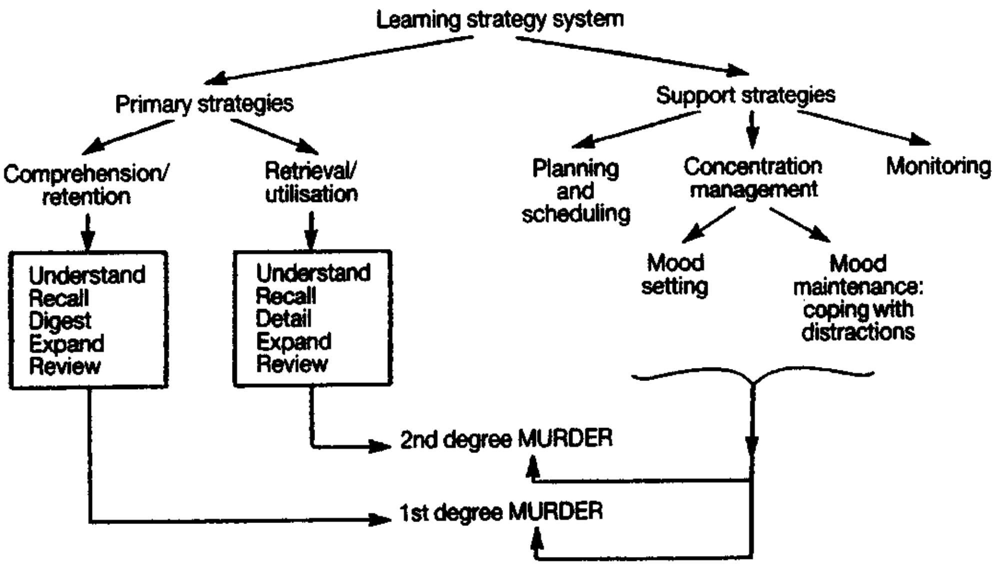


Figure 10.8 Organisation of Dansereau's learning strategy system (Dansereau, 1985).

secondary strategies concerned with setting the *mood* give rise to the acronym MURDER. First degree MURDER represents the comprehension/retention strategies and second degree MURDER the retrieval/utilisation strategies. Dansereau (1985) detailed the following three substrategies which were used in the recall stage of first degree MURDER:

1. *Paraphrase/imagery*. Trainees are involved in summarising the text and developing mental images associated with the ideas and concepts in it.
2. *Networking*. Trainees are taught how to represent the organisation of text using a set of relationships as described and discussed previously (pp. 418–419).
3. *Analysis of key concepts*. This activity involves defining and identifying important concepts in the text and inter-relationships between them. It complements the networking activities.

The support strategies are a reminder that irrespective of how good training might be, it will be doomed to failure unless the trainee is in the correct frame of mind, is motivated, is concentrating, and is planning and monitoring his or her learning activities. Various techniques are used for these purposes.

One evaluation of the first degree MURDER learning strategy training programme was reported by Dansereau et al. (1979). Undergraduate students at the Texas Christian University were split into two groups: one group of 38 students received 24 hours of strategy training and a second group of 28 students did not. The effectiveness of the students' learning strategies was measured before, half-way through, and after the strategy training programme by means of short-answer and multiple-choice tests. These tests were constructed from three 3000 word text passages on educational psychology, ecology and geology. For each test the students were given one hour to study the passage and then one week later they had 45 minutes to complete the corresponding test. After the mid-training test, the students who received training were split into three groups, each of which focused on one of the following: paraphrase/imagery techniques, networking and the analysis of key ideas. The results indicated that the strategy training group was superior to the control group at the mid- and post-test evaluations. Overall this group outscored the control group by about 20% although all of this superiority was achieved by the half-way point of training and it was mostly reflected in better short answers. Comparison of the three training subgroups which received different strategies in the second half of training, revealed that: networking was the best strategy and improved scores from mid-test to post-test; analysis of key ideas had no effect; and paraphrase/imagery had a slightly negative effect. In such an applied study it is not possible to disentangle the reasons for these effects. Presumably, if all students in the training group had been taught networking in the second half of training then the overall score of the training group would have improved from mid- to post-test. A supplementary finding of the study was that students who received strategy training reported a greater improvement in their attitudes and study habits than another group of students which did not receive such training.

Dansereau (1985) concluded that this, and a second similar evaluation study, pointed to the benefits of learning strategy training for text-processing tasks. This conclusion was also supported by studies which have demonstrated the effectiveness of individual strategies. The improvements in learning found in Dansereau's evaluation studies occurred despite the fact that the tests were not specifically designed to measure the contribution of the different strategies which had been trained. More microscopic evaluation studies would improve our understanding of the relative contributions of the different primary and secondary learning strategies. Further questions also need to be addressed. To what extent are some of these learning strategies normally adopted by the better trainees? How do these strategies vary both with the type of subject matter and the experience of different trainees? Dansereau (1985) acknowledged the need for more fine-grained work in this area. He also raised two other basic questions concerned with the transfer and retention of learning strategies. The intention of such a learning strategy training programme is that trainees will apply these learning strategies in similar training situations. Discussion of the transfer issue in Chapter 3 of this book suggests that positive transfer, particularly of cognitive skills, often does not take place even when it is expected to do so. One reason is that trainees find it difficult to judge when certain skills are applicable and how they should be adapted to a new situation. Dansereau indicated that his students had similar difficulties in adapting their learning strategies to different types of text. This suggests that it may be more profitable to try and identify these learning strategies and train each of them in a more embedded fashion. Finally, as with most cognitive skills, there is little evidence about how well learning strategies are retained following long periods of no practice.

Brown and Palincsar's reciprocal teaching

A much quoted recent approach to the training of reading comprehension skills has been developed by Brown and Palincsar (1989), and Palincsar and Brown (1984), named "reciprocal teaching". It is of interest because it not only uses some learning strategies, but also brings together many principles of training, including more contemporary ones, into an approach which the developers claim is "more than the sum of the parts". Whilst one trend has been to analyse the cognitive processes involved in learning in finer and finer detail, this approach seems to buck this trend, preferring not to decompose training into a set of different activities and examine the effect of each. Some impressive evidence is provided that reciprocal teaching can produce considerable benefits, even for poor readers, and that its effects generalise and are sustained over periods of, in some cases, at least six months. Useful reviews of reciprocal teaching are provided by Collins, Brown and Newman (1989) and Glaser and Bassok (1989).

Brown and Palincsar (1989) explained reciprocal teaching as follows:

> Reciprocal teaching takes place in a cooperative learning group that features guided practice in applying simple concrete strategies to the task of text comprehension. ... An adult teacher and a group of students take turns leading a discussion on the contents of a section of text that they are jointly attempting to understand. The discussions are free ranging, but four strategic activities must be practiced routinely: *questioning, clarifying,*

summarizing, and predicting. The dialogue leader begins the discussion by asking a question on the main content and ends by summarizing the gist. If there is disagreement, the group rereads and discusses potential candidates for question and summary statements until they reach consensus. Summarizing provides a means by which the group can monitor its progress, noting points of agreement and disagreement. Particularly valuable is the fact that summarizing at the end of a period of discussion helps students establish where they are in preparation for tackling a new segment of text. Attempts to clarify any comprehension problems that might arise are also an integral part of the discussions. And, finally, the leader asks for predictions about future content. Throughout, the adult teacher provides guidance and feedback tailored to the needs of the current discussion leader and his or her respondents (p. 413).

Reciprocal teaching has many features and from a training perspective some of its important ones are:

1. It trains students in the use of four learning strategies which are embedded within the learning task, that of reading comprehension. These strategies, which are directed toward comprehension monitoring, are questioning, clarifying, summarising and predicting (i.e. anticipating the next part of the text). The first three of these are similar to traditional learning strategies discussed previously. However unlike the learning strategy training programme by Dansereau et al. (1979), these are not trained separately from the learning task. Brown and Palincsar put great emphasis on the fact that these strategies are being taught within a goal-directed activity and context, that of understanding a particular piece of text.
2. The teacher models the use of these strategies. The students observe the teacher and can also ask questions about the teacher's questions etc. Gradually, as the students become more confident and competent to use these strategies, the teacher takes less of the lead and less of a modelling role and adopts more of a monitoring role of the group's activities.
3. The teacher provides individual students with feedback concerning their strategies and suggests how they might be improved.
4. Reciprocal teaching takes place within a cooperative group situation which provides advice, encouragement and support for the individual.
5. Students not only practise their own strategies but they learn to evaluate those of others. Collins et al. (1989) suggested that this forces them to make explicit what they consider to be the qualities of good strategies (e.g. questioning, summarising), which not only helps the development of their own skill, but enables it to transfer more freely to other contexts.

Brown and Palincsar (1989) summarised the findings of some of their studies concerned with the use of reciprocal teaching. Some notable features of the studies were: reciprocal teaching was used in an applied setting with students; the teaching was usually spread across a four-week programme; students' progress was measured by multiple indicators including qualitative changes in the group's discussions, immediate post-training tests of the retention of discussed text and also novel text, and long-term retention and transfer of reading comprehension. Brown and Palincsar reported remarkable improvements which, on average, ranged from 30% to 40% correct at the beginning of the training to 70%–80% correct after four to 15 days of the training programme. In this sort of research, as discussed in previous chapters, it is always difficult to identify what to evaluate the effect of training against. Palincsar and Brown (1984) used a variety of control groups; one being tested in the same manner but having no training, and another receiving training from the teacher who guided the student to the answers in the text. The superiority of the learning scores for the group receiving reciprocal teaching was considerable both during and after training. In a more recent study (Brown et al., work in progress) two more stringent control groups were used: in one, the teacher modelled how to use the four

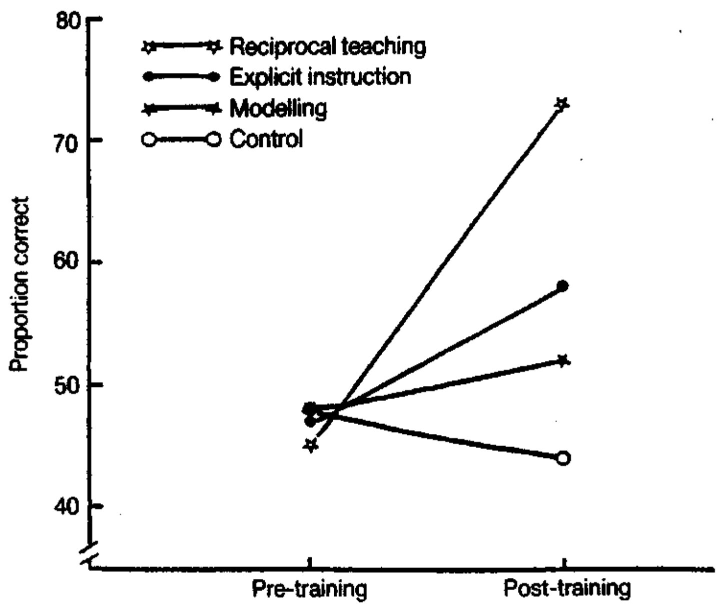


Figure 10.9 The effect of different approaches to training reading comprehension in three groups of matched junior high school students (from Brown et al., work in progress, cited by Brown and Palincsar, 1989).

learning strategies (i.e. only one part of reciprocal teaching) and in another, the teacher discussed the learning strategies and then the students practised using them in pencil and paper exercises (termed explicit instruction). The results are represented in Figure 10.9. The improvement in reading comprehension for the students trained in reciprocal teaching was significantly more than that of the two control groups which received some training. Another control group which had no training was worst of all.

Brown and Palincsar, in their final assessment of what reciprocal teaching has accomplished and what remains to be achieved, confessed that little is known about *how* these skills are acquired. Also they suggested that in the future more complex comprehension tasks should be used in conjunction with longitudinal studies which assessed qualitative developments in this skill.

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