8

Types and styles of thinking

The highest possible stage in moral culture is when we recognise that we ought to control our thoughts.

Charles Darwin, *The Descent of Man*

The art of reasoning consists in getting hold of the subject at the right end, of seizing on the few general ideas that illuminate the whole, and of persistently organising all subsidiary facts around them. Nobody can be a good reasoner unless by constant practice he has realised the importance of getting hold of the big ideas and hanging onto them like grim death.

A. N. Whitehead, 1914 *Presidential address to the London Branch of the Mathematical Association*

Thinking about thinking

So far in this book we have concentrated on the nature of design as a process and on the characteristic qualities of design problems and good solutions. Now it is time in this third part of the book to turn our attention to the thought processes which are required to identify and understand those design problems and create design solutions. In subsequent chapters we will need to consider the principles, strategies and tactics which designers use in this mental process. We study the traps and pitfalls that frequently beset them and examine how designers use drawings, work in groups and with computers. After all designers are not philosophers for whom the thought process itself is centre of study, nor does the designer resemble Rodin's 'Thinker' who sits in solitary mediation. Essentially the designer's thinking is directed towards some physical end product the nature of which must be communicated to others who may help to design it and to construct it.

To begin with, however, we need to study thinking itself and, in the next chapter, that precious and wonderful phenomenon of creativity which is so central to design. The history of cognitive psychology reveals many conflicting views about the nature of thought and the thought process from the most mechanistic to the most mythical. We begin with a problem familiar to those who study design. The word 'thinking', like the word 'design', is used in so many ways in everyday language that we need to specify exactly which versions of it we are examining.

There is the sort of thinking we do when we say are trying to think where we left something. This is essentially remembering and is obviously vital to design but again not the central task. There is the use of the word 'think' which we apply to the act of concentrating or simply paying attention, as when we say 'think what you are doing'. There is the use of the word to mean belief as when someone says what they 'think'. There is the thinking which psychologists would label 'autistic' but which ordinary people might describe as day-dreaming. This leads to a sort of uncontrolled stream of consciousness which in itself can be useful to designers but is certainly not their main tool. There is the sort of imaginative thinking we do which might be described as fantasy anchored in reality. Here we might 'think' through some scenario which is possible but not actual. Clearly this is very much what designers do. Finally there is the sort of thinking which we might call 'reasoning'. This is self-consciously done with a deliberate attempt to control the direction of thought towards some intended end product but where some obstacles have to be overcome. This is reflective thought and problem-solving.

In Chapter 9 we explore creative and imaginative thinking, but it is the last of these many forms of thinking that we are primarily studying here. The great British philosopher and student of thought, Ryle (1949) described even this last version of thinking as being 'polymorphous'. Just as two farmers might do quite different things, with one rearing sheep and another reaping crops, Ryle famously explained, we still recognise them both as farmers. So it is with thinking.

Theories of thinking

This subject is not an easy one since it takes us quickly into the psychology of thinking and to some extent of feeling and emotion. So much has been written about the phenomenon of thought and

the business of thinking by philosophers and psychologists that we cannot possibly do justice to the subject here. However, this chapter attempts the almost impossible, which is a brief survey and summary of the key points from these debates which seem important to the study of design.

Cognitive psychology is one of the most problematic fields of science since it involves investigation of something we cannot see, hear or touch. We know it is going on, and we all think throughout our lives without worrying about it too much, but thinking about thinking is another matter. In terms of modern western psychology, the earliest theories of thinking were very basic indeed. In fact the 'behaviourist' theories of thinking hardly admitted that thinking was any more than very mechanistic behaviour which just happened to go inside the head. The Gestalt psychologists were more interested in how we solved problems, and more recently the cognitive science approach has tried to study humans as information processors.

The behaviourists

The behaviourist Thorndike (1911) believed that human intelligence comprises only one basic process, the formation of associations. In fact the behaviourists were reluctant to admit that humans could be distinguished from other species by our abilities to think at a high level. Following Thorndike's early writings many behaviourist psychologists tried to explain thinking purely in terms of direct associative links between stimuli and responses. They even went so far as to argue that thinking is really only sub-vocal speech or 'talking to ourselves'. Indeed some experimenters found evidence of peripheral muscular activity during thinking but, of course, they failed to show that this was actually the thinking itself. Eventually the idea was modified suggesting that the muscular activity was so small as to have no effect save to act as feedback to the thinker. The idea behind such an apparently curious notion was that in this associationist model of thought, each of our responses could be fed back to act as another stimulus eliciting yet a further response. Writers such as Osgood and Berlyne eventually abandoned the search for 'muscular thought' and introduced the notion of purely cortical responses. For Berlyne (1965), patterns of thought result from us choosing from a variety of responses which we associate with each stimulus. The choice is made simply by selecting the strongest associative link although these links can be strengthened or weakened by our experience of life.

In essence the behaviourist view is that it is unnecessary to hypothesise a complex mental mechanism where behaviour can be explained without one. This follows the sound scientific principle of not inventing complex theories when simple ones will do, but can the behaviourists adequately explain intelligent thought? Their theories have appeared most successful in explaining behaviour such as learning and the acquisition of physical skills. The rat in the psychologist's maze can be seen as learning to associate the response 'left' or 'right' with the stimulus of each junction. Thorndike expanded this simple idea by placing cats in puzzle boxes where a variety of bolts or catches needed to be released to open the cage. The cats escaped by trial and error and thus apparently learned to solve a problem. Behaviourists have thus tended to explain problem-solving or goal-directed thinking in terms of successive mental trial and error. Actually the associationist model of thought seems more applicable to imaginative thought or daydreaming. Here the thinker is not wilfully controlling direction but, rather, is allowing the thought stream to wander. However this must wait until the next chapter.

The Gestalt school

However satisfactory or not their theories may be the behaviourists have contributed little which may be used by designers wishing to improve their thinking skills. It was not until the arrival of the Gestalt school of psychology that we begin to find material useful for explaining design thinking. The Gestalt school established a tradition of studying problem-solving which is continued today by such writers as Edward de Bono. Gestalt theories of thinking concentrate on processes and organisation rather than mechanisms. Wertheimer (1959) saw problem-solving as grasping the structural relationships of a situation and reorganising them until a way to the solution is perceived. This already begins to sound more like designing than Thorndike's cats, but Wertheimer went even further. He maintained that this mental reorganisation of the situation is achieved by applying various mental modes of attack which still persist today in creativity tools such as those advocated by popularist writers. These mental tricks include trying to redescribe the problem in another way and the use of analogy as a way of shifting the mental paradigm. As we shall see later this forms the basis of a number of quite recently proposed design techniques. Whereas

the behaviourists used animals to explain thought, the Gestaltists used animals to show the absence of human-like thought. The Gestaltists were also very interested in perception and, therefore, stressed the importance of context in thought. De Groot's use of words in describing Kohler's experiments with apes is most revealing:

> We humans are struck by the inability of these otherwise quite intelligent animals to take a ring off a nail; a possibility that we immediately see. Due to our experience with nails and rings and their usage, we see the situation in a totally different way than the ape does. Similar examples can be given touching upon the relation between adults and children.
>
> (De Groot 1965)

Thus for De Groot thinking depends upon acquiring the ability to recognise relationships, patterns and complete situations. In his study of chess De Groot shows how experienced chess players 'read' situations rather than 'reason them out' as do the less experienced. Thus chess masters can play so many games simultaneously simply because each time they see a board they are able to recognise the pattern of the game. This 'schooled and highly specific way of perceiving' combined with a 'system of reproductively available methods in memory' (De Groot 1965) produces a rapid and inscrutable response which, to the uninitiated observer, looks like an intuitive flash of genius. Paradoxically, chess masters may also spend far longer examining a situation than their less experienced counterparts simply because they can see more problems, perhaps further ahead, than the average player. Anyone who has watched an experienced designer at work will recognise this description. The designer may appear to be drawing in a very natural and relaxed manner as if no effort were involved at all. As Bruner puts it the designer must 'go beyond the information given' and see possibilities which others may fail to discover for themselves but still recognise as useful, appropriate and beautiful when they are presented.

Markus listed four basic sources of information available in a design decision-making situation: the designer's own experience, others' experience, existing research and new research (Markus 1969a). It is perhaps the inevitable mixing of these sources which contributes to designers' seemingly random behaviour, sometimes apparently intuitively leaping to conclusions whilst at other times making very slow progress.

The Gestalt psychologists paid particular attention to the way we represent the external world inside our heads. Most notably Bartlett in his now classical studies of thinking (Bartlett 1958) and

remembering (Bartlett 1932) developed the notion of an internalised mental image which he called the 'schema'. The schema represents an active organisation of past experiences which is used to structure and interpret future events. In a series of experiments in which Bartlett asked subjects to remember drawings and reproduce them perhaps several weeks later, he showed how such memory is dependent on the drawings being meaningful. That is, we must have already formed the appropriate schemata in advance to interpret and appreciate events. The developmental psychologists such as Bruner and Piaget have shown how human thought processes develop in parallel with the child's formation of such basic and fundamental schemata.

I have for many years tried to teach first year architectural students to remember how they 'see' architecture before they develop the sophisticated concepts which architects use to debate the subject. A real problem for designers is that they have so many more concepts or schemata for describing the objects they design that they genuinely do 'see' them differently to those for whom they design. This can easily lead to a result known as 'architects' architecture', which can only be appreciated and enjoyed by other architects!

The cognitive science approach

The advent of electronic communication devices and information processing machines such as computers has generated a new perspective on human thought. Information theory has provided a metric which allows the amount of information processed during a problem to be measured. Psychologists have attempted to uncover the mechanisms with which we think by measuring our performance on simple tasks against the amount of information processed. Such writers as Posner appear to bridge the gap between the behaviourists and Gestaltists by concentrating on mechanisms while still viewing thinking as a strategic skill. Garner's (1962) influential book on cognitive psychology reports experiments in short-term memory, discrimination, pattern perception, and language and concept formation all using information theory to provide the yardstick for human performance. Other workers in this field have proposed theories of human problem-solving based on the model of the computer program. The most famous application of this technique being the GPS (general problem solver) program of Newell, Simon and Shaw (1958). Such programs cause the computer to exhibit behaviour

resembling such hitherto peculiarly human characteristics as 'purpose' and 'insight'. This has the potential to shatter some of the mystique surrounding work on thought processes by showing how sequences of very elementary information transformations could account for the successful solution of complex problems. Whether such simple processes are actually the basis of human thought is, of course, still open to considerable doubt. Unfortunately there are limitations to the usefulness of such computer programs as models since they rapidly become as complex as the processes they model.

The new cognitive approach to human thinking sees human beings as much more adaptable and genuinely intelligent organisms than the early behaviourist approach. It deals with process and operational function rather than physical mechanism, and it stresses the influence of the context in which problems are perceived on the thought process itself. The cognitive psychologists, while building on the Gestalt tradition, also follow on from the first flush of enthusiasm shown by psychologists for applying information theory to human thought, but are less fanatical about its potential. In his brilliant treatise on cognitive psychology Neisser (1967) points out that humans are different from machines from the very beginning of the perceiving and thinking process:

> Humans . . . are by no means neutral or passive towards incoming information. Instead they select some parts for attention at the expense of others, recording and reformulating them in complex ways.
>
> (Neisser 1967)

As we shall see in later chapters this phenomenon of our selective perception of problems has exercised the minds of many design methodologists who seek to devise ways of broadening designers' perceptions.

Perhaps the most important feature of the cognitive psychology approach to thinking is the new recognition of the existence of some kind of executive controlling function in the mind. Since cognitive psychology accepts that information is actively reorganised and reconstructed in memory rather than passively recorded and recalled, it follows that something must control this process. The existence of such an executive function was denied not only by classical association theory but also by the Gestaltists, however, more recent work on artificial intelligence has shown how executive routines in computer programs can control the order in which a very complex sequence of operations are performed in extremely flexible and responsive ways. There is not space here to do justice to this profound and fascinating subject but the interested reader will find brilliant and readable discussions of the matter in *Plans*

and the Structure of Behaviour (Miller, Galanter and Pribham 1960) and the *Ghost in the Machine* (Koestler 1967). More recently the notion of a single executive has tended to become replaced by the idea of 'agents'. These mental agents look after our thinking just as the human agents we use in everyday life look after our affairs. We employ an estate agent, for example, to find people interested in buying our house, or perhaps to find houses we might like to buy. They thus work purposefully towards a relatively simple goal. A butler is perhaps the ultimate personal agent who operates by really understanding the wishes and aspirations of the master and who almost certainly then subcontracts work to a series of more specialised agents. If the cognitive psychologists prove to be right about executives and agents then we may expect to discover much more about the way we design. If we could understand the forces and operations which are responsible for switching our attention from one part of a problem to another or allowing us to reorganise our perceptions in new ways, we should be well on the way to understanding the design process.

The cognitive theorists' approach to thinking is also attractive to those who seek to understand the design process because it draws many parallels between thought and perception. Both primary and secondary processes are postulated, the primary thought process being a multiple activity like parallel processing in computers. These crudely formed thoughts are similar to the preattentive processes in vision or hearing being only drawn to our conscious attention if selected for detailed and deliberate elaboration by the secondary processes. It is in the secondary processes where all the real work is done. These processes have to be acquired and developed, and are dependent upon what is already memorised and the way material has been organised in primary processing. The cognitive theories thus lay great emphasis upon the way we organise perceived information and store it. Failure to recall is seen as analogous to a failure to notice something in a visual scene. Attention in perception and thought is seen as responsible for directing our thoughts and thus crucial to problem-solving. This theme will be taken up again in a rather less theoretical and more practical way when we consider methods of stimulating creativity and improving problem-solving skills in design.

However, there remain many problems with what has now become known as the cognitive science approach to thought. The actual performance of artificial intelligence remains so far behind that of human thought in so many ways that there must be doubts as to whether the two can ever be comparable. The cognitive science approach is

strongest when dealing with well-ordered problem-solving situations rather than the ill-defined 'wicked' problems which are so characteristic of design. The 'computational theory of mind' underpins the whole of the cognitive science by assuming that thought can ultimately be reduced to a computation process. Now for a such a process to be possible there must be information on which to work. For that information to be capable of being processed it must conform to some rules akin to those of languages which determine the range of symbols and the allowed relationships. The cognitive scientist Jerry Fodor (1975) summarises this problem for us:

> If our psychological theories commit us to a language of thought, we had better take the commitment seriously and find out what the language of thought is like.
>
> (Fodor 1975)

In a book rather neatly entitled *Sketches of Thought*, Vinod Goel (1995) begins to confront these problems. He analyses the sketches produced by designers and finds it impossible to define a language sufficiently rigorously for the demands of the theory. In a later chapter we shall ourselves try to understand the central role of drawing and sketching in design. It is interesting, however, now to find that cognitive scientists are increasingly interested in design for the very reason that explaining it tests their theories to, and possibly beyond, their limits.

Types of thinking

At the beginning of this chapter we saw many types of thinking and concluded that reasoning and imagining were probably the most important to designers. Reasoning is considered purposive and directed towards a particular conclusion. This category is usually held to include logic, problem-solving and concept formation. When 'imagining', on the other hand, the individual is said to draw from his or her own experience, combining material in a relatively unstructured and perhaps aimless way. Artistic and creative thought as well as daydreaming are normally considered imaginative.

This kind of simplistic taxonomy is perhaps as misleading as it is apparently helpful. If reasoning and imagining were truly independent categories of thought, one should not be able to speak sensibly of 'creative problem-solving' or a 'logical artistic development', which are both quite meaningful concepts. Many kinds of problems, even in such apparently logical disciplines as engineering,

can be solved creatively and imaginatively. Certainly art can be logical and have a well-developed structure. It is even possible to study the structure of art forms using the logic of information theory (Mueller 1967). Only rarely can one find an instance in the real world outside the psychologist's laboratory when one kind of thought is employed in isolation. The mode of thinking employed is obviously very much dependent on the nature of the situation. Most writers have concentrated on two main related factors, the thinker's relation to the external world, and the nature of the control exercised over those thought processes.

Murphy (1947) suggested that mental processes are bipolar, being influenced both by the external world and by inner personal needs. In his study of personality he was particularly interested in the individual's susceptibility to these two influences, and the resultant predominance of certain thinking styles which could be observed in the individual. The normal person is rarely entirely preoccupied by either one of these influences for any amount of time but, rather, alternates between the two. It is, however, possible to identify conditions under which one would expect the normal person to attend more to one influence than the other.

Problem-solving obviously requires more attention to the demands of the external world than to inner mental needs. In imaginative thinking, on the other hand, the individual is primarily concerned with satisfying inner needs through cognitive activity which may be quite unrelated to the real world. This seems to offer a psychological distinction which parallels that between design and art discussed earlier. Design is directed towards solving a real-world problem while art is largely self-motivated and centres on the expression of inner thoughts. This does not mean that imaginative thought can be excluded from the design process but that its product will probably always need evaluation by rational thought in order that the designer's work should be relevant to the real-world problem. The control and combination of rational and imaginative thought is one of the designer's most important skills and we shall discuss this crucial issue further in Chapter 9.

Thought and personality

A very popular approach to the study of human intelligence is represented by the factorial school. This work holds that human intelligence is not a simple factor but rather a whole series of related

factors each of which may be present to greater or lesser extents in any individual. In his review of such work Guilford (1956) concluded that intellectual factors could be divided into the two major groups of thinking and memory. The thinking factors, which are of most interest here, Guilford further subdivided into cognition, production and evaluation.

The cognition factors of human thought have to do with becoming aware of and understanding classes of objects or ideas. This analytic ability to classify and recognise is of the utmost importance in everyday thought. For example, it would not be possible to study the differences between the structural systems employed in Romanesque and Gothic churches unless one could first recognise and classify such buildings. Guilford maintains that there are three ways of developing such a class system depending on whether the figural, structural, or conceptual content is used. Thus one might recognise a class by its figural properties. Children may initially recognise all four-legged animals as cows and only later look for further detail such as horns or tails. The second system of class recognition, by structural content, requires some functional relationship to exist between class members such as in the 'complete the series of symbols' type of IQ test question. Finally, one might recognise a class conceptually, such as architects or lawyers as being a group of people having passed certain examinations. For Guilford, then, these cognition factors influence our ability to define and understand problems whether they are to do with the appearance, function or meaning of objects. As Guilford himself points out, problems of figural and structural types abound in design and the ability to discriminate figural and structural classes is likely to be important to the designer.

Guilford's second group of thinking factors is concerned with the production of some end result. 'Having understood a problem we must take further steps to solve it' (Guilford 1967). Just as Guilford's cognition factors deal with the ability to recognise figural, structural and conceptual order, so the production factors hypothesise our ability to generate or produce these three kinds of order, but he found that the reality was not quite as neat as the model suggested:

> In the investigation of planning abilities it was hypothesised that there would be an ability to see or to appreciate order or the lack of it, as a feature of preparation for planning. It was also hypothesised that there would be an ability to produce order among objects, ideas or events, in the production of a plan. A single ordering factor was found.
>
> (Guilford 1967)

Thus Guilford found not two abilities to handle structure or order, but one which seemed to belong amongst the production factors rather than the cognition factors. This is a most interesting observation in the light of my own experiments quoted earlier which tended to show that architects discover about the structure of their problems by attempting to generate order in their solutions, and lends more weight to the argument that analysis and synthesis in design should not be regarded as entirely separate activities (Lawson 1972). Unfortunately, few psychologists seem to have considered both the recognition and production of order at the same time so for the time being we must accept the distinction since the literature on productive thinking has several useful concepts to offer the student of design.

Of course we must not assume that all architects are the same in their thinking style, and certainly not that all designers think in exactly the same way. In an interesting set of experiments Anton van Bakel (1995) has identified what he considers to be a series of identifiably different 'styles of architectural thinking', which he links to personality variations. His experiments and interviews with designers identified the sequence and emphasis of attention to various clusters of factors. Van Bakel chose to map out what he called the solution space as a triangle with the Program (or brief), the Concept (or design principle) and the Site. His categories do not map neatly on to the model of design problems used in this book, but we can see that his Program category of issues are in reality client-generated constraints, his Concept category are designer-generated constraints and his Site category are the chief source of external constraints for architects. These results clearly suggest some consistent variation of approach which could be a matter of personal preference linked with personality factors. However, more work needs to be done to see to what extent this varies with time and types of project before we can be sure just how these various factors really interact to determine the approach a particular designer will take to a particular project.

Productive thinking and design

When Wertheimer (1959) introduced the notion of 'productive thinking' he was primarily concerned with the directional quality of thought: 'what happens when, now and then, thinking forges

ahead?' He showed with a whole series of small experiments how, when in a problem situation, thinking can be productive if it follows an appropriate direction. There are at least two fundamental questions which the experimental psychologist can ask here. Is the thinker trying to control the direction of his thinking and, if so, is the direction productive or not?

It is clear that mental processes are bipolar in their directional quality just as in their relation to the external world. The thinker can wilfully control the direction of his or her thought or he/she can allow it to wander aimlessly. Normally people do not solely engage in either one kind of thought, but rather they vary the degree of directional control they exercise. Here, then, is another distinction between design and art. Designers must consciously direct their thought processes towards a particular specified end, although they may deliberately use undirected thought at times. Artists, however, are quite at liberty to follow the natural direction of their minds or to control and change the direction of their thinking as they see fit. Bartlett's (1958) classification could be used to support this argument distinguishing as it does between the artist's thinking and that of the designer:

> There is thinking which uncovers laws of finished structure or of relations among facts of observation and experiment. There is thinking which follows conventions of society or of the single person, and there is other thinking still which sees and express standards.

Clearly the search for, and expression of, standards forms an important part of artistic thought. Designers must primarily indulge in Bartlett's first kind of thinking in order that they can appreciate the relationships between the given elements of the problem. The amount of purely expressionistic thinking that may take place is largely a function of the degree to which there is room for designer-generated constraints. As we have seen this varies considerably from problem to problem and there will thus inevitably be many instances when design and art are indistinguishable by using only this test.

Bartlett goes on to suggest two main modes of productive thinking which he calls 'thinking in closed systems' and 'adventurous thinking'. A closed system, in Bartlett's definition, has a limited number of units which may be arranged in a variety of orders or relations. Formal logic is such a closed system as are arithmetic, algebra and geometry. Closed system thinking can be highly creative as in the case of discovering new mathematical proofs or making anagrams. Bartlett identifies two processes in closed system thinking, interpolation and

extrapolation. Here again we see the concept of the directionality of the thought process:

> Genuine thinking is always a process possessing direction. In interpolation the terminal point and at least some evidence about the way there are given, and all that has to be found is the rest of the way. In extrapolation what provided is some evidence of the way; the rest of the way and the terminal point have to be discovered or constructed. So it is in extrapolation that directional characters or properties are likely to become most prominent.
>
> (Bartlett 1958)

Although these two processes of interpolation and extrapolation are attractive concepts, when we consider real-world design conditions the situation loses some of its clarity. Rarely in design does one know or not know the terminal point but, rather, one has some information about it; it is a matter of degree. In some kinds of design one knows exactly where one will end up, in others one has very little idea.

Bartlett's other mode of productive thought, adventurous thinking, is less clearly defined than thinking in closed systems. In this mode of thought the repertoire of elements which can be considered is not prescribed. Indeed, adventurous thinking often depends for its success upon elements not normally related being brought together in a new way, hence its adventurous nature. Yet again, however, the distinction between adventurous thinking and thinking in closed systems becomes blurred when applied to design situations. It is certainly possible to find examples of closed system problems in design if we look for them. The problem of arranging tables and chairs in a restaurant certainly requires thinking in closed systems. Often, however, such examples do not bear too close an examination for rarely does the designer work exclusively with a kit of parts. If a particular arrangement of tables will not fit, the designer may often be free to try different sizes or shapes of tables or even alter the shape of the restaurant! Thus the ensemble of elements in design problems is usually neither entirely closed nor entirely open. In fact we often recognise a creative response to a design problem as one where the designer has broken free of a conventionally restricted set of elements. Thus the rigid imposition of closed systems as in the case of system-building is seen by many designers as a threat to their creative role.

Throughout much of the literature on productive thought we find a variety of closely related binary divisions between, on the one hand, rational and logical processes and, on the other hand, intuitive and imaginative processes. These two major categories have become known as convergent and divergent production (Fig. 8.1).

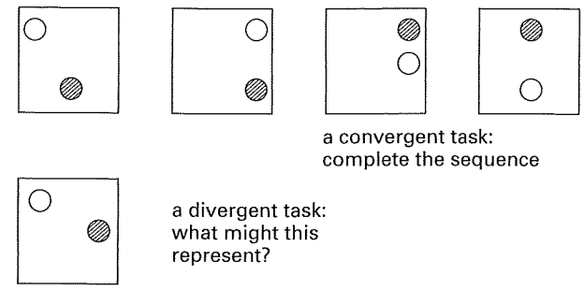

Figure 8.1
Convergent and divergent thinking

Typically the convergent task requires deductive and interpolative skills to arrive at one identifiably correct answer. Convergent ability is measured by many of the conventional IQ test problems and has been associated with ability in science. The divergent task demands an open-ended approach seeking alternatives where there is no clearly correct answer. Divergent ability can be measured by tests mistakenly called creativity tests such as 'how many uses can you think of for a brick' and divergent ability has been associated with skill in the arts. As we shall see in the next chapter these two ideas have frequently been grossly oversimplified and variously confused with intelligence and creativity. Guilford and others treat convergent and divergent thinking as separate and independent dimensions of ability which can occur in any proportions in an individual. Guilford (1967) maintains that, although few real-world tasks require exclusively convergent or divergent thought, the distinction is still valid and useful.

From our analysis of the nature of design problems it is obvious that, taken as a whole, design is a divergent task. Since design is rarely an optimisation procedure leading to one correct answer, divergent thinking will be required. However, there are likely to be many steps in any design process which themselves pose convergent tasks. True, such steps may eventually be retraced or even rejected altogether, but it would be absurd in the extreme to pretend that there are no parts of design problems which are themselves amenable to logical processes and have more or less optimal solutions. Design clearly involves both convergent and divergent productive thinking and studies of good designers at work have shown that they are able to develop and maintain several lines of thought in parallel (Lawson 1993a). However, the relationship between diverging, converging and parallel lines of thought is something we must leave until much later.

References

Bartlett, F. C. (1932). *Remembering*. Cambridge, Cambridge University Press.
Bartlett, F. C. (1958). *Thinking*. London, George Allen and Unwin.
Berlyne, D. E. (1965). *Structure and Direction in Thinking*. New York, John Wiley.
De Groot, A. D. (1965). *Thought and Choice in Chess*. The Hague, Mouton.
Fodor, J. A. (1975). *The Language of Thought*. Cambridge, Mass., Harvard University Press.
Garner, W. R. (1962). *Uncertainty and Structure as Psychological Concepts*. New York, John Wiley.
Goel, V. (1995). *Sketches of Thought*. Cambridge, Mass, MIT Press.
Guilford, J. P. (1956). 'The structure of intellect.' *Psychological Bulletin* **53**: 267–293.
Guilford, J. P. (1967). *The Nature of Human Intelligence*. New York, McGraw Hill.
Koestler, A. (1967). *The Ghost in the Machine*. London, Hutchinson.
Lawson, B. R. (1972). *Problem Solving in Architectural Design*. University of Aston in Birmingham.
Lawson, B. R. (1993). 'Parallel Lines of Thought.' *Languages of Design* **1**(4): 357–366.
Markus, T. A. (1969). 'Design and research.' *Conrad* **1**(2).
Miller, G. A., Galanter, E. et al. (1960). *Plans and the Structure of Behaviour*. New York, Holt Rinehart and Winston.
Mueller, R. E. (1967). *The Science of Art (the cybernetics of creative communication)*. London, Rapp and Whiting.
Murphy, G. (1947). *Personality: a biosocial approach to origins and structure*. New York, Harper and Row.
Neisser, U. (1967). *Cognitive Psychology*. New York, Appleton Century Crofts.
Newell, A., Simon, H. A. et al. (1958). 'Elements of a theory of human problem solving.' *Psychological Review* **65**(3).
Ryle, G. (1949). *The Concept of Mind*. London, Hutchinson.
Thorndike, E. L. (1911). *Animal Intelligence*. London, Macmillan.
van Bakel, A. (1995). *Styles of Architectural Designing: empirical research on working styles and personality dispositions*. Eindhoven, Technical University of Eindhoven.
Wertheimer, M. (1959). *Productive Thinking*. New York, Harper and Row.

9

Creative thinking

It is a well known fact that all inventors get their first ideas on the back of an envelope. I take a slight exception to this, I use the front so that I can incorporate the stamp and then the design is already half done.

Roland Emett

Genius is one per cent inspiration and ninety-nine per cent perspiration.

Thomas Alva Edison

What do we mean by creativity?

Most people would describe design as one of the most creative of human pursuits. The so-called creative arts include musical composition, painting, sculpture and the various forms of two- and three-dimensional design. However, creativity and creative thought can be applied just as much in science, medicine, philosophy, the law, management and many other fields of human endeavour. In the creative arts, including design, the whole point of the business is to create something which other people will experience and which is in some way or other original and new. No book on the thinking processes involved in design could be complete without some examination of the fundamentals of creativity and creative thought.

There is now a huge body of literature on creativity which has been studied extensively not only by psychologists but by philosophers and, more recently, by cognitive scientists and computer scientists. Some of our most profound insights into creativity also come from some famous and outstandingly creative people who have described and reflected on the processes involved. Then there are those who write about how to enhance or increase our creativity offering us techniques to use either as individuals or in groups.