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