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).

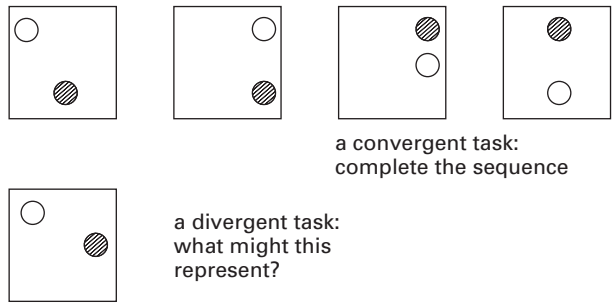

Figure 8.1
Convergent and divergent thinking

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.