4

Creative Cognition in Design I: The Creative Leap

Literature on creativity often emphasises the 'flash of insight' by which a creative idea is frequently reported to occur. The classic accounts of creative breakthroughs in science and mathematics, such as Kekulé's account of his insight into the structure of the benzene molecule, or Poincaré's accounts of his mathematical insights, suggest that creative thought is characterised by such acts of sudden illumination (Koestler, 1964). Wallas (1926) incorporated this view into a general model of the process of creative problem-solving, which consists of the four stages of preparation, incubation, illumination and verification. This model is still accepted as valid today, and the concept of sudden 'illumination' as representing creative thought is so widely understood that cartoonists use a lighted lightbulb as a universal symbol for someone suddenly having a 'bright idea'.

Similarly, in engineering and design, significant innovations or novel design concepts are often reported as arising as sudden illuminations (Maccoby, 1991). The idea of 'the creative leap' has for some time been regarded as central to the design process (Archer, 1965). Whilst a 'creative leap' may not be a required feature of routine design, it must surely be a feature of non-routine, creative design. Some would argue that all design, by its very nature, is creative. However, there are times when a designer will generate a particularly novel design proposal, and there is evidence that the level of 'creativity' of a design proposal can be reliably assessed, at least by peer-groups (Amabile, 1982; Christiaans, 1992). In this case, creative design is related to product-creativity, rather than process-creativity.

In some other fields, the 'creative leap' is characterised as a sudden perception of a completely new perspective on the situation as previously understood. This is the basis of Koestler's (1964) model of 'bi-sociation' to explain the 'creative leap' for example in humour. In creative design, it is not necessary that such a radical shift of perspective has to occur in order to identify a 'creative leap'. There might

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be no unexpected dislocation of the solution space itself, but merely a shift to a new part of the solution space, and the 'finding' there of an appropriate concept. This is what characterizes creative design as exploration, rather than search. Unlike bi-sociation, creative design is not necessarily the making of a sudden 'contrary' proposal, but is the making of an 'apposite' proposal. Once the proposal is made, it is seen to be an apposite response to the given, and explored, problem situation.

In this chapter, creative design is therefore regarded as the apposite proposal of a concept which embodies novel features for a new design product. Such a proposal may or may not arise as a sudden 'flash of insight', but it will constitute a 'creative leap' across the gap between the functional design requirements and the formal design structure of a potential new product. We shall see that the creative cognitive act in design appears to be not so much taking a leap as building a bridge between problem requirements and solution proposal.

An Example of a Creative Leap

This example of a 'creative leap' occurring in a design context comes from one of the protocol analysis studies used in the Delft Design Protocols Workshop (Cross *et al.*, 1996). This Workshop was based on a set of analyses made by different researchers around the world, of the same selected videotape recordings and transcripts of experimental design sessions. Two such experimental sessions were used in the Workshop; one using the 'think aloud' protocols of an individual designer, and the other using the naturally-occurring interactions of a small team of three designers (identified anonymously in the transcripts as I, J and K). The same design problem was set both to the individual designer and the team: the design of a carrying/fastening device for mounting and transporting a hiker's backpack on a mountain bicycle. This device would be something like a special bicycle luggage rack.

A 'creative leap' seems to have occurred as a sudden illumination in the team's design process, at a point when one of the team members, Designer J, suggests the following design concept: *'maybe it's like a little vacuum-formed tray'*. This tray idea is quite quickly taken up by the team, and the other members collaborate in developing the concept into a fully-fledged design. A transcript of the session at the period around the 'creative leap' is given in Appendix A. Their resulting design proposal is shown in Figure 4.1. The proposal is for a plastic tray, positioned over the rear wheel of the bicycle, with metal mounting points onto the saddle tube and onto the rear wheel frame tubes, and with cross-over straps to hold the backpack in the tray.

Records of their own work were kept by the team in the form of sketches on paper, and lists compiled on the whiteboard. They began by attempting to list a 'functional specification' and the problem constraints, and to this was added later a list of features that they intended their product to have. All these items were derived from the brief and related information provided in the experiment. They then developed the problem into three sub-problem areas: 1. the position of the rack device relative to the bicycle, 2. joining mechanisms between (a) the backpack and the rack and (b) the rack and the bicycle, 3. materials for making the rack.

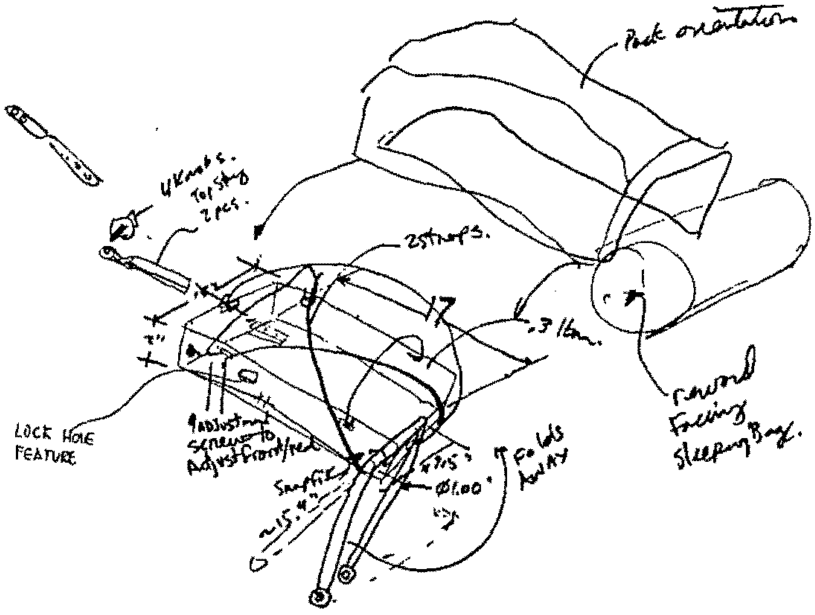

Figure 4.1. The team's design proposal

In each case, they explored problems and solutions together, by proposing concepts (sub-solutions) for each sub-problem and evaluating/discussing the implications and possibilities of each concept. For example, Appendix B is part of the transcript of the team's discussion of the 'rack-to-bike' joining problem. This shows how their thoughts about the positioning of the rack and its supports to the bicycle frame raise issues such as riding stability, ergonomics of use, weight of a full backpack, and user behaviour. In general, they argue from form to function, rather than *vice versa*.

One of the significant issues that arises in this way is that the backpack's own shoulder straps, *etc.*, become hazardous if they dangle into the bicycle wheel. After generating their random concept-lists, the team then review each list to eliminate unsatisfactory concepts and identify their preferred ones. As they go through the pack-to-rack list, the 'bag' concept is stressed as a solution for holding all the loose straps, and then the 'tray' concept suddenly appears, as the transcript shows:

> I: Bag; put it in a bag; we're gonna need some sort of thing to do something with those straps
>
> K: To get this out of the way
>
> J: So it's either a bag, or maybe it's like a little vacuum-formed tray kinda for it to sit in

I: Yeah, a tray, that's right, OK

J: It would be nice, I mean just from a positioning standpoint, if we've got this (backpack) frame outline and we know that they're gonna stick with that, you can vacuum-form a tray

I: Right, or even just a small part of the tray…

K: Something to dress this [straps] in

J: Maybe the tray could have plastic snap features in it, so you just like snap your backpack down into it

K: Snap in these [backpack] rails

J: It's a multi-function part

K: You just snap in these rails

J: Yeah, snap the rails into the tray there

I: OK

J: It takes care of the rooster-tail problem …

In this 1-minute segment, we see the key concept, the tray idea, being proposed, accepted, modified, developed and justified. As well as securely holding the backpack, the proposed concept solves two particular problems: the dangling straps problem and the 'rooster-tail' problem – *i.e.* the water/mud spray (like a rooster tail) thrown up by a mountain bicycle wheel, which would dirty the backpack unless it is protected. The conceptual strength of the tray idea seems to lie in the way it embodies a potential solution form that, once it has been expressed, recognisably satisfies certain key problems and also recognisably can be modified and refined to accommodate other problems and requirements in a satisfactory way. It is an 'apposite' proposal, as defined earlier.

But did the tray idea just come out of the blue? It was certainly the first instance of the use of the word 'tray' in the whole transcript, and from then on 'tray' is repeatedly used as the defining concept for the team's design proposal. (The word 'tray' subsequently occurs 35 times in the last 40 minutes of the transcript.) Possibly related concepts that had been mentioned earlier included references to injection-moulded plastic as a possible material, and flat plastic forms for the rack device. In fact, nearly 20 minutes earlier than the tray idea was first expressed, it's originator, Designer J, referred to a similar kind of rack idea that he recalled:

J: It looks like everything we're looking at right now is wire-form, but actually a friend of mine suggested a product that he would do – an injection-moulded rack that would kind of like fold down – a couple of years ago...

Another team member immediately responded with recalling a similar device that he remembered:

> I: It's like the little rack that was flat, it had these panels... but these panels were solid, it had little wheels... and it would come off and then it would be like a little trailer

Designer J also suggests another kind of flat plastic panel solution a few minutes later:

> J: I think that a super simple solution – might not be strong enough though - if you can imagine just taking a piece of like propylene or something like that, and diecutting this triangle that you can fold, you know, like a cutout from a pop-up book or whatever, and it bolts on down there, and creates a flat surface... kind of acts as a mudguard too

So ideas related to the device as a flat sheet of plastic, which would also act as a mudguard, were being suggested shortly before the appearance of the concept embodied in the apparent creative leap. The significant difference seems to be expressing this concept as a 'tray' – *i.e.* a flat surface with a raised lip around its circumference. (Proposing this as 'vacuum-formed' was also the first time this manufacturing process was mentioned, but as the concept is developed, the manufacturing process reverts to being injection-moulded.) The 'tray' concept summarises, in an envisionable form, a recognisably good solution, in a way that is significantly different from the potential concept of a 'flat', 'folded', 'panel'. The key difference seems to be related to perceiving a tray as a container (like a bag), whereas the previous concepts had only identified a flat surface.

As the earlier transcript extract showed, the first emergence of the tray concept seems to be immediately recognised and accepted by the team as a good concept. However, they return to their discipline of checking-off the other concepts that they had generated. But Designer J is careful to insist that the new concept of 'tray' is added to the list:

> J: I think tray is sorta, a new one on the list, it's not a sub-set of bag...

Very shortly afterwards, as they conclude this stage of their design process, Designer J also makes clear his commitment to the tray concept:

> J: I really like that tray idea ... I think all design eventually comes down to a popularity contest

The ways in which persuasive tactics are used by members of the team to get their own preferred concepts adopted, such as expressing emotional commitment to them, have been referred to in more depth elsewhere (Cross and Clayburn Cross, 1995). The emotional content of creative thought, in the context of computational modelling, has also been stressed by Gelernter (1994).

To summarise how this 'creative leap' emerged, we can see that it draws upon earlier notions that, in retrospect, seem very similar – a flat, folded surface in plastic material – but which lacked the apparently critical feature of 'containment' that a 'tray' has: its generation is perhaps aided by the immediately prior consideration of a more extreme form of containment, a bag; it seems to focus on one particular problem (containing the straps) as the most significant consideration; it is quickly elaborated to satisfy a range of other problems and functions; it is recognisably a bridging concept between problem and solution, which synthesizes and resolves a variety of goals and constraints; and it occurs during a 'review' period, after earlier periods of more deliberately generating concepts and ideas.

Identifying the Leap

The Delft Protocols Workshop was concerned with analysing design activity across a broad spectrum of approaches; it was not concerned specifically with analysing creativity, for example. Of the twenty Workshop papers, ten analysed in some form the team experiment, but none of these concentrated specifically on the 'creative leap' identified above. However, some of the analyses of design activity in these papers provide evidence which identifies when the 'leap' occurs, and its significance in the design process of the team.

Most analyses of the team design process in the Delft Workshop do not indicate how the tray concept originated, but some do reinforce the importance of this concept as marking a key point in the process. For example, Günther *et al.* (1996) classified the team's protocol statements into pertaining to three major stages of a design process: clarifying the task, searching for concepts and fixing the concept. Their resulting chart (Figure 4.2) suggests how the tray concept, which occurred at around 78 minutes, effectively ended the 'searching for concepts' stage. Similarly the graph produced by Maziloglou *et al.* (1996), of 'discourse production' (Figure 4.3), shows how the team's discourse (verbal statements made) peaked in the 'solution' related category in the period around the emergence of the tray concept. Radcliffe's (1996) analysis of the shifting 'work loci' (Figure 4.4) also shows how the focus shifts at around 80 minutes, from handling artefacts (principally the backpack and bicycle provided for the team) and listing on the whiteboard, to developing the final design, largely through sketches.

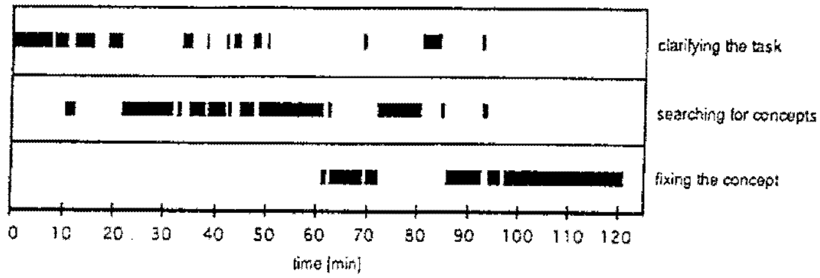

Figure 4.2. Principal phases of the team's design process, identified by Günther *et al.* (1996)

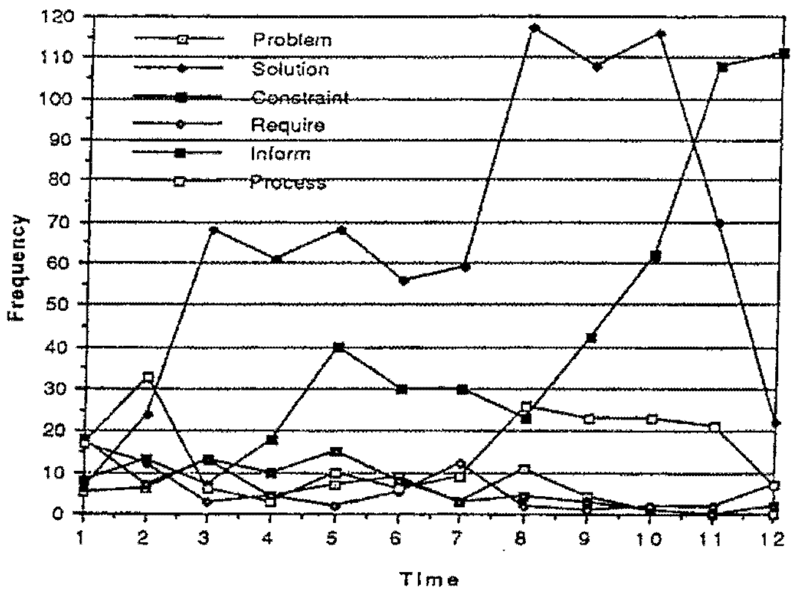

Figure 4.3. The team's discourse production over time (10-minute intervals), identified by Mazijoglou *et al.* (1996)

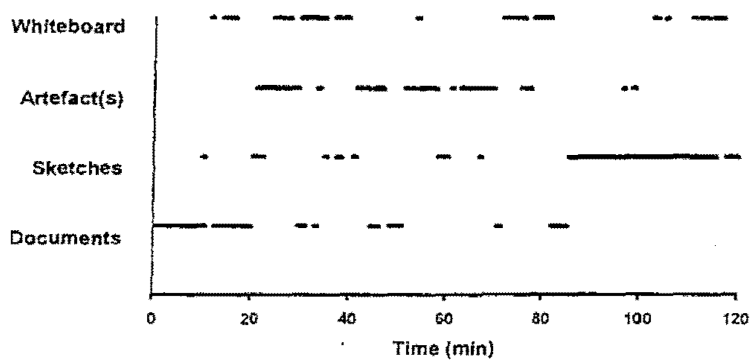

Figure 4.4. The team's shifting work loci over time, identified by Radcliffe (1996)

An analysis which came closer both to tracing the 'history' of the tray concept and indicating its important role was that by Goldschmidt (1996). Her 'linkograph' of the relevant section of the team protocol is shown in Figure 4.5, where J's 'tray' statement is number 30. The linkograph shows how each statement (or 'move') is linked (by a 'common sense' analysis of relationships between statements) to others. Statement 30 in this particular group is identified as a 'critical move', *i.e.* one which has a relatively high number of links to other statements that succeed it. Goldschmidt identifies this set of statements around statement 30 as a particularly 'productive' phase of the team's design activity, relatively rich in interlinks between statements. Again, her analysis does not explain how the significant 'tray' concept came to be generated, but her analysis confirms it as a statement that is very influential.

The linkograph shows a highly-interconnected 'chunk' of statements, from statements 28 to 54. Statement 28 is Designer I's suggestion to 'put it in a bag'; statement 54 is Designer J's insistence that 'tray is sorta, a new one on the list, it's not a sub-set of bag.' In that short period (2 minutes) we see that the tray concept somehow generates a highly productive, cognitively rich sequence of interacting statements, with the team members building on each other's ideas. (The full transcript of statements 28-54 is that given in Appendix A.)

Statement 30 ('maybe it's like a little vacuum-formed tray') does appear to come 'out of the blue' – it has just two 'back-links' in the linkograph, to the immediately preceding statements. (Other 'back-links', for example earlier references to flat, plastic devices, are not shown in this particular, limited section from the full session.) Its importance, though, is clear in the relatively high number of 'fore-links' it has; *i.e.* subsequent statements that build onto, or refer back to, this statement.

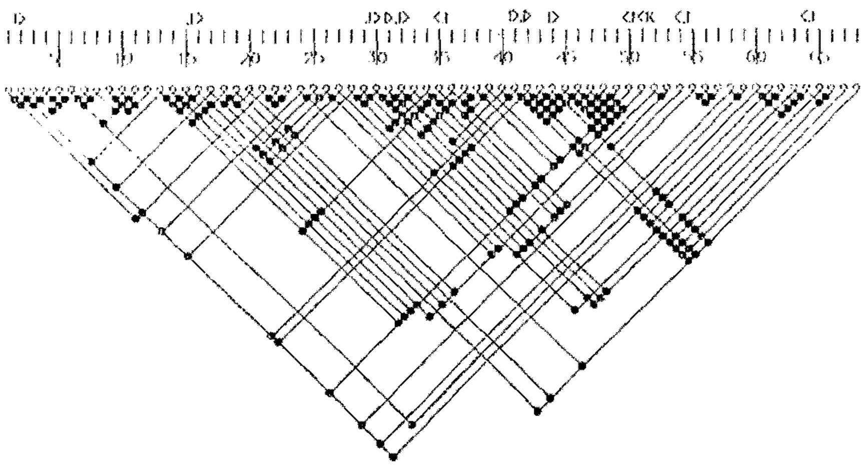

Figure 4.5. Linkograph of the team's design moves around the 'creative leap' (move 30), identified by Goldschmidt (1996)

Modelling the Leap

Research in artificial intelligence has attempted to model and simulate various aspects of design, including creative design. This section will draw from some of these attempts to model creative design, in order to see what insights they add to the previous example of a creative leap in the design process, and whether the example creative leap can be explained in computational modelling terms.

Rosenman and Gero (1993) and Gero (1994) suggested five procedures by which creative design might occur: combination, mutation, analogy, design from first principles, and emergence. In this section I will discuss how these procedures might be used to explain, or at least to shed some light on, the particular 'creative leap' example presented above. I will also discuss the possibilities and/or difficulties that there appear to be within computational modelling of providing adequate models of creative design through such procedures.

Combination

Creative design can occur by combining features from existing designs into a new combination or configuration. In the example of the 'tray' idea, relevant previous concepts that had occurred in the team's discussion were that of a flat plastic panel and a bag. It seems possible that the 'creative leap' occurred by a combination in the designer's mind of 'panel' + 'bag' to give 'tray' (Figure 4.6). In this case, 'tray' is not a new kind of artefact (trays already exist), but the combination of 'panel' + 'bag' in the designer's mind could have triggered an association with 'tray', as suggested by Figure 4.6. In the context of the team's design process, at that particular point, 'tray' was a novel concept.

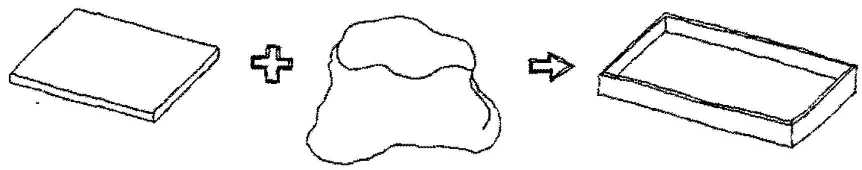

Figure 4.6. Possible combination of 'panel' plus 'bag' to give 'tray'

A more novel concept than a simple 'tray' might have arisen from the combination of 'panel' + 'bag'; for example, a bag with a normal, flexible upper part but a rigid, flat panel bottom (again, such artefacts do already exist). In fact, the team members do go on to propose developments of the tray idea which would have been more novel combinations of 'panel' + 'bag'. Immediately after the initial acceptance of the tray idea, Designer I articulates a concept of a net-like zippered container, which J develops into 'a tray with a net and a drawstring', and K (using analogy) further develops into the net as something like a retractable window blind:

> I: What if your bag were big, or, what if your, er, if this tray were not plastic, but like a big net, you just sorta like pulled it around and zipped there, I dunno
>
> J: Maybe it could be a part, maybe it could be a tray with a net and a drawstring on the top of it, I like that, that's a cool idea
>
> I: a tray with sort of just hanging down net, you can pull it around and zip it closed
>
> K: It could be like a window shade, so you can kinda, it sinks back in
>
> I: It retracts, yeah
>
> K: You pull down, it retracts in
>
> J: A retracting shade

In this sequence of the team's dialogue, we see how the initial (possible) combination of 'panel' + 'bag' ⇒ 'tray' becomes developed into a combination of 'bag' + 'tray' which leads to an original very novel concept of a tray with some form of retractable, net-bag container. (The lack of a familiar term to describe this device indicates its novelty.) This would have been perhaps a 'more creative' combination of 'panel' + 'bag' than the 'tray' concept. In the end, the team does not develop the retractable net-bag idea, but adds cross-over straps to the tray as a means of constraining the backpack.

The team seems to know how far to pursue novel combinations, before withdrawing to reconsider and start another line of reasoning. In computational systems it is difficult to know how to set such a limit; how does a system recognise that a satisfactory, or more-than-satisfactory concept has been created from combinations of previous concepts?

Mutation

Creative design by mutation involves modifying the form of some particular feature, or features, of an existing design. In computational systems, features may be selected and modified at random, and then evaluated, or there may be some directed procedure for selecting and modifying particular features. In the natural design process, it seems more likely that the latter procedure would operate.

In our example, a mutation procedure might conceivably have happened, transforming a flat panel into a tray (Figure 4.7). If Designer J was thinking of the inadequacies of a flat panel (*e.g.* it doesn't securely contain the backpack), he could have thought of putting a raised lip around the edges of the panel, giving rise to the concept of a tray. Designer K's earlier sketch (see Figure 4.10a, and the discussion of 'emergence', below) may also have been influential in suggesting such a mutation. We do not know what cognitive processes gave rise to J's 'creative leap', but it does seem that a mutation procedure could have generated 'tray' from 'flat panel'.

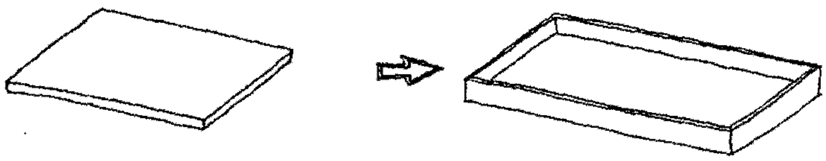

Figure 4.7. Possible mutation of 'flat panel' into 'tray'

The difficulty in computational modelling is identifying which structural features of the existing design to select for modification, and what kinds of modification to apply. In this case, to reproduce 'flat panel' ⇒ 'tray', it would have been necessary to identify the panel edges as relevant features, and to modify them by thickening and/or extending them out of the surface plane of the existing design. The mutation procedure would have to have been based on recognition of the inadequate behaviour of a flat panel in relation to the function of 'containment'.

Analogy

The use of analogical thinking has long been regarded and suggested as a basis for creative design (Gordon, 1961). We have already seen, in the extract above, how 'window shade' is used as an analogy to help describe (if not necessarily to generate) a concept of a retractable net-bag. The 'tray' idea does seem to originate in close association with the 'bag' idea. Designer J says, 'So it's either a bag or maybe it's like a little vacuum-formed tray, kinda, for it to sit in,' which suggests that he thinks of 'tray' as an alternative to 'bag' for the backpack to 'sit in'. This strongly suggests an analogical procedure 'bag' ⇒ 'tray' (Figure 4.8), based on thinking of analogues to 'bag' for something to 'sit in', to be contained and carried.

The difficulty for computational modelling based on analogy is in abstracting the appropriate behavioural features of an existing design. In this example, a bag's behavioural features of enclosing and carrying are apparently selected as relevant, whereas other behaviours such as flexibility are not. Furthermore, it would seem that partial-enclosure (such as in a tray) is more relevant than full-enclosure (as in a bag); about 20 minutes earlier in the session, before the 'tray' idea, J had suggested 'maybe it's a little bucket that it sits in,' but this was ignored by the rest of the team and apparently soon forgotten. 'Bucket' is more 'bag-like' than 'tray', but was apparently not deemed to be an appropriate analogy.

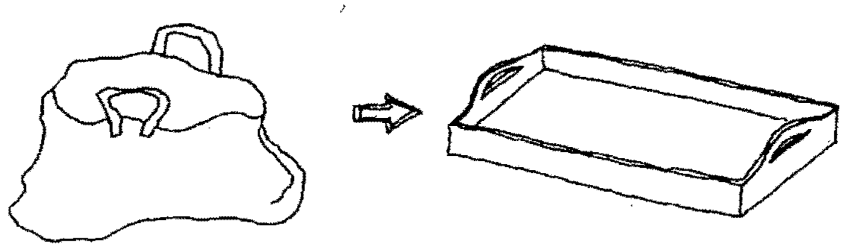

Figure 4.8. Possible analogy of 'bag' with 'tray'

First Principles

Designing 'from first principles' is often advocated as a way of generating good and/or creative designs (French, 1994). The difficulties for both artificial and natural design processes are in identifying what exactly the 'first principles' may be in any design situation, and how they may be used to generate design concepts. The example given by Rosenman and Gero (1993) is Peter Opsvik's design of the novel 'Balans' chair from the 'first principles' of the ergonomics of sitting posture. But what are the 'first principles' for 'a carrying/fastening device for mounting and transporting a hiker's backpack on a mountain bicycle'?

Perhaps we see an attempt at design from first principles in the sketch produced very early in the team's session by Designer K. This is reproduced as the left-hand side of Figure 4.9. K makes this sketch of 'backpack + accessory + bicycle' as though it is a personal attempt to represent the design problem – she does not draw it to the attention of the rest of the team, and it plays no overt role in the design process. However, perhaps it does express the 'first principles' of the design problem, and perhaps it does embody a 'tray-like' solution concept. Designer K later sketched such a solution concept, as discussed below.

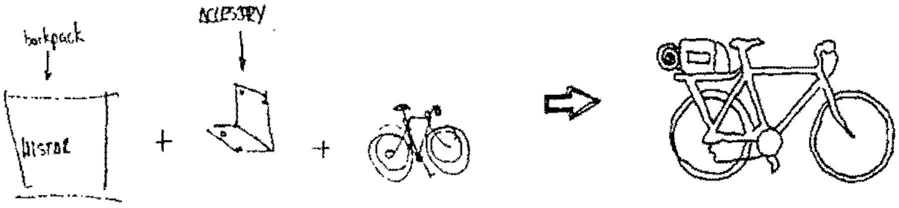

Figure 4.9. Possible inference of design from first principles

Designing 'from first principles' is at the core of any significant understanding of design. It assumes the theoretical position that designing proceeds by identifying requirements, or desired functions, and arguing from these to appropriate forms or structures. It is the abductive leap of reasoning from function to form that is regarded as the kernel of design (Roozenberg, 1993). But in practice, as we have seen in the extracts from the design team's protocols, and has been suggested by others (March, 1976), designers usually proceed by suggesting 'protomodels' of forms or structures, and evaluating these in order to amplify the requirements or desired functions. Takeda *et al.* (1996), in their analysis of the team protocol, showed how functions, as well as structures, develop and evolve during the course of the design process. The 'function' of a product to be designed is not, therefore, a static concept, a 'given' at the start of the design process.

Emergence

Emergence is the process by which new, previously unrecognised properties are perceived as lying within an existing design. Within the artificial intelligence community it has been discussed particularly with reference to the recognition of emergent, or extensional, shapes within the original, intentional shapes (Gero, 1994). However, emergent behaviours and functions, as well as emergent structures, are recognised by designers. For example, Designer J apparently recognises the emergent behaviour of protection from the 'rooster tail' spray in the tray concept, and adds that as a further validation of the concept.

In our example, it is difficult to know whether the 'tray' idea occurred as a case of emergence. In this context, it is interesting that Designer K had made a sketch quite early in the session (around 40 minutes) of what could be a design proposal which has a strong 'tray-like' resemblance (Figure 4.10a). As with her possible 'first principles' sketch, K does not publicly offer this sketch to the team, but makes the sketch whilst the other two team members are engaged in another activity. However, the other two certainly become aware of the sketch later, because they both use it (at around 60 minutes) to overdraw on it some different features – Designer J draws some adjustable stays onto it, and Designer I draws the wheels of his fold-down 'trailer' onto it. Designer I had just previously sketched the 'trailer' concept (Figure 4.10b).

Therefore it would be possible to speculate that 'tray' emerged as a structure from either Designer K's sketch or the previous concept of 'trailer' (Figure 4.10).

However, there is no real evidence for this. If it did, then the emergence procedure would seem to have been one of recognising the box-like structures in the sketches and converting that to a shallow box, *i.e.* a tray.

In anything other than flat-pattern, graphic or decorative design, emergence is not simply a matter of shape recognition. It involves recognising emergent behaviour out of structure, and/or emergent function out of behaviour. It therefore presents significant challenges in terms of computational modelling.

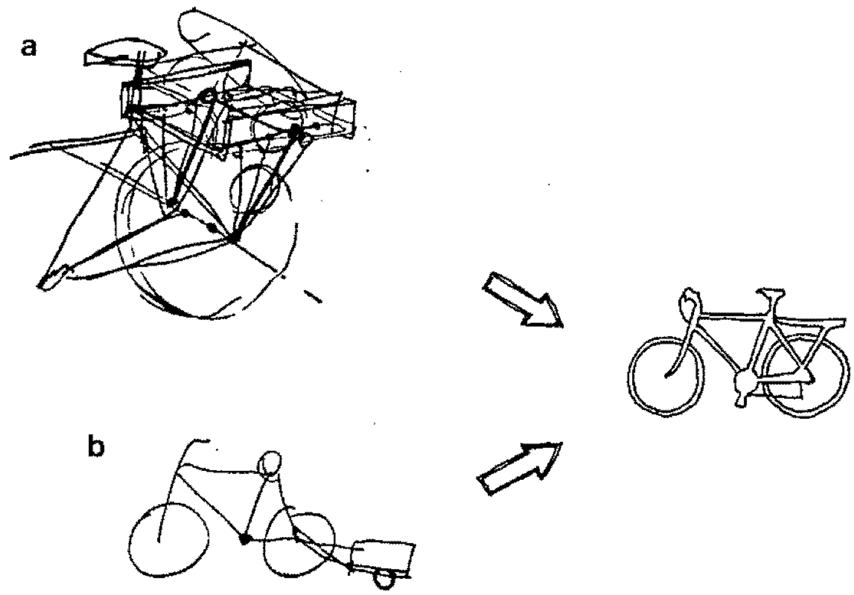

Figure 4.10. Possible inference of emergent concept from previous representations

Not Leaping but Bridging

This study of one example of a 'creative leap' in design has suggested that the example creative leap could conceivably be modelled by procedures such as combination, mutation, analogy, emergence, or designing from first principles. Because there is no overt record of the designers' cognitive processes, it is not possible to identify which, if any, of the creative procedures actually occurred in the example. However, if computational models of such procedures can be constructed, then progress is possible in computational modelling of creative design. Computational modelling of creative processes in the arts and sciences has had some reported success (Boden, 1990). The relative lack of progress in computational modelling of creative design may be due to the 'appositional' nature of design reasoning, in which function and form are developed in parallel, rather than in series.

The appositional nature of design reasoning has been neglected in most models of the design process. Consensus models of the engineering design process (Cross and Roozenburg, 1992), such as that promulgated by Verein Deutscher Ingenieure (VDI, 1987), the German professional engineers' association, propose that designing should proceed in a sequence of stages, like the stage-process adopted by the team studied here. They propose that a product design specification and a function structure should be developed before the search for solution principles and the generation of a principal solution. They also propose that the overall problem should be decomposed into sub-problems, and then sub-solutions found and combined into an overall solution. This is what the team attempted. However, as we have seen, exploration and identification of the complex network of sub-*problems* in practice is often pursued by considering possible sub-*solutions* (illustrated by the transcript extract in Appendix B).

In practice, designing seems to proceed by oscillating between sub-solution and sub-problem areas, as well as by decomposing the problem and combining sub-solutions.

During the design process, partial models of the problem and solution are constructed side-by-side, as it were. But the crucial factor, the 'creative leap', is the bridging of these two partial models by the articulation of a concept (the 'tray' idea in this example) which enables the partial models to be mapped onto each other. The 'creative leap' is not so much a leap across the chasm between analysis and synthesis, as the throwing of a bridge across the chasm between problem and solution. The 'bridge' recognisably embodies satisfactory relationships between problem and solution. It is the recognition of a satisfactory concept that provides the 'illumination' of the creative 'flash of insight'.

This recognition is a perceptual act by the designer (and by his colleagues, in this example of teamwork), and our knowledge of perceptual 'puzzles' can perhaps provide analogies of the process. For example, the recognition of a proposed design concept as embodying both problem and solution together may be regarded as something like the well-known duck-rabbit puzzle (Figure 4.11); it is neither one nor the other, but a combination which resolves both together and allows either to be focused upon. Suggesting that 'Maybe it's a little vacuum-formed tray' is rather like saying 'Maybe it's a duck-rabbit'. Can computational models of creative design recognise a duck-rabbit when they see one?

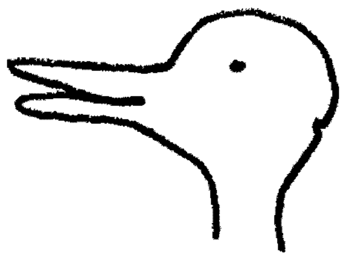

Figure 4.11. The duck-rabbit perceptual puzzle

Appendix A: Transcript of the discussion at the time of the 'creative leap'

I we'll just call it that for now er bag put it in a bag we're gonna need some sort of thing to do something with those straps
K to get this out of the way
J yeah
I yeah either the
J so it's either a bag or maybe it's like a little vacuum formed tray kinda for it to sit in
01:19:00
I yeah a tray that's right OK
J 'cos it would be nice I think I mean just from a positioning standpoint if we've got this frame outline and we know that they're gonna stick with that you can vacuum form a a tray or a
I right or even just a small part of the tray or I guess they have these
K so something to dress this in
J yeah
I or even just em
J maybe the tray could have plastic snap features in it so you just like kkkkkk snap your backpack down in it
I mmmm I was thinking of er
K snap in these rails
J it's a multifunction part huh
K you just snap in these rails
J yeah snap the rails into the tray there
K mm mm
I OK
J it takes care of the easy it takes care of the rooster tail problem on your pack
I uh uh what if your bag were big er what if you're you're on er in this tray were not plastic but like a big net you just sorta like pulled it around and zipped there I dunno
J maybe it could be part maybe it could be a tray with a with a net and a drawstring on the top of it I like that
I yeah I mean em
J that's a cool idea
I a tray with sort of just hanging down net
01:20:00
you can pull it around and and zip it closed
K it could be like a a a window shade so you can kinda it sinks back in so it just
J oh yeah
I it retracts yeah
K you pull down it retracts in
J a retracting shade
I right right

K so that that's not dragging in the spokes if you don't have anything attached

J so what we're doing right now though is we're coming up with like again classifications of solutions of kind of all they're all either or things I mean like we wouldn't do the net and the shade and the snap in with the tray either or any one of those will probably

I yeah OK

K a net can be combined with a shade I mean you could have a retractable net that that's how I thought of it

I so we I think the issue that we're talking about is is straps so we'll just keep that one on the burner

K yeah maybe there's some cool innovation there

J well yeah OK

I OK now er it had er has er

J I think tray is sorta a new one on the list it's not a subset of bag it's a kind of er yeah but oh yeah yeah yeah oh I see shade straps is how do you dress the straps on the back

I yeah yeah OK

Appendix B: Transcript of part of the discussion of joining 'rack to bike'

J um one of the things I was thinking that if you did this one of the things that could be neat is people were talking about like centre of gravity and I think that it'll be

00:46:00

different for different people what their preference is a little bit

K mm mm

J like where they want that mass maybe the if there's a thing that comes down to here you could have it so that it adjusts so you could kinda lever the pack up or down a little bit y'know if it's not a a fixed

K seems like lower is better regardless as you say like we design in the low position and not necessarily try and get

I you're gonna have um

K the adjustability

I is there gonna be an issue of the height of this I mean

J what about clipping under the bottom of the seat

I yeah or even the the seat post neck

J oh these things yeah

K the other thing we ought to be concerned about ergonomically is that when you're at the bottom of your stroke your leg is is right in here you want to make sure you don't get too close to the seat

J so you need to you need to come back from that

I or

K not too far back

I lower back

K yeah it's just one thing I've noticed when I put stuff on a big bike rack and it's sticking out kinda like a tent back here

I yeah it'll bend to your legs yeah

K then the back of my legs I can feel it

J I mean what what how much weight do you think somebody could realistically put in that pack

K probably thirty fifty

00:47:00

thirty pounds

J fill it with sand

I is that information we have access to um

J yeah what's typical weight that people carry in a backpack

I do we have information about what er weights are that people might carry in a backpack or

J have they done any market surveys

I market surveys about

Experimenter We do have some facts on the use of the backpack here

J OK – fiftyfive and sixtyfive litre versions of the backpack

K twentytwo kilograms

J so fortyfive pounds fifty pound yeah

K including sleeping bag oh so I suppose that's an issue too when you put this thing on

I oh yeah

K you want to make sure that that is

J still fits

I (inaudible)

J it says people are generally going to put that at the base of the pack

Nigel Cross

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