

AID'02 ARTIFICIAL INTELLIGENCE IN DESIGN 2002

Cambridge, UK, July 2002

5,8 ANALOGIES PER HOUR

A designer's view on analogical reasoning

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Abstract. Several studies have pointed out *that* analogy is used in architectural design. By contrast, this paper reports a study that sheds more light on *how* this use actually takes place, i.e. at what point in the design process, for what purpose, in what range, etc. In order to study these questions, 3 architects were asked to design the interior of a sailing yacht while being exposed to material on small spaces, whether or not related to boats. Analysis of these design sessions unmasks analogical reasoning as a concrete, often spontaneous, and generally profitable design strategy that is used frequently, if not constantly throughout the design process.

1. Introduction

Throughout the design literature, analogy has been ascribed a key role in the design of architectural masterpieces (Broadbent 1973, 1980; Lawson 1994; Rowe 1982). Examples can be found in the oeuvre of no less than Frank Lloyd Wright, Rem Koolhaas and Gerrit Rietveld – to name only a few. The columns of Wright's Johnson Wax building, for instance, would have been shaped by analogy to water lilies, while Koolhaas' project for the Sea Trade Terminal in Zeebrugge suspiciously looks like a bollard to moor ships at the quay. Rietveld's Schröder House in Utrecht, for its

part, strongly resembles a Mondriaan painting, both in the formal delineation of its façade and in its interior plan.

Whether based on water lilies, a bollard or a Mondriaan, the use of analogy in architecture is typically discussed because of the added value it gives to the building, in other words because of the design product. To our knowledge, however, this use has rarely been considered from the perspective of the design process. Therefore, through an experiment, this paper will try to depict the use of analogy in architecture from the point of view of an architect being involved in designing. For instance, when/at what point in the design process do architects resort to analogy? Why do they resort to it, and in what context? Do they use the analogy deliberately or spontaneously, and what (if any) are the differences between both? Under what conditions does the analogy lead to success and under what to failure? These and other questions are addressed in the experiment reported below.

After a short introduction to analogy and an overview of related research, the paper will describe the setting and procedure of the experiment, followed by the methodology and results of the analysis. It concludes with lessons learned from this experiment and topics for future research. The results of our experiment may shed a surprisingly new light on the CBR model as advocated in the early 1990s (Kolodner 1993).

2. Related research

2.1. ANALOGY

Derived from the Greek *ana logon* (“according to a ratio”), the term analogy originally denotes a similarity in proportional relationships, e.g. between two triangles that differ in scale (Britannica.com, 2001). In general, analogy can be defined as a likeness of relations, such as ‘A is related to B like C is related to D’, or in short, ‘A:B :: C:D’. Such likeness implies the existence of a higher-order abstraction that holds equally well for A:B (the *source* or *base*) and C:D (the *target*). In case of *within-domain* analogies, source and target stem from the same domain, whereas in *between-domain* analogies, source and target stem from different remote domains (Vosniadou and Ortony, 1989).

Obviously architects do not hold absolute sway over analogical reasoning. According to George Polya, analogy “pervades our thinking, our everyday speech and our trivial conclusions as well as artistic ways of expressions and the highest scientific achievements” (1973). Observations of these pervading analogies have inspired several theories,

which mainly differ in how they characterize the relationship between source and target. Some tend toward the ‘structural’ point of view, others towards a more ‘semantic’ one.

Dedre Gentner’s Structure Mapping Theory, for instance, considers an analogy as a mapping of knowledge from one situation onto another, supported by a system of syntactic relations that is transferred from the source objects to the target objects (Gentner, 1983; 1989).

By contrast, Keith Holyoak and his colleagues assert that analogical mapping is activated when trying to achieve a specific goal, and a source analog provides a more efficient solution procedure than on hand knowledge (Gick & Holyoak, 1980; Holyoak, 1991; Holyoak & Thagard, 1989). By consequence, mapping is directed entirely by the importance of the – largely semantic – predicates to one’s current goals, whereas structural principles play second fiddle.

2.2. IN ARCHITECTURAL DESIGN

In architecture, as in other design domains, design problems are typically ill-defined or wicked. This very wickedness makes reasoning by analogy a potentially powerful design strategy, as it can bring forth valuable knowledge from a known situation (the source A:B) to the ill-defined design situation at hand (the target C:D). Architects may reason and learn about their design by relating it to a more familiar situation that can be viewed as structurally or semantically parallel.

Empirical research on analogy in architectural design has focused primarily on the use of visual analogies. A case in point is the work by Gabriela Goldschmidt, who has pointed out that designers may identify visual displays as candidate source analogs and establish mappings through structural or surface relations (1994; 1995). In order to investigate the impact of such displays, a series of experiments was set up in which novice and expert architects were asked to solve various design problems, with and without exposure to visual displays, and with and without explicit requirements to use analogy (Casakin 1997; Casakin & Goldschmidt, 1999). The findings of these experiments suggest *that* visual analogy is used and across the board improves the quality of the design result, particularly in the case of novice designers. A question that remains largely unanswered, however, is *how* this use takes place.

Indeed, if we are to develop efficient design tools for architects, we must know more about analogy in architectural design than that it affects the quality of the result. We need to develop a more differentiated understanding of how, when and why architects resort to analogy during design. That is exactly what the following experiment tries to do.

3. Protocol of the experiment

Let us first describe the specific conditions of the experiment set up to open up the discussion on the questions mentioned above.

Recall that this experiment simply aims at placing some markers in the study of analogical phenomena in architectural design. Taking into account the sample (see 3.3 below), it is out of the question to identify through statistical analysis what parameters lead to success when designers resort to references external to the design problem in order to solve it. Instead our objective consists in generating elements of qualitative replies to the questions raised.

3.1. ASSIGNMENT

The assignment was purposely developed to place the subjects observed in a condition that forces them to resort to analogy during design. The duration of the experiment is limited to 3 or 4 hours; the objective is precise, limited in size and directly links up with the subjects' experience, yet it comes from an unusual domain: they are asked to design the configuration of the interior spaces of a sailing boat (yacht for 6 to 8 people, cruising on the Aegean sea).

The problems inherent to this type of design are closely related to problems in architectural design, in which the subjects are skilled. Yet, besides the exiguity of spaces, 2 constraints are completely new: the functions' overlap in 3 dimensions (see Figure 1) and, especially, the deterioration of the reference to a horizontal floor (when navigating, the sailing boat pitches in the direction of its route and lodges strongly on port or starboard), thus challenging the verticality and work in plan.

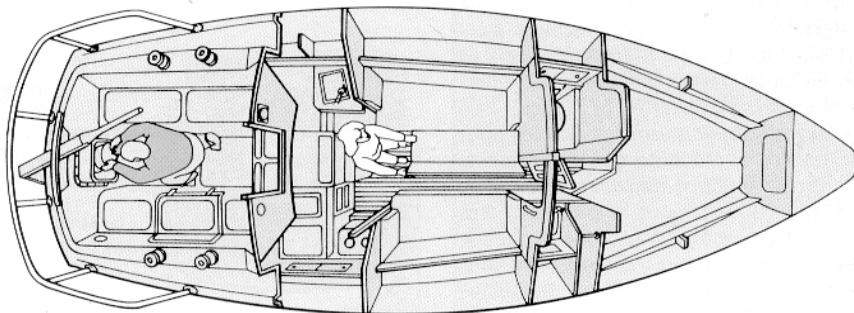


Figure 1: 3D overlap of functional spaces.

3.2. PROCEDURE

The experiment consists of 2 sessions, separated by 2 days.

During the 1st session, the assignment is presented to the subjects and observers (see 3.3 below). Some general and specific information is given, drawing the attention on the functional programme and the constraints specific to naval design. Subsequently the subjects have approximately one hour to study some documentation prepared in the context of this experiment (see Figure 2). This information mainly consists of marine images and technical files provided by manufacturers of sailing boats, but also comprises images from other fields: sleeping-car, shuttle, Spacelab, Soyuz, catamaran, etc. It is supplemented by plans, sections and a 3D model of the yacht to be designed.

The remainder of the 1st session is devoted to the actual design work. During 2 to 3 hours, each subject works on the development of a proposal for a spatial configuration, thereby drawing from all resources s/he considers necessary – whether they come from the initial oral recommendations, the documentation provided or any knowledge derived from the subject's personal experience. Of course, subjects are invited "to think aloud" so as to allow 2 observers to capture their train of thoughts. It is important to note that subjects and observers were involved in the practice of this particular type of exercise before, thus minimizing inevitable biases of the think aloud method.



Figure 2: Extract from the documentation provided.

The 2nd session is entirely devoted to the analysis of each subject's work. Under the direction of the 2 observers who compare their notes, subjects are invited to supplement, clarify or develop each action of their design. In particular, each episode during which an analogical transfer took place is depicted in terms of a series of criteria (origin, type, range, success, chaining, ...) that will be used later on in the overall analysis (see 4).

3.3. SUBJECTS AND THEIR OBSERVERS

The subjects are 3 last year students civil engineer architect of the University of Liège. As trained architects, they are no longer considered novices in designing interior spaces, nor in engineering as regards managing technical constraints. They are, however, not yet experts in their field; they do not control the market supply, or the detailed budgetary aspects of an architectural design. Yet, in the case of naval design, which interests us here, subjects find themselves, facing the new constraints, in a beginner's position. It is in this way that we push them to seek – in the documentation or in their personal experience – references to hook on to an adapted design strategy.

The 6 observers (2 per subject) are also last year students civil engineer architect. Sharing the same level of knowledge and know-how as the subjects, they are cut out to follow and re-transcribe the thoughts of their fellow students. If their role is to remain passive during the acquisition phase of the experiment, they are the principal actors in the analysis phase.

4. Proposal of a diagram of analogical thinking

We propose to describe each analogical transfer in terms of 9 specific parameters. Figure 3A summarises them in a diagram, which also presents their relations; Figure 3B illustrates them by a concrete example. With these Figures in view, let us define the different parameters.

The *target* (B) is the principal element of the analogy. It constitutes the object of attention and, in general, the problem to be solved. In our example (Figure 3B), it relates to the manual water pump in the kitchen corner. In a small sailing ship, there is no water under pressure, it should be pumped from the tank: the tap thus consists of a pumping lever.

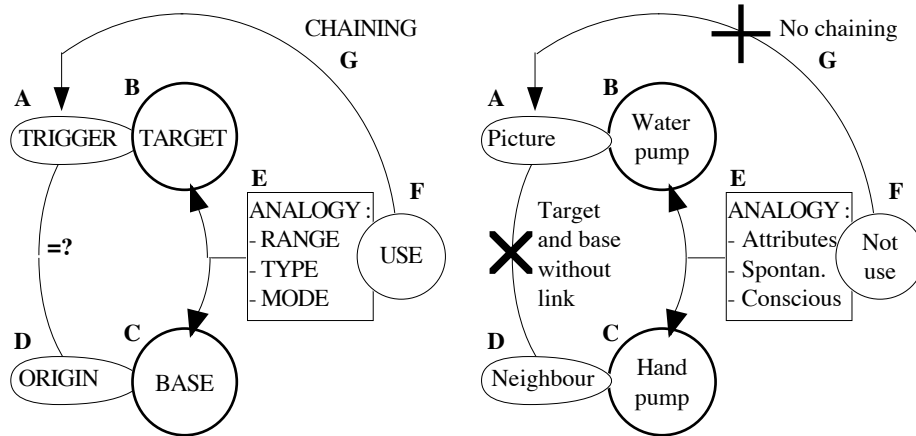


Figure 3A and 3B: Diagram and example of analogical thinking.

The *trigger* (A) relates to the context of the target. It often allows the subject to identify the latter and perceive it as the next target. In our example, the photographs of the kitchen corner, extracted from the catalogue of a naval manufacturer, acted as trigger. Without having seen these photographs, the subject would not have identified the problem of running water on board.

The *base* (C) is the extra-contextual reference the target is associated with. This base constitutes the structuring element of the knowledge that will be adapted to the target. In our example, the kitchen tap-pump is associated with a lift & force pump.

The *origin* (D) is the context of the base. This context gives the base more body as a solution, by adding surrounding knowledge. In our example, the origin of the lift & force pump is situated in the subject's personal memories: his neighbour uses such a pump to sprinkle his garden.

The actual analogy (E) is the phenomenon of association taking place between target and base. First of all we characterise the analogy according to its *range* (Figure 4): pairing can be achieved by associating objects (A1), object attributes (A2) or relations between objects (A3). Target and base are linked directly when, stemming from the same domain, they relate to the same object or object attribute (e.g. the subject derives the height under the ceiling of the square directly from a value seen previously in a technical file). Target and base are linked indirectly when, coming from the same domain, they relate to different objects (e.g. to determine the height under the ceiling of the square, the subject bases itself on the size of an individual). Target and base are extra-contextual when they result from different domains (e.g. in case of the water pump).

The analogy can also be indexed according to its *type*, i.e. according to whether it is spontaneous (it emerges automatically from the subject's thought) or controlled (the subject expresses a priori the will to associate a base with the target, then searches – sometimes explicitly – an origin, identifies the base and ends up applying a knowledge transfer).

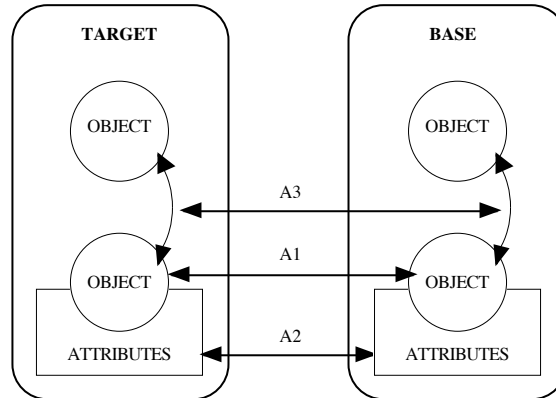


Figure 4: Range of an analogical association

In addition, it is sometimes possible to distinguish between conscious and unconscious analogies. We will refer to this as the *mode* of analogical transfer. In an unconscious mode, the subject, unlike the observers, is not even aware of the acquisition of tacit knowledge, nor of its implementation in the design process. In our example, the analogy between water pump and lift & force pump involved pairing an attribute (the shape of the lever of the 2 pumps) spontaneously and, since it was verbalised, in a conscious way.

The *usefulness* (F) of the analogy gives an account of its outcome. Did the operation lead to a success (the pairing allowed to solve the target-problem), to a failure (the adaptation between base and target field did not succeed) or to a non-use (the transfer took place, but brought nothing to the design process).

Finally, the phenomenon of *chaining* between analogies (G) allows tracking possible cascades of pairings. In these cases, the success of a first analogy establishes a new trigger, which in turn urges subjects into an analogical reflection to continue their work.

5. Quantitative results

Upon completion of the experiment, we thus disposed of the handwritten description of 3 complete design processes with, for each one, the sketches and final proposal drawn by the subject, the notes of the observers and the concerted list of "analogical thoughts", analysed according to the parameters defined above. Coding these data (for an example see Appendix 1) allowed us to compile them in a dozen easily accessible summary tables. Which observations can we make from these tables?

5.1. ON THE NUMBER OF ANALOGIES OBSERVED

Analysis of the 3 design sessions observed reveals between 12 and 17 instances of analogy during 2,5 hours of design (see Table 1). This corresponds to an average of one analogical thought every 10 minutes, which confirms the significant recourse to this design strategy. Apparently analogy concerns a frequent and permanent practice in architectural design, used on an operational and concrete level throughout the design process. This practice has nothing in common with the well-known surface and illustrative analogies – often exclusive and made up a posteriori – ‘justifying’ the finished design product.

TABLE 1: Number of analogies observed.

Subject	Number	Time [min]
Julien	12	12.5
David	15	10.0
Cécile	17	8.8
Σ and Mean	44	10.2

5.2. CHARACTERISTICS OF THE TRIGGER

Triggers are particularly difficult to capture (see Table 2): a good half of them is not identifiable in our experiment. This is of course due to the impossibility of accessing the subject's thoughts instantaneously, forcing the observers to follow only their expression.

With regard to the triggers known, half of them relate to the documentation we had provided the subjects. The memory of specific information, suggested not long before the design session, thus influences directly the knowledge the designer will use.

This average observation, however, should immediately be nuanced by the case of the 3rd subject (Cecile) who resorts mainly to triggers resulting

from her personal knowledge: 5 personal recourses against 2 triggers related to the documentation provided and, above all, 10 triggers not verbalised, i.e implicit and thus probably closely related to her personal experience.

TABLE 2: Characteristics of the trigger.

Subject	Personal	Document	Chaining	Unknown
Julien	1	5	0	6
David	1	4	3	7
Cécile	5	2	0	10
Σ	7	11	3	23
Distribution	16%	25%	7%	52%

5.3. LINK BETWEEN TARGET AND BASE

Comparison of each target and the base it is associated with provides some indications of possible links between the associated domains associated. Our observation (see Table 3) suggests a majority of extra-contextual associations: base and target do not belong to the same domain. Again, this average should be considered in the light of the behaviour of the 3rd subject (Cecile) who associates 15 targets out of 17 with an extra-contextual base (88%), whereas the two other subjects make only 5 associations of this type (18%), against 22 that present a direct or indirect link between target and base.

TABLE 3: Link between target and base.

Subject	Direct	Indirect	Extra- contextual
□	□	□	
Julien	5	5	2
David	9	3	3
Cécile	1	1	15
Σ	15	9	20
Distribution	34%	20%	45%

5.4. ORIGIN OF THE ANALOGY

On average, the origin of the analogy seems to lie more in personal references than in the documentation provided (Table 4). However, also here the influence of the 3rd subject is significant. Without her, the

distribution of the origins is completely reversed: 2/3 of the origins would result from information given before the design session.

This suggests the existence of 2 analogical strategies: one based on specific knowledge directly related to the design's constraints, the other drawing its sources from personal knowledge. We will pick up this distinction again in the discussion.

TABLE 4: Origin of the analogy.

Subject	Document	Personal
Julien	8	4
David	9	6
Cécile	2	15
Σ	19	25
Distribution	43%	57%

5.5. LINK BETWEEN TRIGGER AND ORIGIN OF THE ANALOGY

In addition, we wished to investigate whether there exists a relation between an analogy's trigger and origin, corresponding to the contexts of its target and base respectively. Unfortunately, 7 times out of 10, this link cannot be identified, mainly because, as already mentioned in 5.2, very often the target remains implicit and is thus not verbalised.

5.6. RANGE OF THE ANALOGIES: OBJECT, ATTRIBUTE OR RELATION

What is the range of the analogies observed? Pairing between target and base is chiefly accomplished by associating two objects based on one of their attributes (66% of the analogies on average and 76% for 2 subjects). One time out of 3 (see Table 5), pairing is achieved via a similar relation between several objects in target and base domain. Rare are the cases where the analogy involves a direct mapping of the target object onto a base object (5% of the analogies).

TABLE 5: Range of analogies observed.

Subject	Objects	Attributes	Relations
Julien	1	9	2
David	0	7	8
Cécile	1	13	3
Σ	2	29	13
Distribution	5%	66%	30%

5.7. SPONTANEOUS VERSUS CONTROLLED ANALOGIES

The analogical thoughts mainly appeared spontaneously (70%) and almost constantly for all subjects (Table 6). The tactics of resorting to analogy in design are thus a privileged activity of the mind: generally, subjects do not decide to resort to analogy deliberately, but are guided by their imagination.

TABLE 6: Spontaneous versus controlled analogies.

Subject	Controlled	Spontaneous
Julien	3	9
David	4	11
Cécile	6	11
Σ	13	31
Distribution	30%	70%

5.8. (UN)CONSCIOUS ANALOGIES

By using the "think aloud" method, subjects are forced, as much as possible, to verbalise every single of their thoughts. Therefore we supposed this experiment to deal with completely conscious analogies only, as only those that are expressed can be captured. To our surprise, however, 2 out of the 44 analogies observed turned out to be unconscious!

These two exceptional captures were possible thanks to the sketches and the certainty that subjects had no experience with sailing. The 2 unconscious analogies were posed by the same subject in relation to the same object: they concern the shape of the deck of the sailing boat, which is drawn very accurately twice during his design session. In section, this shape is particular so as to meet 3 requirements: (i) to provide the greatest height possible in the square, under the deck; (ii) to allow the team-members to pass on the deck from the cockpit to the front for manoeuvring the veils and (iii) to quickly evacuate the water the waves leave on the deck. A designer who has never navigated cannot produce a deck of the adequate shape without a long reflection, sullied with trials and errors... unless being inspired directly by a shape seen in the documentation provided. By consequence, the fact of drawing twice, from the first strike, the correct shape of the deck without mention may be taken to betray the unconscious borrowing of specific knowledge.

5.9. CHAINING OF ANALOGIES

The sequence of analogical thoughts remains a marginal phenomenon in our experiment: only 10% of the cases and each time for no more than a doublet of analogies. Note, however, that these sequences only took place after the 1st analogy met with success. No sequence occurred after a failure of base-target transfer.

6. Discussion: about the effectiveness of analogies

6.1. GENERAL SUCCESS RATE

Table 7 lists the effectiveness of the analogies in design: 3 times out of 4, they meet with success! In these cases, the link between target and base is valid, retained and applied in an adaptation phase that fully succeeds.

TABLE 7: General success rate.

Subject	Success	Failure	Not used
Julien	11	0	1
David	11	3	1
Cécile	11	3	3
Σ	33	6	5
Distribution	75%	14%	11%

Analogical reasoning is thus a generally profitable strategy during design. In our experiment, the failure rate is limited to 14% of the attempts. Our data do not allow detecting easily whether failures are due to mapping the target onto an erroneous base, or whether it is the adaptation phase that fails and thus causes the attempt to be abandoned. In the latter case, the very limited time left to the subjects to propose a complete configuration for the boat may have weighed heavily on the maximum time devoted to the adaptation. Note, however, that this failure rate is of the same range as the “not used” rate (11%): certain analogical thoughts arouse from the mind some ideas that have nothing to do with and are of no use to the design problem. For instance, upon reading the sentence "cruising on the Aegean sea", one of the subjects evoked the state of emergency issued in Macedonia, neighbouring country of Greece. No relationship whatsoever with the interior configuration of a sailing yacht!

6.2. SUCCESS AS A FUNCTION OF THE LINK BETWEEN TARGET AND BASE

Can the success of the analogies be differentiated according to the type of link between target and base domains? Table 8 suggests that success is characteristic of within- or between-domain analogies in the same proportions (39 and 36%)! One would thus obtain the same effectiveness with thoughts from the same domain as the target object as with thoughts that are completely unrelated! An analogy emerging from a direct link between target and base leads more than 8 times out of 10 to success (Table 9). This exceptional rate may be explained by the deadline imposed on the subjects: they often tried to solve a sub-problem of the design by directly borrowing a solution from documentation available at hand. We are probably, in these cases, at the limit of a real analogical thought. In our opinion, the between-domain associations are more authentic in this respect. These are profitable in 60% of the cases against a failure rate of 15% and a useless rejection of analogies of 25%: 1 idea out of 4 would thus be unusable, but nearly 2 out of 3 can effectively contribute to the design process.

TABLE 8: Success as a function of the link between target and base.

	Direct	Indirect	Extra- contextual	Direct	Indirect	Extra- contextual
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Success	13	8	12	39%	24%	36%
Failure	2	1	3	33%	17%	50%
Not used	0	0	5	0%	0%	100%

TABLE 9: Success as a function of the link between target and base.

	Direct	Extra- contextual	Direct	Extra- contextual
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Success	13	12	87%	60%
Failure	2	3	13%	15%
Not used	0	5	0%	25%
Σ	15	20	100%	100%

6.3. SUCCESS AS A FUNCTION OF THE RANGE

69% of the analogies established through association of an attribute lead to success, against 92% of those achieved by a corresponding relation in

base and target domain: analogical thinking can thus lead to success by using complex associations (Table 10). Apparently, the success rate would even rise with the degree of complexity of the link connecting target and base! This suggests that the cognitive activity put into operation during analogical reasoning in design by far exceeds the simplistic representations of current theories. By consequence, research on case-based design (CBD) should concentrate more on sophisticated modes of pairing concepts.

TABLE 10: Success as a function of the range.

□	Objects	Attributes	Relations	Objects	Attributes	Relations
Success	1	20	12	50%	69%	92%
Failure	0	5	1	0%	17%	8%
Not used	1	4	0	50%	14%	0%
Σ	2	29	13	100%	100%	100%

6.4. SUCCESS OF SPONTANEOUS AND CONTROLLED ANALOGIES

The success ratios of the spontaneous and controlled analogies are equivalent (74 and 76%, see Table 11). The former, however, are twice as numerous and arise only under injunction of the subject's intentions: the spontaneous options are thus targeted and produced by the mind with the confidence of a raised effectiveness. In other words, the 'freewheeling mind' does not spout no matter what associations of ideas; it produces analogies that are as beneficial as those generated by controlled reflection.

TABLE 11: Success of spontaneous and controlled analogies.

□	Controlled	Spontaneous	Controlled	Spontaneous
Success	10	23	77%	74%
Failure	3	3	23%	10%
Not used	0	5	0%	16%
Σ	13	31	100%	100%

6.5. SUCCESS AS A FUNCTION OF THE ORIGIN

Not counting unused attempts, analogies originating in personal experience show the same success rate (84%) as those resulting from knowledge acquired through the documentation provided before the experiment, which is, remember, directly related to the problem situation

at stake. It should be noted that no analogy was established starting from the documents with extra-contextual information: neither Space Lab, nor the sleeping cars have, for example, lead to an analogical thought. The subjects thus get an idea either in their personal general knowledge, or in new knowledge, but only if they directly relate to the object of their design.

7. Tentative conclusion

The use of analogy in architectural design is typically discussed and studied in terms of (its impact on) the resulting design *product*. By contrast, this paper has reported a study that adopts a different perspective on the phenomenon, by switching attention to the design *process*.

In order to identify and study analogy from this point of view, we have proposed a scheme that characterises an analogical transfer according to 9 parameters. The parameters were chosen with an eye to answering questions like when/at what point, why/for what purpose, and how/in what range or mode do architects use analogy as they design.

Subsequently, we have tried out this scheme to analyse 3 design sessions, in which architects worked on the interior configuration of a sailing yacht. As such, the scheme has proven a useful pair of glasses to observe, inventory and understand analogies throughout the design process, allowing us to formulate tentative answers to some of the questions raised above.

At what point in the design process do architects resort to analogy? The results of our analysis strongly suggest that analogical thinking is used frequently, if not permanently throughout the process. These numerous analogies may be triggered by personal knowledge in the designer's memory as well as by external information exposed to before designing. Also their origin may lie in personal or external sources. Which type prevails seems a matter of preference, yet further research is needed to clarify this issue. At this point, our results only demonstrate that architects use a mix of 2 analogical strategies: one relying on personal knowledge and experience, the other supported by external knowledge delivered 'just-in-time', i.e. not long before design starts.

As to the question why architects resort to analogy, a tentative answer inspired by our results may be: simply because it is their second nature. Indeed, a large majority of the analogies observed seem to occur spontaneously, i.e. without mention of any specific or explicit reason, suggesting analogical reasoning to be a natural, if not favourite strategy of the human mind.

Whether spontaneous or not, how exactly do these analogies unfold? According to our analysis, analogies are established both within one domain – the domain of naval design – and between different domains, the relative weight of which varies considerably across individual designers. What does not vary across individuals, however, is that the analogical transfer unfolds not so much between objects in base and target domain, but rather between object attributes or relations. The exceptionally high success rate of analogies of the latter range chimes with the more ‘structural’ theories on analogy mentioned above and may have serious consequences for the development of successful CBD systems (and other tools that aim at providing designers with relevant analog candidates). Indeed, if this success rate can be confirmed by further experiments, it suggests that the representation of cases – and other potential sources – should focus not so much on the individual objects that constitute the case, but rather on the structural relations between them.

However, we deliberately use the term *tentative* answers, for it is obvious that further evidence is needed before we can even start thinking of drawing general conclusions from our study. The experiment presented in this paper is very limited, in terms of both time (the 2,5-hour design sessions represent but a fraction of a real world design process) and number of subjects observed. Studies of this nature cannot produce results that may be generalized straightforwardly. They are nevertheless important as preliminary work in developing a more profound understanding of analogy in architectural design, which in turn should allow developing more effective design support.

As such, the study has produced useful observations and encouraged us to repeat the experiment with more and other subjects. The most encouraging observation is perhaps that on average designers resort to analogical thinking no less than 5,8 times per hour. Therefore, we cannot resist the temptation to close this paper with the (tentative) conclusion that the water lily-like ‘1 analogy per architectural masterpiece’ view, propagated by architectural and design literature, seems to do little justice to the reality of architectural design.

Acknowledgements

The research lead by Pierre Leclercq is funded by the Research Council of the University of Liège. Ann Heylighen is a postdoctoral fellow of the Fund for Scientific Research Flanders.

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