The Psychology of Designer Style

Andrew Dillon, Marian Sweeney, Val Herring, Phil John and Enda Fallon.

HUSAT Research Centre, Elms Grove, Loughborough, Leics. LE11 1RG.

---

1. INTRODUCTION

Underlying the notion of style is a basic premise that all designers are not the same and that the manner in which any designer tackles a problem and proposes a solution may be qualitatively different from other designers. If this is shown to be the case and the concept of designer style can be meaningfully discussed then any model of the process of design should allow for such variation at the level of the group or individual. This basically describes the starting point of the HUSAT team's investigation of the concept.

2. INITIAL INVESTIGATIONS

2.1 Literature review

Work commenced by carrying out an in-depth review of the literature on design in order to glean all relevant information on style. It soon became obvious that definitive works in the area were not going to be found and as a result the search was broadened to incorporate literature on creativity, psychological style and problem solving. This search consisted of two on-line searches at Loughborough University of Technology library and a search of the HUSAT databases which consist of a substantial collection of references and abstracts. A manual search of the more general design, human factors and psychology journals was also carried out.

In reviewing this literature it became clear that two distinct trends were emerging. The first of these was in the more traditional psychological arena of cognitive style which attempts to identify, describe and dichotomise innate information processing propensities of humans. The second trend used the term style synonymously with the problem solving strategy employed by an individual in a given task. It was felt at this stage that neither category captured the essence of the concept of designer style and a firm understanding of the concept would not emerge from the literature alone.

2.2 Experimental Investigation

As a result of this it was decided to carry out a short experiment involving a room layout design task using 4 subjects. A review of methodologies was carried out for the purpose of identifying how to best investigate the problem and the use of verbal protocol analysis was identified as being most suitable for our purposes. The purpose of the experiment was two-fold. Primarily we wanted to operationalise the concept of designer style and secondly we felt that such an investigation would benefit the team methodologically by familiarising us with the use of the protocol analysis techniques in a situation that was not dissimilar to the experimental situations we envisaged working in later.

Employing verbal protocols and relating them to the manifest behaviour of the individual led to the development of a rudimentary procedural and cognitive model of performance in the experiment. This suggested that while it was possible to identify the types of strategy employed by an individual these in themselves were little more than descriptions of overt behaviour and that interesting reasoning and decision making processes were also occurring that governed the deployment of one or other strategy. It appeared that the notion of style was somehow best understood at this level.

On the basis of these findings a view of style emerged that led to the proposal of the "sandwich" model of the concept. Briefly, this model proposed that designers generally cluster at similar points on most cognitive style dimensions but may differ noticeably in their manifest strategies for solving problems. Designer style was therefore best understood as "sandwiched" between these two forms of cognitive processing, controlling strategic action while itself being influenced by underlying cognitive dispositions. In this way interest focused less on what designers do but more on how and why they do it.

As a result of these findings a preliminarily definition of style as an evolving characteristic pattern of problem solving that is influenced by experience, values, personal preferences and external factors was proposed.

3. EMPIRICAL INVESTIGATION AT BRITISH AEROSPACE

Having exhausted the relevant literature and as a result of this brief experiment, arrived at an understanding of the complexity of the style concept, arrangements were made to visit the British Aerospace site at Filton to carry out experimental investigations on real designers. After discussions with staff at Filton a design task of suitable realism that would facilitate the expression of style was decided upon. The task required the designer to design a system of tracks that would drive a wing flap into specific positions. A time scale of 3 hours to complete the task was considered suitable by the task developer.

3.1 Method

16 designers (9 Computer Aided Design and 7 Drawing Board users) from the structures and systems departments of British Aerospace volunteered to participate in the study. Each designer had the purpose of the investigation explained to them and was allowed to ask any questions of clarification. Two experimenters sat with each subject as they

performed the task and elicited verbal protocols which were recorded using discrete audio equipment. Subjects were encouraged to perform the task in their regular manner. Post-experimental interviews were carried out to obtain background information on the individual designer such as experience, training etc. and to pursue any points of interest that emerged during the task.

3.2 Data Analysis

At the end of the experiment over 50 hours of verbal protocol and interview data had been captured. Verbal protocols are probably the richest source of data that can be captured experimentally but can prove difficult to analyse meaningfully. The correct means of analysis requires the development of a framework for categorisation of elicited comments (or parsed units thereof) and independent raters who compare results in order to minimise subjective interpretation or experimenter bias.

In the present situation the experimenters familiarised themselves with the material by listening to a random selection of half the total number of tapes. The development of an analytic framework turned out to be a more difficult process than had been envisaged. Initial attempts at classifying designers at the level of statement on the basis of knowledge directed decision points proved unsuccessful as our knowledge model did not fully account for the differences observed in approaches to the problem solution and parsing at a purely statement level deprived the protocols of essential contextual information. It thus became necessary to construct an expanded framework to classify pathway differentials in terms of WHY and HOW the designer proceeded. This framework distinguished between rationalised decision pathways, non-rationalised action classification and personal default (for full details of the analysis procedure see MMI142/HUSAT/7.0).

By proceeding in this way a number of discriminatory category descriptors of designer performance emerged such as global solving which refers to the designer's tendency to tackle a number of problem elements at a time, or detailed planning which describes the individual who spends much time and effort at the outset in calculating, checking and preparing his/her approach to the problem. By listing such descriptors and their opposites, a number of style dimensions were drawn up as a method for scoring the protocol data. These are fully described in the MMI142/HUSAT/7.0 report.

Each subject's protocol was rated independently by two experimenters (inter-rater reliability $r > 0.90$) according to manifestations within the protocol of the dimensions outlined. It should be noted that the characterisation of a designer on any style dimension was contingent upon observable protocol data rather than inference from absence of data. In other words, the lack of firm data to classify a designer as "systematic" does not therefore imply that the designer is a "trial and error" type, or that failure on the part of a subject to express geometric rules for solution generation automatically leads to a classification of "intuitive".

As a result of this scoring scheme, all subjects were not rated on every dimension, and so variance exists in the number of subjects scored on any one style category. Table 1 describes the number of subjects on each dimension and the relative style ratio.

Dimension	Total	Ratio
Global - Micro	13	7:6
Visualiser Space - Dynamic	14	8:6
Detailed - Rough Planner	14	9:5
Field Dependent- Field Independent	12	9:3
Check/Review: Frequent - Overall	9	8:1
Problem oriented - Solution oriented	9	6:3
Deep - Shallow	7	4:3
High - Low level awareness	14	7:7
Innovative - Merge,manipulate,modify	6	4:2
Geometric - Intuitive	11	6:5
Systematic - Trial and Error	9	4:5
Exactor - Approximator	9	2:7
Closure: Extended - Narrow	11	5:6
Rigid - Flexible	3*	2:1
Impulsive - Reflective	4*	0:4
External - Internal locus of control	10	6:4
Anxious - Relaxed	4*	3:1
Cautious - ?	6	6:0
Presentation: Concern - Unconcern	14	13:1

Table 1. Style dimension scores and ratios.

Any dimension that failed to classify at least 1/3 of the sample (*) was deemed to have little relevance to the majority of designers and was therefore excluded from subsequent analysis. Similarly the "presentation" dimension was also discarded due to to its failure to adequately discriminate designers.

An elementary linkage analysis was then carried out to identify inter-related dimensions e.g. are subjects classified as "innovative" also classified on other dimensions? In this way a classification network was drawn up which demonstrated where relationships lay (and where they did not lie!). Through a process of linkage and elimination, several clusters of inter-related dimensions were identified. These numbered four in total and are interpreted for the present purposes as unique designer styles. However it should be noted that no one designer is likely to satisfy every criterion for classification within a style, and several factors within any overall style will cluster better than others.

3.3 The identification of styles

3.3.1 Style 1

Micro - problem oriented - visually dynamic - narrow closure- low level awareness - approximator.

This style represents designers who tend to break the problem down into sub-tasks and tackle these one at a time, concerning themselves more with how the problem could/should be solved rather than how a solution should look. Such designers manifest a narrow sense of closure. A tendency to visualise dynamically rather than concern for mathematical or geometric precision is manifest in these designers. Little awareness of the overall constraints influencing the operation of a proposed solution is demonstrated.

3.3.2 Style 2

Global - visually spatial - high level awareness - extended closure - detailed planner - checker - solution oriented.

This type of designer adopts a breadth first (as opposed to depth first) approach to the problem, and is engaged in solving more than one aspect of the problem at a time. Being extended closure types they are capable of sustaining the solving procedure over large problem units. Typically, such designers spend a lot of time planning in detail before attempting to solve the design problem, and similarly, check and review their progress frequently. As spatial visualisers, occupancy and positioning are important to them, and as they possess high level awareness they are capable of identifying most or all possible constraints acting upon any proposed solution.

3.3.3 Style 3

Field dependent - visually spatial - low level awareness - shallow knowledge - trial and error - rough planner.

This style of designer tends to approach the design in a trial and error fashion, not planning in advance but rather relying on their spatial visualisation skills to evaluate attempted solutions. Due to their low level awareness of possible problem constraints and shallow knowledge base, designers with this style appear less expert than their contemporaries.

3.3.4 Style 4

External locus of control - geometric solver - field dependent - checker/reviewer.

The fourth style to emerge tends to use geometric rules and principles for tackling the problem. Their tendency to field dependence implies a need for clarity in the visual representation of the task. Possessing an external locus of control, these designers tend to rely heavily on feedback from others as to the suitability of their design and the link with frequent and detailed checking may further suggest the need for constant reassurance.

These are the styles that emerged from the verbal protocol analysis. They suggest that the concept of style as operationalised in this work can lead to meaningful distinctions between a sample of designers.

3.4 Interview data

Interviews were also carried out after the experimental session in order to supplement information obtained through the verbal protocol analysis and identify potential variables influencing performance. Four main areas were investigated: background, experimental contaminations, output evaluation, and self-awareness of style.

The background data consisted of information on the designers' training, work experience and education. An attempt was made to relate such factors to classification in terms of style. The results were mixed however. Designers classified as Style 1 tended to have similar backgrounds i.e. served apprenticeships, came from the same department (structures) and had more than 6 years experience on this type of work. Style 2 designers were all graduates and came from the systems department. However there was wide variation in terms of their experience. Commonality existed amongst designers classified as Style 3 in terms of training (all having served apprenticeships) and having more than 10 years experience. Style 4 designers though were largely dissimilar in all background factors.

The possibility of experimental contaminations in the situation was investigated in order to appreciate the extent to which this conceptualisation of style may be based on evidence extracted from an artificial situation. However designers felt that the situation was relatively realistic although they felt the time constraint posed some difficulties and verbalising their thoughts not always easy. Confidence that the experimental scenario did not distort the evidence is justifiable.

Asking the designers to assess their own output afterwards was considered a useful way of extracting interesting information on how they perceived their performance. The majority of designers felt satisfied with their performance and accepted that a three hour timespan for a job was not typical of their work. A few designers felt that they had underperformed.

Discussing with designers their own conceptualisation of style acted as a useful exercise by facilitating a better understanding of how designers see design and the terminology they employ in describing their work. While many had difficulties with the abstract concept of style as such, they were able to describe typical design practices such as "merge, manipulate and modify" as indicative of their own or colleagues' ways of working.

3.5 The notion of style "backbone"

In the main the interview data did not contradict the evidence from the verbal protocol analysis and occasionally lent support to the claims for style and the suitability of an

experimental investigation of this kind. Upon completion of this investigation it was felt that a useful understanding of the style concept had been arrived at. It certainly appeared on the basis of this evidence that the level at which style was operationalised (that of rationalised / non-rationalised pathway differentials, action classification and personal default) had proved fruitful.

In general many aspects of the styles that emerged in this study appear to make sense. In Style 1 the link between "micro", "narrow closure" and "problem orientation" is intuitively satisfying as one would hypothesise that designers who tended to deal with smaller problem chunks would possess stronger need for closure and thus lack the necessary cognitive skills for tackling more than one problem element at a time. Similarly the corollary of these aspects linked in Style 2 i.e. "global", "extended closure" and "solution oriented" seems equally apt.

In Style 3, the link between "trial and error " and "rough planner" was absolute, all designers classified as one were also classified as the other. This makes sense as designers who do not spend time or effort planning in advance need to attempt solutions on some basis and a trial and error approach is likely to emerge. All designers who manifested an external locus of control were also categorised as field dependent. Psychologically, the link between these two aspects is not surprising given that a classic facet of field dependence is the lack of suitable internal frames of reference for abstracting information. This would not be unexpected in people with an external locus of control who manifest a reliance on other people's judgements over their own. The tendency of external locus of control types to frequently check and review and employ rigid geometric procedures throughout their designs can be interpreted as a manifestation of the need to maximise the use of taught rules and procedures and limit the use of any personal judgement or intuition.

On the basis of these results the notion of style "backbone" emerged. This refers to those particular combinations of style dimension that strongly correlate. This "backbone" of style can then be subsequently developed and influenced by the presence or absence of further dimensional facets. Thus the styles outlined above may only be task-specific varieties of many possible styles that are constructed around similar "backbones". It is therefore possible that, for example, the backbone of Style 3, "trial and error" and "rough planner", when combined with a factor such as "high level awareness" on a different task may lead to more creative and effective designs, than were found in the present study.

In this way, the "backbones" of any particular style may be understood as relatively constant attributes of a designer's pattern of problem solving. However to these attributes are added further style facets as a result of both task and environmental factors. Thus any individual's style is seen as a combination of core or primary dispositions towards design and their response to the task and situation.

Obviously this work required replication, ideally with a further sample of designers under similar experimental constraints. Firstly, this would serve to indicate the strength of the investigative procedure outlined above to extract styles in other design situations.

Secondly, such a replication would provide greater insight into the affect of task and situational variables on manifestations of style.

4. SURVEY ANALYSIS

A further study of this nature was arranged with designers from a different organisation involved with pipe layout designs for diesel engines. However due to difficulties in arranging access at a late stage in negotiation this study had to be cancelled. Further experimental investigation was by now impossible given the time limitations of the project. A recovery strategy was implemented which consisted of the development of a survey tool that could be dispatched to a number of sites and analysed quickly. It was hoped that this would allow a validation of this interpretation of style in a wide variety of settings differing in terms of task, situation and organisational culture.

An item pool was generated consisting of a number of items designed to tap the characterisation of operations, activities etc. associated with the polarities of any dimension. However not all dimensions were easily translated into survey-type questions due to the fact that many dimensions have desirable poles e.g. few designers would prefer "shallow" to "deep" knowledge or "low" to "high level" awareness. It therefore proved difficult to generate items for a full survey of the style dimensions. A reduced set of items therefore formed the pilot survey which was tested out at Brush Transformers (Loughborough) and Rolls Royce (Derby) where 16 designers were requested to comment freely on any aspect of the survey they felt uncomfortable with or thought to be unclear. In the light of these comments and an analysis of obtained data, a revised survey was drafted and dispatched to 126 designers, from nine companies, of whom 109 responded.

Survey Data Analysis

The initial analysis of the obtained data was aimed at revealing the internal consistency of this type of tool in order to validate its ability to evaluate style dimensions. A descriptive analysis was carried out and a number of strict criteria defined in terms of the question set's ability to differentiate designers on a dimension. On the basis of this invalid question sets could be identified. Unfortunately only three dimensions: Rigid - Flexible; Exactor - Approximator; Checker - Reviewer managed to satisfy these criteria. Consequently it was felt that any attempt to validate the style backbones on the basis of such data would be misleading and further analysis was therefore unwarranted.

From an empirical standpoint the survey investigation must be viewed as disappointing as we were unable to capture suitable data on the concept of style. In retrospect however valuable lessons have been learned. It is possible that any survey or questionnaire-based investigation of such a nebulous concept is prone to difficulty if not outright failure. It may well be that style has the same vague and value-laden structure as some traditional psychological constructs such as personality which have taken many years of research to become susceptible to this type of investigation. The concept of style on which we based the survey is at an early phase of comprehension and we suffer the handicap of asking

questions about aspects of performance and cognition that we are not certain form part of style and that respondents may not perceive as applicable to themselves.

Furthermore the survey was generated rapidly on a tight timescale and as a last minute recovery strategy, lacking scope for frequent iteration which is so much a part of the psychometric tradition. Had the development of such a survey been part of our original plans and not a reaction to circumstances beyond our control iteration would certainly have occurred. At the end of the day it must be said that we are not in a position to extract substantial evidence from the survey to support or contradict our view of style based on the data from British Aerospace, or to state categorically that the survey method is unsuitable in this area.

5. THE CONCEPT OF DESIGNER STYLE

On the basis of the work carried out this year it is felt that it is possible to meaningfully discuss the concept of designer style. This notion of style is distinct from general cognitive style which refers to an innate manner of processing and responding to information. In terms of cognitive style it is expected that designers cluster around similar points on any of the style dichotomies such as field dependence / independence, or serialism / holism.

In more specific terms than cognitive style, it is possible to describe design activity in terms of the strategies employed by the designer as a means to problem solving. Strategies are much discussed in the design literature and range from general high level ones such as Darke's (1979) "generator - conjecture - analysis" model to specific low-level ones such as "random searching" (Rzevski and Evans 1985), though the distinction between these is at best blurred in the literature. Design strategies tend to be either prescriptive methodologies or situation specific heuristics. Either way they are less characteristic of a designer's processing than is implied in our notion of style.

This year's work suggests that designer style can be meaningfully understood without recourse to such descriptions and that a characterisation of individual designers in terms other than those just outlined is possible. This characterisation, based on rationalised and non-rationalised pathway differentials, action classification and personal default, facilitates an analysis of designers at a level between the extremes of innate cognitive preference and problem solving technique.

Style in this sense is in no way absolute or context independent. The possiblity of external forces such as task and organisational culture influencing any designer's manifest style is an essential part of our thinking. Any designer would be expected to exhibit some degree of stylistic variance over his / her career as a function of such external factors. Failure to allow for such flexibility would have been reductionist in the extreme, attributing design style with the permanence of innate cognitive style, not to mention highly implausible.

On the other hand design style is neither reactionary to the task in hand or unstable as style by definition must have some element of consistency. Our evidence suggests that the "backbone" elements uncovered in the data do indeed represent the unchanging, context independent facets of any designer's work. These "backbones" are the primary dispositions any individual designer brings to bear on his / her attempts at problem solving and solution generation. They almost certainly result from a variety of influences such as cognitive style, training and experience. In other words they are both innate and environmental. These are supplemented and merged with other stylistic features as the demands of the task and situation change.

On the basis of the British Aerospace study four basic backbones are proposed. These are by no means definitive or exhaustive of the number that may exist in the real world. As so often ends discussions of this type, further research must be done.

6. IMPLICATIONS FOR THE DESIGN OF CAD INTERFACES

An understanding of the concept of designer style can have implications for any model of the designer and any recommendations that are proposed for CAD systems. Qualitatively distinguishing the end users of a computer system has been a goal of much research in the area of general interface design and given rise to the attempted categorisation of user types. In this way an attempt is made to target specific interface features to particular groups of users. The characterisation of designers in terms of style can offer similar targeting facilities for CAD developers.

The argument here is that a designer who for example manifests a global and visually spatial style would probably require or prefer the availability of certain features in a system interface that may be considered less important by designers who manifest a micro and visually dynamic style.

Obviously there is no hard and fast distinction here, any feature implemented within an interface will almost certainly be required by all designers at some stage. However the nature of the design task and the degrees of freedom contingent upon any individual's attempts at solution generation would strongly suggest that all users will not interact similarly with a system. The identification of style within or across a group of designers is seen as one way of indicating how to provide the most suitable features and their means of access to users.

An attempt has been made to see how this would work out in practice. Particular design aids that may be contained in a CAD system have been identified and the possible effects of style variables on the amount and type of usage these facilities will incur have been discussed in a general way (MMI142/HUSAT/11.0). So for example, sketching facilities are likely to be of use to all designers but particularly to those who manifest Style 1, being less concerned with geometric or mathematical accuracy and more with conceptual presentation. The more geometric solver (e.g. Style 4) may require more sophisticated calculation facilities than would be used by other designers.

Such links are, by their very nature, tentative. There can be no rigid classification of feature type to style dimension at this or perhaps any stage. However such an approach serves to highlight how the concept of designer style may facilitate a greater appreciation of how designers work for the developers of systems with these end users in mind.

7. RELATIONSHIP OF STYLE TO THE BLACKBOARD MODEL

In an earlier report tentative links were drawn between the blackboard model and the concept of designer style. It was felt that the interpretation of low level strategies was similar to the types of production systems that triggered activities on the blackboard i.e. they are collections of rules, of the form IF - THEN which express what the designer or problem solving individual, does under what conditions. From this perspective therefore the activities traced on all three levels of Whitefield's (1986) blackboard model are representations of the strategies employed by the designer throughout the design process

Following this premise the notion of style is equatable to the scheduler in the blackboard model i.e. style is the controlling mechanism of strategic action. The fact that the control mechanism in the blackboard architecture is seen as reflecting the "intelligence" of the system (Hayes-Roth 1983) would suggest that individual experience and training etc. are important variables in successful problem solving and dictate how and why the problem solver proceeds in a task environment. This equates with the current conceptualisation of style.

However style is not just the "intelligence" of the individual but rather includes numerous other factors as detailed e.g. values, personal preferences, task contingencies, environmental influences etc. According to Hayes-Roth (1983) the actual blackboard element of the model may have a user-defined internal structure which defines important personal relationships for the problem solver. This suggests further relevance for the concept of style within the blackboard model. That is, stylistic differences may influence both the structure of, and process through the blackboard. It is difficult at this stage to pursue these ideas without clarification of the exact nature of the blackboard model as it pertains to design, given that numerous applications of the model differ in terms of structure (architecture) and process (see e.g. Hayes-Roth 1983 and Nii 1986).

It would seem that two options exist in bringing the concept of style and the blackboard together. The first would be to consider it directly equatable to the scheduler and conceptualise it as the controlling influence, directing process through structure. This would be the most obvious route though criticisms of reductionism may apply. The second option involves restructuring the blackboard to allow a greater variety of level and transfer across these levels i.e. alter the very architecture of Whitefield's model. Obviously this would require a complete re-analysis of designers to identify alternative blackboard structures and would allow designer style to permeate the complete model. This may prove unmanageable.

However the development of links between style and the model will remain tentative at best until a fuller understanding of the blackboard model is arrived at.

Acknowledgement

The present work was carried out under the SERC-funded ALVEY programme, project : User Modelling Tool for Enabling Technology/ MMI-142.

The authors wish to thank the designers at BAe for their considerable time and effort, and good spirits throughout this study. Without their co-operation this work would have been impossible.

Thanks are also due to our colleagues at City Univeristy and the Ergonomics Unit at UCL.

References

Hayes-Roth, B. (1983) The blackboard architecture: a general framework for problem-solving? HPP Report No. HPP-83-30. Stanford University, Dept. of Computer Science.

Nii, H.P. (1986) Blackboard Systems: The blackboard model of problem solving and the evolution of blackboard architectures *AI Magazine*, Summer, 38-53.

Whitefield, A. (1986) A model of the engineering design process based on the Hearsay II Balckboard model. Unpublished PhD thesis. University College London.