DESIGNING SIMULATORS FOR STRATEGIC MANAGERS[1]

by
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Abstract

The activity of strategic management is important because it is the activity through which the structure of an organisation is developed and adapted in relation to its environment. The activities within an organisation are systematised within structures because they enable the organisation to ensure the effectiveness of those activities, and there already exist teaching methods appropriate for training managers in the operation of such structures. Few teaching methods exist however for teaching managers about structure itself. This paper initially discusses what structure is, and then goes on to describe an approach to the support of managers' learning about structure: how structure can be related to the activities of managers, and how managers can explore the implications of adopting alternative structures within their organisation. The paper puts forward symbols for describing structure. It is then shown how the symbols can be combined by a manager to describe a particular organisational context in the form of a simulator, and how the resulting design can be transformed into the form of a computer program. This enables the resulting simulator to be used by the manager to explore the implications of adopting particular structural choices as he has defined them within the organisation. Finally, the nature of the teacher's role is considered when supporting the learning of managers using this approach.

Introduction

This paper is addressed to teachers concerned with helping managers to learn about the structural choices open to the strategic manager. Its main purpose is to show how simulators can be used to support the development of the manager's ability to make decisions about structure. The approach described can be used by managers both to think about the structure of their organisation, and to explore experientially the possible futures which might develop from choosing alternative structures. It is in this sense appropriate therefore for supporting learning about strategic management (Ansoff, Declereck and Hayes, 1976): the management of structural uncertainty, or ambiguity.

The arguments presented here are based on experience, gained within a project concerned with developing teaching methods for managers: the Management Decision-making Project, jointly funded by the National Development Programme in Computer Assisted Learning and the London Graduate School of Business Studies. The project focused on the ways managers' judgement could be developed (Boxer, 1978). In the course of this project a number of simulators were developed for use by managers within given course contexts. The paper describes the approach used for

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designing those simulators, and the learning gained in using them with some 400 managers on a series of courses over a three-year period.

The aim here is to answer four questions in relation to the basic objective of learning about structure. First, what concepts are useful for describing the structure of organisations; secondly, how does the experience managers have within organisations relate to these concepts of structure; thirdly, how do those concepts relate to the way in which a particular structure operates over time in relation to an organisation's aims; and, finally, how does the use of simulators, designed using these concepts, affect the learning opportunities which the teacher can create?

The conclusions reached are based on the ways in which simulators can be used to support learning about structure (Duke, 1974). The word 'support' is used here instead of 'produce' because of a fundamental assumption made that choice of structure is as much affected by the manager's own intuition and sense of purpose as by the nature of the context in which the manager's choice is exercised. The evaluation of the approach, therefore, identifies both the obstacles created by the simulators for managers' learning, and the constraints placed upon such learning by the teacher and the course context in which the simulator is used. This evaluative outcome results from the simulators described being reflective methods (Boxer, 1978): methods which *support* individuals' learning but do not claim to *determine* learning, any more than a slide-rule can determine learning about thermodynamics.

Structure

What is the concept of structure being used in this discussion? The manager experiences reality in the form of observed phenomena which he assumes bear some constant relation to a physical world which exists independently of himself. Thus when he walks on the shop floor and observes pallets loaded with part-finished work, he expects to see that fact reflected in the work-in-progress figure produced by the management accounting system. Further he will assume certain causal relations to exist between those phenomena: work-in-progress will involve varying amounts of machine work on raw materials, while the cost of work-in-progress will reflect that of labour and materials used. Taken in aggregate, all these causal relations will constitute a structure which has the capacity to operate as a whole, absorbing inputs of materials and manpower, and outputting finished products (Klir, 1969).

Many of the causal processes within a structure will be man-made: for although the heat-treatment of metal will be governed by the thermodynamic and chemical laws of nature, the way in which an accounting system calculates work-in-progress costs will be governed by choices made by the chief accountant. Thus, although the structure of some parts of an organisation will be outside the control of managers, the operation of other parts will result from structural choices which managers have made about how parts of their organisation will respond to each other and to external events. The important characteristic of the approach to designing simulators described in this paper is that it includes these decision-making processes of exercising structural choice as 'purposeful' sub-structures within the structure of the organisation as a whole.

If an organisation is to survive, however, it must have the capacity from time to time to reorganise itself in relation to its environment, and thus to produce new products for new markets (Yoshihara, 1976). This process of introducing structural change is the underlying concern of strategic management: other types of management activity can be understood as operating within structures which determine the causal

assumptions within which their problems can be analysed. The existence of structural choice is experienced by the strategic manager as ambiguity, and it creates a paradox for him: if he seeks to analyse such choice using a pre-determined structure, then he will have removed the very choice which he is to manage by removing the ambiguity, rather than by resolving the underlying structural choice. Thus a tension exists between the tolerance of and the removal of ambiguity which is both necessary and unique to the strategic manager's role if he is to satisfy the development needs of his organisation.

Strategic issues, however, form only a small part of a manager's activities within an organisation. He therefore will not necessarily have had sufficient experience of ambiguity to know how to respond to the demands of this strategic role: he will have spent the majority of his time managing within pre-determined structures. Rather than being able to create new structures, therefore, the manager may well find himself either unable to recognise the existence of any structural choice or, alternatively, unable to evaluate one choice in relation to another (Morris, 1975). Therefore the aim in supporting managers' learning about structure is, first, to enable managers to describe how the particular causal processes within their organisation combine in the form of a structure; and, secondly, to enable them to consider the adoption of different structures and their consequent dynamics.

Designing Simulators

An organisation simulator is something more than just a simulation of an organisation *per se.* It is a simulation of the organisation as it appears and behaves *in relation to* decision-makers within the organisation (Cruickshank and Mager, 1976). For example the simulation of flying can be produced by the combination of pilot and flight simulator if the interest is in exploring the changes to which the aeroplane can be made to respond, and with which the aeroplane's autopilot and automatic landing system cannot cope. The pilot has the capacity to create new ways of operating in response to unforeseen situations in a way in which machines cannot. All machines ultimately have determined structures and thus cannot create new structures (Weizenbaum, 1976). The problem faced in designing the organisation simulator is therefore to recognise what can and what cannot be simulated.

The answer to this question can be provided by analysing the way in which the decision-maker himself experiences his organisation and its environment. It is not possible to do this using most approaches to analysing organisations because the analyst is assumed to be external to it. The analyst does not set out therefore to understand the organisation as it operates in relation to himself (Sachs, 1976). The approach to analysing organisations which includes analysing the process of managing 'sentient' structures does not suffer from this shortcoming, however, because it includes the decision-maker's perspective as part of the organisation (Miller and Rice, 1967). This approach identifies the primary input-conversion-output activity in relation to the organisation’s survival and the constraints it places on those activities. It also identifies the regulatory decision-making processes needed both to control the organisation’s activities internally; and its internal boundaries and boundaries with other organisations. The essence of this approach to analysing organisations shares with other approaches the identification of sub-components of the organisation and their relationships. What makes it different, however, is the fact that the sub-components identified correspond to phenomena in the real world as experienced by the

decision-maker; and that the decision-making processes correspond to the activities of particular decision-makers. The question to be answered, however, is how do these sub-components relate to the concepts of structure identified earlier? If this relationship can be defined, then it becomes possible to create a computer programmed simulator directly from the manager's experience of his organisation, since the computer is a very convenient medium for representing well-defined structures; and it also serves the purpose of enabling the manager to interact with the structures which he has previously defined.

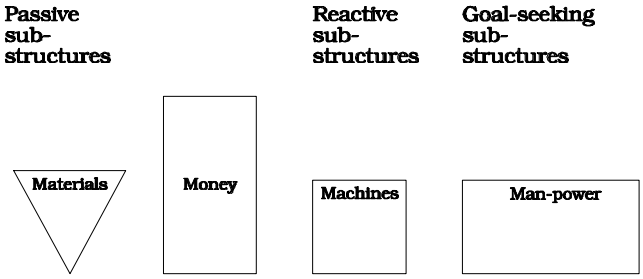
The relationship can be defined using concepts of structure which differentiate four classes of system in terms of their degree of and kind of structural flexibility (Ackoff and Emery, 1972). These four classes of system are respectively *passive, reactive, goal-seeking* and *purposeful* systems. The simplest *passive* system has a single structure which has no operating relationship with its environment. The *reactive* system has a single structure which does operate in relation to its environment. The *goal-seeking* system has a number of reactive sub-structures which are internally related by a set of rules, so that as a whole it has the capacity to choose between alternative reactive sub-structures in relation to its environment. Finally the *purposeful* system has the capacity to operate as if it were a goal-seeking system and, additionally, to adopt alternative goal-seeking behaviours in ways which are environmentally independent. These different classes of system are summarised below:

System Structure	**System's Choice of Sub-Structure**		
	None	Environmentally determined	Environmentally independent
Unrelated to environment	PASSIVE (paper-weight)	-	-
Related to environment	REACTIVE (television)	GOAL-SEEKING (thermostatically-controlled heating system)	PURPOSEFUL (people)

The concept of a purposeful system therefore corresponds to the concept of a self-determining autonomous individual, who has the ability to make structural choices in ways which are not themselves determined by a structure. Although it is possible to argue that accepting the existence of purposeful systems assumes a prior belief in their existence, for the purposes of this paper, this assumption is taken as given: individuals are intrinsically purposeful and not simply very complicated goal-seeking systems. The implications of this assumption are very important since it means that whereas passive, reactive and goal-seeking systems can be simulated by virtue of their determined structures, purposeful systems cannot be simulated by virtue of their intrinsic nature: their structure cannot be determined. Thus identifying those individuals within an organisation whose behaviour is not determined identifies the boundary between the strategic managers and their organisation simulator. The next two subsections will describe symbols that may be used to design a simulator and to give an example of their application.

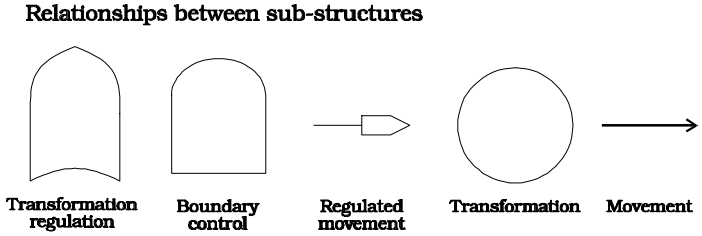
The design symbols

Within the organisation, the manager will be able to describe sub-structures as he experiences them: their relationship to him in terms of how they operate. The sub-structures thus identified can be described as one of the four classes of system introduced above, and their relationship to the other sub-structures can then be defined. The simplest substructures are the money and materials used by the organisation (for these and the subsequent symbols, see below). Although capable of being transformed by various processes, materials by themselves constitute passive systems. Money is identified by a separate symbol because, although it is passive, it serves a dual function both as a passive object which can be transformed in various ways and, also, as information about other events in the organisation and its environment. Many of the sub-structures in the manager's environment, however, will operate in some way relative to their environment - machines, for example, react to their environment. It will also be true that most of the individuals within the organisation, although individually purposeful, for the purposes of the organisation will work within predetermined structures and thus effectively be goal-seeking.



The symbols above enable the manager to identify the sub-structures within his organisation in terms of how each one operates. In order to be able to describe the operation of the organisation as a whole, however, it is necessary also to define the relationships between those sub-structures both within the organisation and with its external environment. Figure 3 shows the symbols used: *transformation* and *movement* define relationships between substructures which are unregulated. The symbols for *transformation regulation, boundary control* and *regulated movement* qualify all transformations or movements by the addition of logical rules.

These rules are either explicit, or implicit in the decision-making behaviour of

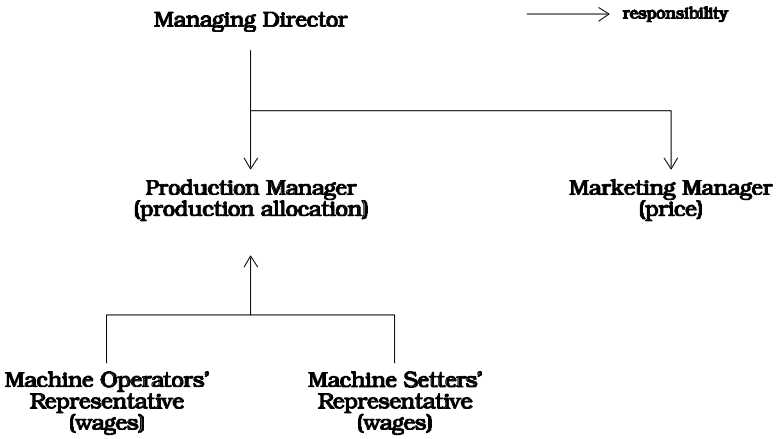


purposeful individuals who have responsibility for regulation within the organisation. The purposeful individuals within the organisation are therefore represented by decision roles, each one of which is defined in terms of three dimensions (Reed, 1976): their control over particular regulatory activities; their formal relationships with other decision roles and, during the operation of the simulator, the informal relationships which develop between them. The purposeful individuals within the organisation

therefore define the decision roles which interact with the simulator, and to which individual managers are allocated when the simulator is operated.

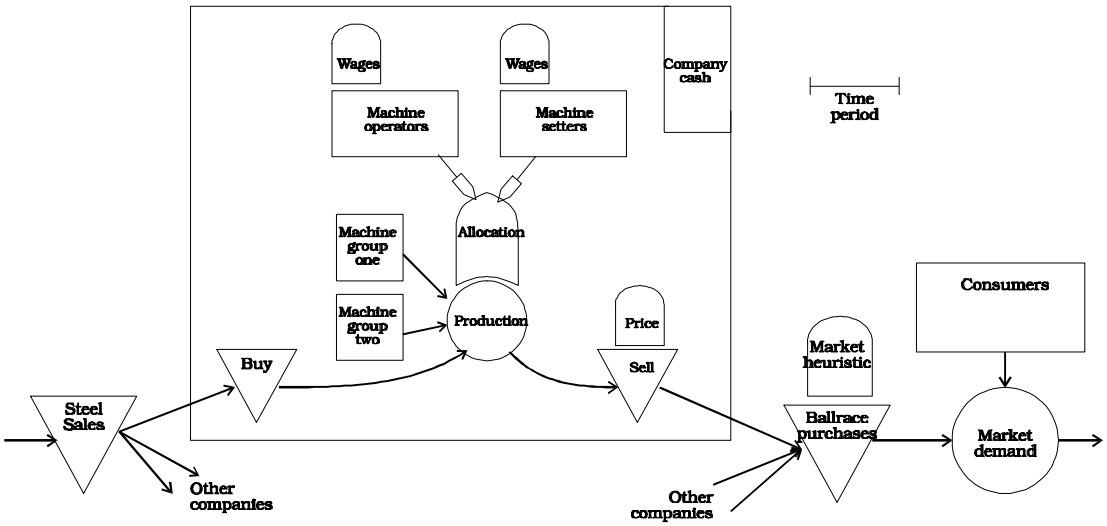
Ball Bearings Limited.

Ball Bearings Ltd (Boxer, 1977) is an example of a simulator designed to give managers experience in negotiation. This simulator was designed to create real structural choices for the negotiators as to how the relationships between and within companies could be formed. The creation of such choices was necessary if the conflicts experienced as a result of using the simulator were to raise strategic issues (Walton and McKersie, 1966). The simulator was designed to represent a variable number of companies, and the organogram below shows the decision role structure for one company in terms of the formal relationships between the roles, with particular regulatory activities being allocated to each decision role.



Thus, the managing director owns the company and has two managers working for him: the marketing manager, who is responsible for the relationships he creates with the other companies through the market; and the production manager, who is responsible for the relationship he creates with the workforce through wage negotiations. Representing the different skills within the workforce are two other decision roles which are responsible for the man-hours the workforce puts into the company in return for wages paid. The individuals using the simulator therefore have structural choice both about wages in relation to work effort and also about output levels in relation to prices.

In order to create an organisation context of sufficient complexity to support the negotiating behaviour of the individuals in the companies, the task structure shown below was designed. Each company transforms materials (passive sub-structures), bought in as steel, into ballraces. The supply of steel and the market for ballraces are external to the companies, and the supply is unlimited. The demand for ballraces is represented by a market heuristic, buying for a growing but price elastic consumer market. In this way structural choices open to the decision roles are limited to being made within their companies, and there is no ambiguity in the operation of the simulator's external environment.



Involved in each company is a production process which uses two machine groups (reactive sub-structures) and two types of skilled worker (purposeful individuals constrained to operate as goal-seeking sub-structures): setters and operators. The process is regulated so that control can be exercised over the level of production on each machine group. The simulator is designed so that no stocks are held by the company and no constraints are placed on the money surplus or deficit produced by the company. Boundary control is therefore exercised only over the relationship between the company and the market, and the relationship between the man-hours put into the company and wages paid to the workforce. The way in which these regulatory activities are allocated to the decision role structure is shown in the organogram.

The types of decision made by the managers within the decision roles are shown below. With the exception of the basic rate, all of the decisions can either be set at zero or can take a value. Thus, although the decision-makers do not have complete structural flexibility within the simulator's boundaries, each manager faces a large degree of structural choice within the areas of negotiation which the simulator is designed to support.

Price
Volume
Basic rate
Weekday overtime rate
Weekend overtime rate
Bonus rate
Days holiday
Days layoff
Maximum hours available at basic rate
Maximum hours available for weekday overtime
Maximum hours available for weekend overtime
Days strike
Worker effort variation

The same design approach was used to create other simulators for managers in the energy industry (The Power Game), in the manufacturer-retailing industry (Offal Industries), the European petrochemicals industry (Chemicals Consolidated), and the manufacture of television tubes (T.V. Tubes Ltd.). The approach is thus also used to give managers experience in making strategic decisions associated with industrial marketing, government-industry and public-private industry relationships. The

experience gained in using these simulators on courses has however raised some important issues, concerning how the simulators may be used by teachers, and, particularly, for what purpose they can be used within a given course context. These issues are considered in the next section.

Simulating Organisations

The use of the design symbols for defining the substructures within a manager's environment, and their relationships to each other, makes it possible to represent the resulting design in the form of a computer program. To make this possible, however, it is necessary to choose a timescale over which the simulator is to operate. In principle this must reflect the timescale over which the managers wish to explore the consequences of their decisions. In the case of industrial marketing the timescale chosen was three months, for the Power Game it was half-yearly, and for Ball Bearings it was yearly. A chosen timescale results in the allocation of a series of decision periods during which the managers interact with each other and the computer. Between these decision periods, time is accelerated. At the end of this period the consequences of decisions taken are reported to each decision role in the form of a computer printout:

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COMPANY 1 RESULTS FOR PERIOD ENDING: 30/6/1980
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PROFIT AND LOSS STATEMENT			£,000
SALES ON HOME MARKET AT £0.95			380
SURPLUS SALES AT £0.3			0
			380
	MATERIALS	123.2	
	LABOUR	120.6	
		243.8	
CONTRIBUTION			136.2
LESS	OVERHEADS	60	
	MARKET RESEARCH	0	
		60	
NET PROFIT			76.2

MAXIMUM PRICE FOR THE NEXT DECISION PERIOD £1.06

	SALES	PRICE	COSTS	PROFIT
	£,000	£	£,000	£,000
COY 2	440	0.8	334	46
COY 3	396	0.9	266	70
COY 4	405	0.9	272	73

****
COMPANY 1 RESULTS FOR PERIOD ENDING: 30/6/1980
****

	MACHINE GROUPS A	B
AVERAGE CYCLE TIME/UNIT		
TOTAL(MINS)	9.96	11.04
% PRODN	68.67	81.52
% SETTERS	10.24	9.24
PRODN COST/UNIT WITHOUT BONUS (P):		
BASIC	22	23
O/T 1	27	28
O/T 2	33	34
MAX. PRODN OUTPUT AVAILABLE		
BASIC	162650	244565
O/T 1	81325	122282
O/T 2	0	0
ACTUAL OUTPUT		
BASIC	162650	237350
O/T 1	0	0
O/T 2	0	0

	SKILL GROUPS PRODN A	PRODN B	SETTERS A	SETTERS B
NO OF WORKERS	15	25	2	3
VAR. EFFORT %	0	0	0	0
RATE PAID INCL BONUS (P/HOUR):				
BASIC	146	132	159	157
O/T 1	182	165	199	196
O/T 2	219	198	239	235
HOURS WORKED PER MAN PER WEEK:				
BASIC	40	40	40	40
O/T 1	0	0	0	0
O/T 2	0	0	0	0
TOTAL PAY PER MAN PER YEAR (£):				
BASIC	2624	2381	2871	2819
O/T 1	0	0	0	0
O/T 2	0	0	0	0
HOLIDAY	175	159	191	188
TOTAL	2799	2540	3062	3007

A number of issues arise which have to be considered by the teacher if he is to use the simulator effectively in supporting learning about structure. These issues fall into four areas: (i) the complexity of the simulator itself, (ii) the relationship the manager has with the simulator; (iii) the dynamics created by using the simulator; and lastly (iv) the boundary the whole learning activity has with other activities.

First of all, the main problems created by the complexity of the simulator itself have to do with the clarity with which its structure can be explained to the managers allocated to the decision roles. The technology should be easily accessible, the introductory documentation clear, and the logistics of running the simulator well organised. If the managers are able to help design their own simulator, many of these problems disappear, but even so the teacher has to be well versed in these technical matters.

Second, and more important than the complexity of the simulator, is the extent to which the manager can identify with the decision role he is allocated. If he is to be able to make structural choices effectively, he must find the decisions he makes and their consequences within the simulator familiar and related to his real world, so that he can operate in his individual way. The alternative is to force the manager to behave as someone he is not, which may be useful for learning about how others behave, but will not be useful if the manager is to learn about his own ability to manage ambiguity.

The importance of this relationship between the manager and the simulator makes the process of role allocation crucial. The teacher can allocate roles on the basis of three dimensions (Reed, 1976): first, by the control he exerts over which individual managers are allocated to which particular regulatory activities and what particular information they are given; secondly, by the formal relationships he can define between the decision roles; and, thirdly, by the effects both the mix of personalities and the physical allocation of rooms and space have on the informal relationships between the managers. The first of these dimensions is obviously constrained by the internal structure of the simulator, whereas the second is independent of it. The use of the last dimension is wholly dependent on the teacher's 'feel' for the managers and for the operation of the simulator.

Thirdly, the teacher must understand the dynamics of the processes generated by the simulator as it is operated. After the initial introduction to the simulator, the managers make their first strategic decisions. There is then a period during which those strategic decisions begin to take effect. During this time the managers' focus shifts from coping with the initial ambiguity created by the simulator to the tactical decision-making and developing relationships with other decision roles. After three or four decision periods, the interactions between the various strategic decisions begin to create new ambiguities which have to be resolved. The involvement of the managers therefore goes through a number of transitions: from technical learning about the simulator, to coping with ambiguity, to tactical decision-making, and then back to ambiguity. During this time no two managers are at exactly the same stage, and the learning derived from the experience is very much dependent on the managers becoming conscious of the structural choices they are making, both in the simulator and in their relationships with the other decision roles. The teacher therefore has an essential process role in supporting the managers' reflective learning (Casey, 1976).

Finally, to provide this supportive role effectively, the teacher must manage the boundary between the learning activity as a whole and other activities, both 'back at work' and, if it is the case, in other parts of the course. It is essential that the managers

commit themselves to a responsibility for their own structural choices and for the experiences produced by the consequences of those choices. Many course contexts make it difficult to create this learning contract with managers either because the methods being used elsewhere are normative, or because the managers themselves have dependent expectations. In essence, therefore, it may be said that while the simulators have the capability of creating an effective context for learning about strategic management, such learning is very much dependent on the relationships existing both between the players themselves and the teacher. Their behaviour is constrained and supported by the simulator but their learning is not determined by it.

Conclusion

The simulator is at its most useful when it can be used by managers to follow the link from theories of structure through to their own experience of structure. As such the simulator is a useful tool for the teacher, linked as it can be to the manager's experience of his organisation. It is as a method of supporting reflective learning that its full potential may be realised, and as such it has the ability to raise issues about the quality of the structural choices managers can make.

The computer fulfils an interesting role of allowing the manager to focus solely on purposeful activity within the context of his organisation. From the experience gained in the development activity outlined here, it would certainly be possible to automate the process of producing a simulator based on a particular design. The methods for doing this have also been explored elsewhere (Hudetz, 1977). Given this approach as a design tool, it makes it possible to create a simulator around the experience of particular groups of managers. The experience thus generated would enable the groups not only to explore their understanding of the structure of their own organisation, but also to test the implications of making different structural choices.

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