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PRIMATE PERSPECTIVES ON HUMAN EVOLUTION

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ABSTRACT
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PRIMATE PERSPECTIVES ON HUMAN EVOLUTION
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The work undertaken for this thesis addressed the issue of the relevance of study of living primates for inference concerning the evolution of social behaviour in extinct hominids. A series of studies are reported in which hypotheses concerning the evolution of human behavioural traits are evaluated using data and theory derived from primate studies.

These studies were as follows:

(1) a re-evaluation of Deacon's (1988a,b) model of human brain evolution and specification of a test of the model using archaeological data from the Lower Palaeolithic;
(2) a re-analysis of Dunbar's (1992) study of primate brain-social system relationships, using new data compilations and alternative multivariate statistical methodology;
(3) an experiment in simulation modelling of regional patterns of information exchange using primate dispersal patterns as a guide, and application of the model to interpretation of Acheulian biface morphology;
(4) specification of a new primate model of the origins and function of human language, and analysis of socioecological correlates of analogous behaviours in other living primates;
(5) pilot experimentation using a new method of evaluating claims for inbuilt human reasoning biases in the Wason selection task (Cosmides 1989), and using a personality test which differentiates individual subjects by their 'Machiavellianism' (following work in primate studies on the 'Machiavellian' hypothesis of primate brain evolution [Byrne and Whiten 1988]).

The introduction and the concluding discussion describe the relevance of these studies to the new paradigm of 'evolutionary psychology'.

Finally, in an epilogue the candidate notes the changing context of research in the higher education system, and suggests that a measure of relevance and application could be sought for these studies in the context of recent debates concerning the purpose of the undergraduate arts curriculum, particularly as this relates to the contrast between social and academic skills development.

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CHAPTER ONE: INTRODUCTION

INTRODUCTION

This thesis addresses several related issues in Palaeolithic archaeology. These all relate to the uses of interdisciplinary research in the solution of fundamental anthropological problems.

The issues are those of the evolution of the brain, cognition, language and social behaviour in the hominid lineage. In the Chapters which follow, I criticise a series of interpretive positions found in the Palaeolithic archaeological literature and offer alternative models derived from analyses of databases which are in the field of neighbouring disciplines. Principal among these is the database of comparative living primate anatomy and socioecology, as it has been compiled and used in biological anthropology and primatology.

The approach taken to human behaviour and its evolution is consistent with the various approaches currently being developed under the banner of 'evolutionary psychology'. This means looking at human propensities as the products of evolution, and thus of natural selection in primarily Pleistocene selection regimes. However, the extent and the specificity of the human propensities which are held to be the product of this process varies enormously between different schools within the 'evolutionary psychology' framework. For instance, whereas Cosmides and Tooby (1989) see evolved predispositions as highly domain-specific and modular determinants of human behaviour, Parker and Gibson (1990) see cognitive evolution as operating at the very general level of cross-domain ability as this is understood in the Piagetian tradition.

In this thesis, I look only at two specific evolved propensities, those of language and of cooperative social exchange. Moreover, I am extremely careful to specify the extent to which the mechanisms underwriting these propensities are or are not understood, since there is no point in looking for the fossil record of their evolution if we do not know what fossil character we are to look for. My interest is not in itemizing a list of these propensities, as some sort of sociobiological shoring-up of the billboards which proclaim the existence of human universals in the academic marketplace. However, in focussing on the individual's behavioural capacities I am certainly opposing myself to the extremes of social constructivism. In this respect, I am reminded of a phrase from a recent essay on 'Body, Brain and Culture' by the social anthropologist Victor Turner, who wrote that "the present essay is for me one of the most difficult I have ever attempted. This is because I am having to submit to question some of the axioms anthropologists of my generation - and several subsequent generations - were taught to hallow. These axioms express the belief that all human behavior is the result of social conditioning" (1983:221, quoted Brown 1991). The point is not that all human social behaviour can be reduced to this single level of evolved individual propensities. Quite evidently social behaviour is the product of processes which must be analyzed at several levels. However, if there is a real issue at stake it is that of the extent to which these processes can be analyzed as autonomous processes with respect to the organization of processes at lower levels.

The strategy used here follows Tooby and DeVore's (1987) arguments in favour of conceptual models. They note that hominid behavioural evolution must be reconstructed using a combination of empirical data and models, and propose that 'referential' models which use one real world phenomenon as a model for its referent, as in single-species analogies between living primate and extinct hominid strategies, should be abandoned. They propose that a stronger base will be found in 'conceptual models' - "sets of concepts or variables that are defined, and whose interrelationships are analytically specified" (*ibid.*:185). Strategic modelling in this sense denotes conceptual modelling of hominid behaviour based on the assumptions of behaviour genetics (genic unit of selection, phenotypic maximization of inclusive fitness), and estimation of model parameters based on a range of data: patterns of primate homology, modern human characteristics, palaeontological and archaeological evidence, and palaeoenvironmental reconstruction. Thus for example a model of extinct hominid brain function based on modern human analogies (for instance, presence or absence of Broca's area) is a referential model, as is a common chimpanzee model of the socioecology of *Australopithecus robustus*. A conceptual model, by contrast, would be based on comparative data on brain structure-cognition relationships across living species, and would interpolate cognition values on the basis of brain structure data from extinct species; a 'strategic' model would then incorporate the interpolated value for cognition parameters in the extinct species into a cost-benefit model of the evolution of this trait as an inclusive-fitness maximizing character in the ancient socioecological context.

Although I use all these types of data in this thesis, the particular focus is on use of living primate comparisons. The reason for this is that understanding of living nonhuman primates is increasing so fast that we need constantly to reconsider our assumptions concerning the key features of divergence in the evolution of human behaviour from a common ancestor shared with other living primates, and structured analysis of the comparative database on living primate anatomy and socioecology is one of the most useful ways of confronting that need and procuring the observational base for such a reformulation.

In this Introduction I shall briefly review my research strategy in each Chapter, and its relation to this overall project. I shall then discuss the methodological issues which this sort of hybrid research raises. Finally, in recognition of the difficulties such hybrid theses present for assessment, I shall briefly discuss the points in each Chapter which I believe to be original research contributions, whether of methods, ideas, experimental datasets, or compiled datasets from other sources.

CHAPTER SUMMARIES

Human brain evolution and Palaeolithic archaeology (Ch. 2).

In this Chapter I note the rise of 'evolutionary psychology', and argue that Palaeolithic archaeologists are well placed to test the models of Pleistocene adaptations which are invoked by 'evolutionary psychologists' to explain various human evolved propensities or predispositions. I take Terry Deacon's model of language evolution as a well-specified model which should enable us to locate the evolution of the capacity for language in the fossil and artefactual record. I reanalyse the data used by Deacon to reach contrasting conclusions to those which he reached, and develop two alternative models of human language evolution which can be tested using archaeological data. I outline a strategy for such a test. I suggest that such a strategy is necessary if we are to isolate the periods in the Pleistocene record of human evolution when the selection pressures for language ability postulated by evolutionary psychologists ought to have been in evidence.

The principal contribution of this Chapter to archaeological debate is probably twofold: the development of a testable hypothesis concerning the timing of the evolution of an evolved human propensity (speech), on the basis of comparative primate brain structure data, and the new emphasis placed on a primate model of the prefrontal cortex and its role in complex behaviours such as language and tool production, as an advance on the conventional archaeological emphases on symbolism or on the abstract concept of 'encephalization'.

Human brain evolution and hominid social systems (Ch. 3).

In this Chapter I argue for the importance of primate models of hominid behaviour and social systems, and discuss a recent integrated model of brain evolution which causally links interspecific variation in relative neocortex size to parallel variation in mean group sizes. I suggest that Robin Dunbar's model is fatally flawed both by empirical errors in data compilation and by the use of a bivariate methodology which masks the interplay of a number of intercorrelated factors in primate socioecology. I provide an alternative dataset and analyse it using an alternative methodology which is more sensitive to multivariate relationships, and conclude that the model which Dunbar presents is inadequate to explain the evolution of the human brain and language capacity.

Hominid culture and dispersal strategies (Ch. 4).

In this Chapter I follow on from previous Chapters on hominid brain-cognition relations and on hominid social system evolution, by addressing the issue of cultural continuity in the Acheulian tradition. Following on the work of Glyn Isaac, I propose an alternative model of the determinants of a sexual division of labour based on the occurrence of single-sex dispersal from the natal group, and report a simulation experiment designed to test the properties of regional social networks of different types. I conclude that a network in which the contacts between groups are made by dispersing individuals, and in which the pattern of dispersal distances corresponds to that thought to exist in African monkeys, best reproduces the patterns of variability and convergence on a mean which Isaac identified as the characteristics of Acheulian biface morphological diversity in space and time.

Structural and ethological models of human language: toward an evolutionary socioecology of talk (Ch. 5).

In this Chapter I criticise formalist models of language for eliminating intentionality in natural language use, and note both evidence for a foundation for syntax in the causal structure of the perceived individual environment, and evidence of the universality of relexivity in human natural language use. I propose an ethological model of conversational talk which derives from the analogy with social grooming, and emphasize the importance of prosodic elements of language in engaging conversational participants in a process of mutual affiliation and adaptation.

I note the recent interest among primatologists in species-specific temperament or dominance style, and in reconciliation behaviours, and argue that language has its closest parallels with other primate behaviours which play specific roles in maintaining valued social relationships in this way. I then examine the socioecological variables which appear to differentiate primate species by their 'dominance style', and propose a model of the evolutionary socioecology of dominance style in *Homo sapiens* which may account both for the later phases of language evolution and for the rate of global colonization in 'Out of Africa 2'.

Human evolved predispositions for social exchange (Ch. 6).

In this Chapter I report an experiment replicating Cosmides' findings of a content bias in human deductive reasoning skills, and extending her findings by looking for the personality correlates of this content bias in an undergraduate population. Cosmides argued that her evidence of a population-level increase in accuracy in reasoning about problems framed as questions of social exchange (entailing costs and benefits) indicates an evolved predisposition in humans for 'social contract reasoning' - a so-called Darwinian algorithm for detecting cheating, which manifests itself in this experimental finding of a content bias in reasoning skills.

This Darwinian algorithm is the most clearly specified instance of an evolved predisposition (after language) in evolutionary psychology. However, whereas in the case of language the anatomical correlates of language ability are fairly well defined, to the extent that one can set out testable models of their evolution in Pleistocene selection regimes, this is not the case for the 'social contract reasoning algorithm'. Consequently, in this Chapter I set out to define the nature and specificity of the underlying skills or cognitive modules which facilitate reasoning in these sorts of contexts. I use the Machiavellianism construct introduced into recent debate on primate brain evolution by Byrne and Whiten, and test subjects for Machiavellianism as an index of perspective-taking skills: the premise is that personality variation in social perspective-taking is a likely correlate of variation in accuracy in social exchange versions of the deductive reasoning task, after controlling for effects of 'general academic ability'. From an archaeological viewpoint, the point here is that there is no sense in modelling the Pleistocene socioecology of social contract-type cooperative behaviour unless one first understands the cognitive and physiological determinants of contemporary human propensities for social exchange.

Summary (Ch. 7)

In this Chapter, I attempt to draw together the findings of the various analyses and experiments reported in the preceding four chapters into a composite model of the evolutionary socioecology of hominids, and I attempt to specify its relationship to the 'evolved propensities' or predispositions which are the focus of 'evolutionary psychology' of modern human behaviour.

Epilogue: the search for relevance and application (Ch. 8).

In the epilogue, I discuss the current state of higher education in Britain, on the premise that this is both the institutional base for pure research (including research into the structure and evolution of human social behaviour), and the primary site for communication of the results of that research. I argue that both contemporary policy shifts and the tenor of the research which I have discussed in the body of this thesis mandate a more careful consideration of the nature of the contract between teachers and students in first degree courses, particularly where the focus is on transferrable skills and abilities which can be used outside the specific task domain of the degree subject. I take some care to support my claims about the nature of these policy shifts using tabulated and graphed data, since this is not an area which researchers in a particular subject discipline tend to recognize as amenable to quantitative (as contrasted with emotive or partisan) analysis. Finally, I note the evidence for a distinction between social and academic intelligence, and propose that the research focus of this thesis could lead on to a reconceptualization of undergraduate curriculum design as a form of 'active research' designed to experimentally implement the models of human cognition and behaviour which are the focus of 'evolutionary psychology'.

METHODOLOGICAL ISSUES IN INTERDISCIPLINARY RESEARCH

It is quite common to hear researchers using, but also disclaiming responsibility for the quality of work conducted outside their own specific field of research competence, on the grounds that they are incompetent to assess it. Equally, it is quite common (perhaps increasingly common) to hear researchers denouncing models of the phenomena which are their specific research focus, when these models are constructed by scholars whose expertise is in other fields or other disciplines. Most frustrating of all, it is increasingly common for researchers whose area of expertise is not that of human evolution, to denounce all reconstructions of the specific course of human behavioural evolution as speculative exercises in myth-making.

These strategies jointly lead to the inevitable cosy introversion of clustered invisible colleges, each conducting only internal communications, and accepting findings in other fields on the basis of faith in the internal efficiency of professional standards as mechanisms for maintaining overall coherence in the 'scientific enterprise'. It is not surprising, therefore, that when general models are constructed of complex phenomena such as human brain and language evolution, these should so often seem tainted by the flavour of quirkiness or amateurism.

My view is that this represents a serious problem for the intellectual integrity of scholarship, and should not be dismissed as the acceptable cost of disciplinary specialization. Certainly, it is an arduous process understanding work in other research fields, which may have become highly specialized and have evolved a high degree of tacit knowledge and lexical specialization. Equally, it is certainly the case that only workers disciplined in the methods and conceptual apparatus of that research field can reliably be expected to generate genuinely new and progressive synthetic models of their special topics. Nevertheless, to refuse to take responsibility for assessing the adequacy and quality of what is going on in neighbouring research fields cannot be acceptable in areas where there are many problems, few researchers, and thus a high probability of undetected error in the current state of analysis of any single problem. This applies all the more when we are working in a field which bears so directly on the definition of what it is to be human, and on how we have come to be - issues of personal and social identity which by that token are also issues in the political negotiation of recognition, of obligation, of ethics and of rights.

As a consequence, I would argue that my attempts to assess work in neighbouring fields (biological anthropology, Darwinian psychology) should be seen as signalling my acceptance of that responsibility toward the wider goals of scholarly research. The adequacy of my assessments must then be judged on the basis of the quantitative methodology used, and the clarity with which I may have suceeded in defining a problem in another field which needs to be resolved before proceeding to build models of archaeological processes. After all, the assessment of research in relevant neighbouring fields presupposes a basic accessibility to researchers in other fields of the methods and databases used, and it would be more than worrying if that presupposition was seen as *a priori* untenable.

A NOTE ON ALLOMETRY AND METHODS.

The analyses reported in Chapters 2 and 3 are based on regression analysis of primate datasets using the least squares model (conventionally, the most common model used in allometric line-fitting). There has been a lot of debate about line-fitting techniques in biology during the last ten years, the upshot of which is that least squares regression may not be suited to this kind of analysis. The reasons for this are as follows: the least squares model assumes no error variance in the X variable, and a bivariate normal distribution of data points. Biological data often contains error in the X variable, such that a symmetrical line-fitting model would be more appropriate. Furthermore, if the existence of a strong bivariate linear relationship implies the action of natural selection, then we may expect data to be normally distributed in the plane perpendicular to the line, and not normally distributed along any axis drawn through the scatter, while there is also no biological reason to expect either X or Y variables to be normally distributed in themselves. This leads Martin and Barbour (1989) to argue for use of other line-fitting techniques, such as major axis (which minimizes "the sum of the squared perpendicular distances between individual points and the best-fit line"[*ibid.*:68]), and the reduced major axis (in which the slope is simply "the ratio betweeen the standard deviations of the two parameters Y and X" [*loc.cit.*]). However, Martin and Barbour are equivocal as to the best method of deriving exact residuals for estimating deviation from a line and for partial correlation analysis.

In the circumstances I have stuck with the traditional least squares method, while accepting that this may introduce errors into the calculations both of slope and of correlation coefficient. This is partly because the work I criticise, by Deacon and by Dunbar, also make use of this model. Deacon's analyses were based on least squares regression analysis of comparative primate brain structure data, while Dunbar, who used reduced major axis techniques to fit lines in his bivariate analyses of brain size and socioecology, nonetheless apparently used the least squares model to derive partial corrrelation coefficients in his multivariate analyses. While I may have lost some accuracy in bivariate line-fitting, my points about data compilation, data transformation prior to analysis, and about the importance of multivariate analysis of complex life history databases, retain their validity. Indeed, the fact that partial correlation analysis depends on estimating residuals from multiple regression equations derived by the least squares method highlights a statistical deficiency which may stimulate further work to make path analytical techniques compatible with what is alleged to be the typical shape of biological data distributions.

Given the uncertainty of many of the individual data used in these analyses, it is perhaps particularly important to understand the status of statistical analysis in this field: namely, to refine hypotheses and suggest directions in evolutionary modelling which may be the most profitable or consistent with what we presently understand. It is a grievous error to confuse the asterisks of a statistical significance test, or even the strength of a correlation coefficient in a bivariate regression, with confirmation of a causal model: the problem of latent variables, and the problem of inaccurate estimation of coefficients and exponents of slope, remain even when a bivariate analysis appears to have conclusively demonstrated and described a strong linear relationship between two variables.

ORIGINAL CONTRIBUTIONS OF THIS RESEARCH TO PALAEOLITHIC ARCHAEOLOGY

In conclusion to this introductory Chapter, I would like to point out areas in which I think that I have made significant original research contributions. I should perhaps point out that this is at the specific request of my research supervisor, and is a response to the anticipated difficulties of assessing a thesis which makes eclectic use of methodologies encountered in more than one field outside the discipline of archaeology.

Chapter 2 is original in its reanalysis of Deacon's work, and in its development of a summary of the functional role of the prefrontal cortex in cognition as applied to archaeological problems (for instance, the concept of '*chaine operatoire*'). Furthermore, it is one of the first attempts to derive archaeological tests of the theories of 'evolutionary psychologists'.

Chapter 3 is original in its reanalysis of Dunbar's work, in its use of path analysis as a tool in primate allometry, and in its compilation of a number of new tables of comparative primate data from a number of sources.

Chapter 4 is original in its specification of an implementable network model of cultural diffusion, and in its use of network models of role segregation in primate social systems. It is also original in addressing the question of the archaeological evidence for regional interaction systems using the dispersal patterns of monkeys as a reference point.

Chapter 5 is original in the direction taken in its ethological model of language evolution, in its use of new trends in primate socioecology to specify a model of language as a behaviour characteristic of a species with relaxed dominance style, and in its proposal of a model in which language and global dispersal are seen as the joint products of a latent variable emerging in the evolution of anatomically modern humans, namely a decrease in dispersal costs.

Chapter 6 is (astonishingly in view of the size of the academic psychological community) original in its attempt to look for the correlates of individual variability on the Wason task, and in its use of the Mach V personality test (which tests for

Machiavellianism in a very direct way, but which is evidently unknown in the research commnity associated with Byrne and Whiten).

Finally, the Epilogue (Chapter 8) makes original points within archaeological debate, and gives new compilations of data on a number of variables both within archaeology and at the level of disciplinary and faculty structure in the British university system as compared with other systems abroad.

In conclusion, I would ask assessors to bear in mind the additional originality which is entailed in adopting such an eclectic research strategy in pursuit of solutions to research questions which are still emerging on the archaeological and palaeoanthropological agenda. They must be the judges of whether that originality is a form of virtue, or a form of deviancy.

CHAPTER TWO: ARCHAEOLOGICAL CORRELATES OF LANGUAGE CAPACITY, TWO MODELS.

INTRODUCTION.

Palaeolithic archaeology and the Darwinian approach to brain-behaviour relationships.

After the dominance of the postprocessual school in British archaeological theory, there is an increasing turn to evolutionary theory and to the development of models of human social behaviour and of cultural transmission and cultural change which draw on evolutionary theories of culture. This includes the postulating of universal behavioural predispositions which shape human actions in diverse contexts. For archaeology, the principal interest is likely to be in the behavioural predispositions which underly the information exchanges that generate or maintain cultural 'signatures' in the archaeological record.

The appropriate framework for analysing 'evolved predispositions' in contemporary human populations would seem to be *evolutionary psychology* as advocated by Tooby and Cosmides (1989), focussed on itemizing the set of (mostly domain-specific or special purpose) psychological mechanisms that allegedly generate and shape culture. Their own work focusses especially on human evolved predispositions to participate in social exchange relations where there are costs and benefits, and where it is necessary to detect cheating - simple social contracts. Tooby and Cosmides argue that the appropriate level of analysis of such mechanisms is the cognitive-psychological (modelling of the cognitive processes underlying observed behavioural tendencies), rather than the neurophysiological (observing the actual neural circuits implementing such behavioural strategies), which they characterize as an "immensely intricate and largely unknown area" (*ibid.*:32). Similarly, Prince and Pinker (1988) argued that the naturalistic claims for connectionist modelling of neural networks in language acquisition were too reductionist and ignored the complicating design features of ordinary language, which could only be given their appropriate weight by cognitive scientists (working at the level of rules, representations, and symbol systems). By implication, the strategy of evolutionary psychology in contributing to a new science of culture is to proceed from observed behavioural predispositions to cognitive or information-processing models, and then to generate 'scenarios' of the natural selection context in which the proximate cognitive mechanisms of these behavioural predispositions would have been adaptive.

Advocates of this Darwinian framework will therefore look to palaeoanthropology and Palaeolithic archaeology to provide a sequence and a time scale for the evolution of some set of behavioural 'predispositions' (which may be so universal and canalized as to appear to develop in individuals as innate modules), an account of their organization as this affects transmission probabilities for cultural traits, and an analysis of the adaptive context in which these predispositions evolved in the hominid lineage. This has a spin-off benefit for Palaeolithic archaeology: the Palaeolithic archaeological record becomes the testing ground of hypotheses concerning the evolution of hominid behavioural predispositions, testing them against hard evidence of tool-use, ranging, foraging strategy, and (by extending the evidential field to include palaeoanthropology) of evolving functional anatomy and life history strategy.

Palaeoanthropology is best placed both by tradition and by the nature of its database to contribute to the debate on the neurophysiological implementation of such predispositions, as monitored by absolute and relative brain size increase and by neocortical evolution in the hominid lineage. A strategy with which the palaeoanthropologist may therefore have greater affinity is that of 'comparative-developmental evolutionary psychology' (Parker and Gibson 1990), based on the integration of human developmental psychology, comparative studies of primate abilities, and the evolutionary biology of brain size and maturation rates across taxa as a correlate of these cognitive-developmental similarities and differences. What we need to move towards is a new synthesis: the psychological modelling of evolved predispositions (imitation, social learning, language, etc.) and the evolutionary neurobiology of their implementation. *Palaeolithic archaeologists* can contribute to the analysis of evolving hominid social behaviours through correlational analysis of hominid morphology, lithic assemblages, dietary and ranging strategies, and cultural site formation processes, as these vary in space and time as functions of the behavioural capacities of a fossil morphology, of habitat variation, of social network structure, and thus even of neutral 'inertial' factors in cultural transmission through descent lines.

PART ONE.

Human brain evolution and evolutionary psychology.

In this Chapter, I want to describe a recent model of the evolution of the human brain which postulates a functional reorganization in *Homo* as contrasted with nonhuman primates and which speculates that this reorganization was driven by selection processes favouring language evolution. I shall then give evidence and analyses of extant primate brain organization which call into question the validity of this model, propose an alternative model, and propose a way in which the archaeological record can serve to test predictions derived from the two competing models. The object of this exercise is to show that Palaeolithic archaeology has a central role to play in falsifying or strengthening the claims of rival accounts of human behavioural predispositions and their evolution.

The model which I shall examine is that proposed by Terrence Deacon in a series of recent publications (1988a,b, 1990a,b,c), in which he uses primate comparisons to argue for a divergent course for human brain evolution since the appearance of genus *Homo*. Deacon conducted an axonal tracer study of the homologues of the Broca and Wernicke areas in the macaque brain. He found that a homologous fibre tract linking the two areas exists in this monkey species to that found in humans (the arcuate fasciculus), and which has been held to implement our speech production and conmprehension abilities by linking the auditory and speech motor areas in a cortical circuit loop (Deacon 1988a). Deacon argued that since this circuit appeared not to subserve vocalization functions in the macaque, it must represent an 'exaptation' in the human lineage, by which an inherited circuit of uncertain original function was taken up and used as a fundamental part of human language circuitry.

Deacon then presents an ingenious and elegant reinterpretation of data on human and nonhuman primate brain structure volumes to complement this finding (Deacon 1988b). Specifically, he argues that while absolute brain size is a more appropriate gauge of brain organization in primates than brain size relative to the size of the body, models of human brain evolution which hold that the *human* brain organization is the product of the same allometric scaling ratios as those of other anthropoid primates are construed on the basis of faulty statistical analysis. If one regresses data on the size of the neocortex against data on size of the whole of the brain for anthropoid primates, the human datum lies comfortably on the regression slope. However, the neocortex is a large part of the whole brain volume, such that one is not comparing two distinct variables. If we regress neocortex against the volume of the rest of the brain, the human datum lies far above the regression line: we seem to have more neocortex than would be expected for an anthropoid primate with our quantity of non-neocortical brain tissue.

Deacon extends this reanalysis, aggregating data on anthropoid brain structures into two categories, cortical and nuclear, according to their tissue type and mode of developmental expression. When the same regression analysis is performed on these data sets, the results appear conclusive: humans have far more cortical neural tissue than would be expected for an anthropoid with the human volume of nuclear structures. This is, then, an apparently unrecognized anomaly which may explain the superiority of human brains over those of other primates for many complex, iterative, or generative cognitive tasks, since it is in the cortical tissues that such computations take place.

Deacon then generates a model of the evolution of changes in developmental timing for different stages of ontogenetic brain growth which can explain this divergent course of human brain evolution. He argues that the disproportionate enlargement of cortical structures in the human brain could have resulted from a high-level genetic change relating to the migration of neurons to form cortical layers during embryogenesis: "Whatever the causes of cellular overproduction in these structures they must have their effect at this early stage of neurogenesis in order to produce a correlated deviation of size in such diverse brain structures" (Deacon 1988b:398).

We may recall, then, Deacon's arguments that the human brain deviates from primate trends in a disproportionate increase in 'cortical' structures (including neocortex, palaeocortex, septum, cerebellum, pallidum) relative to nuclear, grey-matter structures (Deacon 1988b), and we may recall also that the human *body* appears to develop at growth rates which are in many local aspects *retarded* relative to primate trends (discussion in Shea 1989). Variation in growth rates and in adult body size (as in human pygmies) appears to relate to circulating levels of growth hormone (Shea 1989, cf Armstrong 1990): Deacon (1990b) has suggested that the relationship between cortical:grey matter disproportion in the human brain, and brain:body size deviation relative to primate trends, are causally related due to the role of the hypothalamic-pituitary system (a grey-matter brain structure) in regulating target adult body size through growth hormone secretion. This is Deacon's 'King Kong' hypothesis (1990?:275): in human evolution, the brain tissues which have become enlarged are those which are are not involved in regulating postnatal growth, such as the hypothalamus. Consequently, in human evolution (by contrast with brain evolution in other anthropoid primates), relative brain size is a key index of brain organization: the relative expansion of the cortical structures in *Homo* is necessarily accompanied by an increase in the ratio of brain to body size.

In addition, Deacon draws attention to apparent anomalies in the functional division of processing tasks within the human neocortex which also appear to diverge from anthropoid allometric trends. In particular, we have a proportionally reduced area of neocortex given over to the primary visual assocition area in the occipital lobe (at the back end of the human cerebral hemispheres), but we have a proportionally enlarged area in the front of the neocortex given over to the functions which underwrite complex, flexible, hierarchically structured motor output - namely, the prefrontal area. Indeed, according to Deacon (1988b), the prefrontal area of the human brain takes up twice the amount of the human neocortex which would be expected for an ordinary anthropoid primate with a neocortex that big. It is for this reason that specialists such as Fuster (1991:558) have noted "the supreme specialization of the entire prefrontal cortex, including Broca's area, in the brain of the human".

Although language development is generally held to be a domain-specific human trait, distinctive features of the behavioural capabilities of pre-linguistic infants (lesser ability to inhibit habituated response sequences, a basis of behavioural flexibility) relate to the degree of maturation of the prefrontal cortex, rather than to the independent acquisition of language (Diamond 1988). Furthermore, clinical evidence suggests that meaning in language is dependent on the integrity of nonverbal analogue mental representations (Bisiach 1988), rather than the reverse. This suggests that design features of language such as flexible, recombinant formulation, and semantic richness derive from more general organizational features of the human brain (relative size of the prefrontal cortex, absolute size of cortical association areas). Deacon's findings, of a homology for the speech motor and auditory comprehension circuitry, but a doubling in the relative size of the prefrontal area, therefore seem to give a conclusive account of the key neural correlates of human language ability as these are the product of a divergent brain evolution from the anthropoid pattern.

Deacon's model of human brain evolution is complex, not least because of the numerous different strands which he weaves together to compile his overall account of what is different and how the differences arose. For our purposes, however, it is necessary to understand one further aspect of his model, and this is his account of the processes which led to the evolution of a functional reorganization of the human neocortex itself (particularly, the expansion of the relative size of the prefrontal area). Deacon (1988b, cf 1990c) argues that the functional division of the neocortex is ultimately a product of an equilibrium-seeking process in which different input-output circuits compete for neuronal connectivity and network extension in the neocortex, and in which the competitive differentials derive from differences in the strength and number of the input signals which are processed in different projection areas of that brain structure. Specifically, in the human neocortex, incoming signals from peripheral structures such as the eye (via the optical tract) will have an input strength and frequency which scales with eye dimensions, such that with a relative neocortex size which is so great compared to the size of the body (and thus of the eye), the area of the cerebral hemispheres which is primary visual association cortex receiving projections from the eyes will be proportionally reduced. Contrariwise, areas such as the prefrontal area, which are involved in working memory functions and in integrating sensory data with motor output and which are most densely interconnected with other neocortical areas (reflecting the prefrontal area's role as a high-level integrative centre) are not constrained by the scale of peripheral input signals in any so direct a fashion. These areas will have a competitive advantage in the parcelling out of the neocortex into functional areas, and thus appear proportionally enlarged in the human brain. In fact, Deacon (1990c) has also suggested that while this allocation of computational resources according to strength and number of incoming signals may initially represent this kind of 'equilibrium-seeking' process, in the course of subsequent evolution this neocortical reorganization will become fixed by developmental biassing factors favouring the fixation of the new pattern of neocortical connectivity, leading to a secondary implication of some sort of irreversibility to human brain evolution, as an expression of 'Dollo's Law'.

Given Deacon's neuroanatomical work on homologues of human speech circuitry in macaque neocortex, it seems likely that the inspiration for Deacon's elaboration of his observations on neocortical functional reorganization derived from the assertion by Blinkov and Glezer (1968:179) that:

"The regions of the cerebral cortex may be subdivided into three groups according to the change in the size of their surface from the macaque to man: (1) regions in which the relative size increases (frontal, temporal, inferior parietal); regions in which relative size is stable (precentral); (3) regions which decrease in size (occipital, limbic, archicortex, and paleocortex).

Thus, the relative size of the regions mainly associated with speech, gnosis, and praxis increase in size most intensively during phylogenesis."

It is clear, however, that Deacon has taken this observation to a level of sophistication which is an order of magnitude more systematically modelled and specified than this early proposal. Deacon sees these analyses as going beyond any previous work on human brain evolution. To encephalization theorists such as Jerison, he points out that absolute brain size is the key index of brain organization, but that relative brain size is a key index in human brain evolution (although for more complex reasons that encephalization theorists have believed). To Passingham (1982), who has argued for the importance of allometric scaling ratios to absolute brain size for anthropoid primates, including 'the human primate', he reasons that the part/whole bias in neocortex/brain volume regression has masked the extent of human divergence from anthropoid trends.

Finally, to theorists of mosaic reorganization such as Holloway, he points out the conservatism of the speech motor and auditory language circuitry, and the importance of allometry to the expansion of the prefrontal area in the human neocortex. This implies that human brain evolution *and correlated brain reorganization* are the product of a set of simple alterations in the growth rates of these different elements of anatomical structure. Indeed, given the gross morphological differences between humans and chimpanzees, and the closeness of the genetic constitution of the two species, we should expect human evolution to have been largely the product of such simple changes in the regulation and timing of development of different bodily structures. I have long regretted the difficulty for archaeologists of appreciating the elegance and sophistication of Deacon's model, since for the Palaeolithic archaeologist who is interested in the archaeological correlates of language and cognitive ability in ancestral hominids, the implications are revolutionary.

Deacon's model and the Palaeolithic archaeological record: some implications.

I have described Deacon's model and shown how the increasing role of the prefrontal area in the human neocortex seems to be a product of reorganization in human brain evolution. In fact, Deacon proposes a tentative evolutionary scenario for human brain evolution, which summarizes the points I have just discussed, and also indicates a probable rough time scale for the evolution of this divergent brain growth trajectory (Deacon 1988b:408). I want to quote that scenario in full, despite the length of the quotation, since it sets the position statement from which I shall work in the remainder of this Chapter.

Deacon's scenario (*loc. cit.*) is as follows:

> "The earliest development of symbolic communication (in whatever form - probably multimodal) approximately two million years ago provided significant (unspecified) reproductive advantage to those most facile with its acquisition and use and so established powerful selection for these abilities. Most

> significant of these were selection for enhanced learning of complex conditional associations and enhanced oral-vocal motor-sequencing skills. Since prefrontal areas, and most particularly the posterior inferior region destined to become Broca's area, play a significant role in these functions, increased information processing capacity of these areas was selected for. This relative increase of functional capacity (and perhaps functional dominance of these processes over other competing processes) occurred in brains in which these areas occupied a relatively and absolutely larger proportion of the cerebral cortex than in a typical large ape brain. However, the ontogenetic process by which prefrontal areas acquired proportionately more cortical space is indirect (though perhaps the most direct mechanism when one considers embryological constraints) and involves many other areas than just prefrontal cortex. On the bases of volumetric analyses of brain structures I have proposed an ontogenetic mechanism for this change that does not invoke a highly specialized genetic basis. Rather, an essentially bimodal distribution of neuron overproduction throughout the brain is responsible for a cascade of secondary, system by system parcellation processes, one of which is relative prefrontal expansion. The overall expansion of brain volume relative to body size is considered secondary to this effect. The evolution of language is thus considered the principal correlate of human brain evolution, implicated in the beginning stages of relative brain enlargement two million years ago. Relative brain enlargement is correspondingly the major fossil indicator of brain reorganization for language. It suggests that neural specialization for language began with *Homo habilis* and essentially reached the modern condition in neanderthal and archaic modern *Homo sapiens* specimens with modern brain-body proportions."

It is important to understand that this is speculative inasmuch as the relative expansion of the prefrontal area has consequences for many different activity domains, of which language is only one. In Figures 2.1 and 2.2 I have summarized some recent discussions by specialists of the cognitive and emotional role of the prefrontal area in regulating behaviour in humans. The comparison of models of prefrontal function in human neuropsychology and in Goldman-Rakic's monkey-based work (Figure 2.1) comes from a study by Daigneault *et al.* (1992). In this study, the authors tested two opposing models of prefrontal function empirically using normal human subjects. From work in human neuropsychology, they derive a set of functions which have been held to represent the core role of the prefrontal area in regulating behaviour: planning (or the elaboration of strategy), and execution of sequences of planned responses; self-regulation of behaviour in response to environmental contingencies (including one's own errors); maintenance of a nonautomatic cognitive or behavioural set; spontaneity/sustained mental productivity; and spatiotemporal segmentation and organization of events. The functional constructs drawn from the literature in human neuropsychology proved less robust in this test than the functions postulated in Patricia Goldman-Rakic's more globally specified model (e.g. Goldman-Rakic 1987), which involve the area as a sort of executive workspace in which sensory, mnemonic and symbolic representational input from other cortical areas are held 'on line' in representational memory "long enough for this live memory to modulate behavior appropriately despite the absence of external contingencies or despite the presence of external task-irrelevant 'discriminative' stimuli" (Daigneault *et al.* 1992:50).

The quotations from three other recent papers on this area and its functional role (Figure 2.2) amplify this point (Fuster's model of the prefrontal area's role in 'mediating cross-temporal contingencies'), and draw attention also to the underlying motivational factors which are involved in prefrontal activation, particularly with respect to the approach phase of a complex episode of appetitive behaviour.

For the *Palaeolithic archaeologist*, the relevance of this is surely that prefrontal cortical expansion in hominids has implications not just for language capacity, but also for the capacity for fine motor output in other domains, including manual object manipulation. If, therefore, we can devise protocols for quantifying the complexity of some 'prefrontal measure' of artefact production or spatial behaviour, we can not only make strong inferences about analogous development of language capacities, but also test models of the timescale of their evolution (inasmuch as the artefacts are linked to a fossil hominid of known brain and body size). Thus, we can set out to *test* models such as Deacon's using the Paleolithic archaeological record. In this endeavour, we are following in the footsteps of Glyn Isaac, who argued in 1976 that "Comparative studies can indicate phylogenetic patterns, while detailed understanding of the structure and physiology of modern human linguistic capabilities can suggest possible successive stages of prehuman development; however, beyond a certain point, historical understanding demands dated evidence for successive developmental stages. This record, if it is to be obtained at all, must be sought from paleontologists and archaeologists. It is probable that the search is not quite as hopeless as it may look at first glance, but it is equally certain that there are no very simple answers." (1976:2750).

I shall consider language indicators at greater length later in this Chapter, but let me now suggest a number of possible archaeological indicators that may be amenable to use as a 'prefrontal measure'. They are in two domains: artefact study and intrasite spatial patterning. In artefact study, I propose a measure derived from the notion of hierarchical constructional skills (Gibson 1990, Greenfield 1991), and suggest that this can be found in the already-existing literature on '*chaines operatoires*' and, perhaps, in the literature on artefact elaboration and differentiation. In the domain of intra-site spatial patterning, I propose to derive a measure of spatial segregation of activity patterning, based on an observation of Brothers and Raleigh (1991) that nonhuman primates are adept at parsing social scenes and adjusting their spacing behaviour relative to others in a group according to rules of geometrical relation and category membership (analogous to the generative rules underlying human language). The hypothesis here is that spacing behaviour of this sort (i.e. governed by social rules) may also entail the sort of working memory-intensive calculations which are implicated in Goldman-Rakic's model of the prefrontal cortex of the primate brain.

PART TWO.

Testing Deacon's model of human brain and language evolution against the neoanthropological data.

In the course of this study I had reason to replicate Deacon's statistical analyses of the primate brain volumes database, and found sufficient cause for concern as to the accuracy of his own interpretations of the differences between human and nonhuman primate brains which are in need of explanation. A scatterplot of cortical structures against the complementary half of the brain (I used telencephalon less olfactory structures, and less piriform lobe, combined with cerebellum as a proxy index of cortical structure volume) shows that the primate are themselves a 'grade' of corticalization higher than the basal insectivores (Figure 2.3). While one might expect the hypothalamus of all members of this database (insectivores and primates) to scale to body size, this does not appear to be the case: again, hypothalamic volume in primates is a grade greater relative to body size, compared with basal insectivores, while the scatterplots of hypothalamic volume against body size and against brain size suggest that the hypothalamus scales with the latter rather than the former, across these two grades of corticalization in insectivores and nonhuman primates (Figure 2.4). If we graph the log-log regression slopes of neocortex against rest of brain volume for the insectivores, prosimians, and nonhuman anthropoids, we see that the grade effect appears also to differentiate anthropoids from prosimians (Figure 2.5). This observation holds if one conducts the same exercise with data on cortical versus noncortical structures (Figure 2.6). This suggests that the grade effect of expansion of cortical tissues relative to nuclear tissues is not unique to human brain evolution, but has been a repeated pattern in primate brain evolution in general. Furthermore, it raises the question of whether there is any causal relationship between grades of corticalization and grades of encephalization (in the sense of total brain size relative to body size). The first question then becomes, given that for the human 'grade' alleged by

Deacon we have only a single data point, is the evidence really conclusive that the humans diverge sufficiently form anthropoid scaling ratios to justify interpreting the human brain as the product of divergent evolution? The second question becomes, is body size causally related to corticalization grades either in nonhuman primates or in humans in the way which Deacon has suggested?

In Figure 2.7 I have graphed the point scatters of data for anthropoids in a regression of neocortex volume against rest of brain, firstly with both variables unlogged and then with both variables logged. The regression residuals have also been plotted, with species codes for points which appear to show greatest deviation from the regression line. It will be clear from the unlogged regression scatterplot that the data distribution violates the rule of least-squares regression that data must be distributed normally. Thus the apparent patterning in the residuals, which suggests that *Homo* is an outlier point, disappears in the log-log regression, where the effects of the long positive tail in the unlogged distribution is removed. In other words, after transforming the data to meet the assumptions of the regression model, there is no indication that *Homo* has markedly more neocortex (relative to the rest of the brain) than would be expected for an anthropoid of that brain size(in fact, *Homo* lies just outside the first confidence interval above the log-log regression line). This is surprising, since the scatterplot of neocortex against rest of brain volume for the insectivores, prosimians, and anthropoids suggests that grades of 'corticalization' are pretty clearly visible in the vertical separation of the grades in the neocortex/rest of brain relationship alone. We should note, however, that for prosimians and for anthropoids the slope coefficient of the relationship between neocortex volume and rest of brain volume is steeper than isometry (Figure 2.5), such that larger brains will have proportionally more neocortex, and that given the large absolute brain size of *Homo* this alone could explain the increase in 'neocortex ratio'.

The same exercise was repeated for data on anthropoid cortical versus noncortical structure volumes, with less clearcut results (Figure 2.8). Logging both variables has the effect of proportionally reducing the residual deviation of the *Homo* datum from the regression slope, but the datum for *Homo* remains just outside the second confidence interval. Thus we cannot reject Deacon's interpretation of the anthropoid primate data as showing that humans are a corticalization grade above the nonhuman anthropoids, after controlling for absoute brain size scaling. However, further investigation clarifies this result. The classification of structures into cortical and noncortical or nuclear stands or falls on its validity in embryological terms. If we individually log-log regress the various 'cortical' structure volumes against aggregated nuclear structure volume data for the anthropoids, we find that in all cases but two the *Homo* datum lies inside the confidence intervals for this relationship: thus *Homo* has no statistically significant difference from other anthropoids in volume of cerebellum, striatum, schizocortex, or hippocampus, relative to the anthropoid trend, when these are regressed individually against total volume of the nuclear structures. This is not the case with neocortex or septum (a small component structure in the telencephalon), for which the *Homo* datum lies just outside the second confidence interval as regressed against the nuclear structure aggregated datum. What is relevant here is that while for *Homo*, the other 'cortical' structures are not significantly deviant from the anthropoid trend, they are mostly above rather than below the regression line. Thus by aggregating these structures and thus reversing their effects on the neocortex/rest of brain regression, the total figure pushes the *Homo* datum over the confidence interval for this relationship. The problem then is that the justification for dividing brain structures up into these two categories must now be found in embryological and neurodevelopmental theory, rather than in the data themselves.

There is a further cause for concern with Deacon's result, however, and that is that he (like me) used least-squares regression to derive best-fit lines for this dataset. This technique tends to underestimate the slope exponent for bivariate relationships with r-squared values less than c. 0.97, and the high positive residual deviations from the line reported for *Homo* in the foregoing paragraph may be an artefact of this methodological error. This will be checked by reanalysis using major axis or reduced major axis line fitting techniques in future extensions of this work.

We see, therefore, that Deacon's reasoning about the divergent evolution of human brain organization from the anthropoid plan rests on fairly weak or ambiguous statistical grounds. How well does his account of the functional reorganization of the human neocortex stand up to closer analysis?

We may note at the outset that only two subdivisions of the human neocortex appeared to deviate to a statistically significant level from anthropoid scaling trends in Deacon's own analysis, due to the paucity of data available for other areas. These two subdivisions were the area striata (primary visual association cortex), and the prefrontal cortex. With regard to the first of these, my suggestion is that we should expect primary visual association cortex to scale not to neocortex size, but to the size of the peripheral optical system - for instance, retinal surface area and cone packing, or optical tract cross-sectional area and fibre density. A scatterplot of data on neocortex size, area striata, optical tract, and lateral geniculate nucleus size (the thalamic relay nucleus for this system) suggests that this may indeed be the case (Figure 2.9). The way to test this would be to use data on eye size and complexity: my prediction is that area striata volume should scale to the peripheral optical apparatus, and that it should not be construed as scaled to neocortex volume separate from this relationship. This is in fact consistent with Deacon's position, but it hardly has revolutionary implications for human brain evolution.

With respect to Deacon's interpretation of the scaling of the human prefrontal cortex relative to neocortical area as a whole, I have found it difficult to reproduce his result (namely, his figure of 202% for the alleged doubling in proportion of the neocortex which is prefrontal cortex, relative to anthropoid scaling trends). In Figure 2.10 I have tabulated some figures for these volumes from the two sources Deacon cites, Brodmann 1912 and Kononova 1962 (as reproduced by Markowitsch 1988 and Blinkov and Glezer 1968, respectively). It will be seen from this that the two sources are discrepant as to the volumes of PFC for both humans and for great apes relative to papionines. Presumably Deacon made his own decision as to which data to take in formulating a nonhuman anthropoid regression relationship. All I can say is that if one regresses the nonhuman anthropoid data given in Brodmann's study, one derives a slope which quite closely predicts the human PFC ratio (in fact, the human ratio is slightly less than one would expect) (Figure 2.11). Moreover, Uylings *et al.* (1990) have since criticized dependence on these old sources, and have given data based on new and much more precise microscopic measurement techniques which suggest that the ratio of prefrontal cortex to isocortex (neocortex and mesocortex), or indeed to total brain volume, exhibits a scaling relationship which holds for humans as well as other primates, indeed perhaps as for other mammals generally (Figure 2.12). Thus just as we have cause to doubt Deacon's arguments concerning the importance of relative brain size for human cortical evolution, so we may doubt his arguments for the evolution of human neocortical functional subdivisions as being divergent from absolute size-related scaling trends.

PART THREE

Two opposing hypotheses and the Palaeolithic record of hominid cognitive capacities.

I have developed the preceding analysis as part of the argument of this Chapter, which is that Palaeolithic archaeology has a central role to play in testing out the increasing numbers of speculative reconstructions of Pleistocene hominid behaviour patterns which inform the various versions of 'evolutionary psychology'. Deacon's work has the great merit of being highly specified, and of generating predictions concerning human behavioural evolution which expect behavioural capacity in *Homo* to have varied as a function of a brain reorganization which left detectable markers - the fossil record of hominid relative brain sizes. The alternative interpretation of human and nonhuman primate brain data which I have also offered has similar merits for our purposes, in that it specifies behavioural consequences of change in hominid absolute brain size (another fossil marker).

A number of aspects of functional organization in brains are related to absolute size parameters. At mammalian size levels, increasing absolute brain size (size of neuronal population) cannot go with a constant level of 'percentage connectedness' between the neurons in the whole population, since this incurs efficiency costs due to the spatial requirements of positive curvilinear increases in number of axonal and dendritic connections between cells, and due to the finite conductance time across a connecting axonal fiber or fiber tract. Thus in mammals we see a correlation between absolute brain size and areal specialization in the neocortex, from the level of parallel visual association areas to the level of hemispheric specialization (which is most marked in humans and much less marked in the small-brained rat) (Ringo 1991, cf Deacon 1990a). Furthermore, there appears to be a correlation between the occurrence of multiple cortical areas in primate somatosensory cortex, and tactile discrimination capability (Carlson 1985). Laterality and tactile discrimination may therefore be homologous traits which derive from absolute brain size increase, rather than functionally and evolutionarily separable anatomical modules. Whether the expansion of the prefrontal cortex in humans requires explanation additional to this process is an issue which deserves to be resolved.

I noted earlier the need to develop archaeological indices of prefrontal cortex expansion, some sort of suite of 'prefrontal measures'. In order to test the two models archaeologically, we need not just the 'prefrontal measures' as derivable from artefact and intrasite spatial patterning. We also need to isolate periods when the conditions of prefrontal expansion as specified by one only of these two models are met - namely, a period in the evolution of *Homo* when there was increase in absolute brain size but not any increase in relative brain size, due to parallel evolution of larger absolute body mass. The prediction of the Deacon model would be that in such conditions, there should be no marked increase in behavioural capacity as indexed by a 'prefrontal measure'. The contrasting prediction of the opposing model is that such evidence should indeed exist.

Testing the two models: a preliminary assessment of methods and evidential base.

In Figure 2.13 I have formalised the conditions which must be met for this archaeological test of the two models of human brain and cognitive evolution. Clearly if the test condition was never met in the course of human evolution, then the test as here devised will not be capable of implementation.

The overall tendency in the course of hominid evolution has been for brain size to increase more rapidly over time than body weight (Figure 2.14). This suggests that the condition of absolute but not relative brain size increase may not have been met during this evolutionary process. However, it is evident from more detailed inspection of the data that the rate of increase of hominid endocranial volume has not been constant, but markedly accelerated during the last 500,000 years (Figure 2.15). Contrariwise, body size (as estimated from various fossil indices) appears to have increased with early *Homo*, especially with the appearance of *Homo erectus*, to approximately the range of contemporary human body sizes (Figures 2.16, 2.17). Endocranial volume appears to have stabilized within a range of variance for the period ca. 1.5-0.5 Myr BP (Figure 2.18). Thus from ca. 1.5 to ca. 0.5 Myr BP we have a constant absolute brain size and a constant body size, within a finite range of variation. From ca. 0.5 Myr BP we see increasing relative brain size, since the brain enlarges while the body size remains fairly stable, and we also of course see increasing absolute brain size. Consequently, the archaeological record from transitional/archaic *Homo sapiens* onwards is unsuited to the test which I am proposing of these two brain evolution models. However, in the case of *Homo erectus* we see an increase in absolute brain size, and a correlated increase in body size. This has led some authorities to conclude that there was no increase in relative brain size for *Homo erectus* over *Homo habilis* (e.g. McHenry 1988). Thus, we may suggest that the period ca. 1.5 - 0.5 Myr BP, contrasted with the preceding period (ca. 2.0 - 1.5 Myr BP), corresponds most closely to the conditions which we have stipulated for this archaeological test of the models: namely, the condition of absolute brain size increase but relative brain size stasis. If we find no archaeological evidence of an increase in some 'prefrontal measure' in the second period over the first period (they correspond to Phase Two and Phase One, respectively, of the formal model [Figure 2.13]), then we will have failed to support the alternative to Deacon's model which I argued for in the preceding sections. Thus Deacon's model of human brain and language evolution will have received indirect archaeological corroboration. The conditions are illustrated graphically in Figure 2.19.

At this juncture, it is appropriate to note that body size estimation for fossil hominids is a very uncertain science, and that the assertion that the conditions of my test have been met in the way described should be treated as an assumption which we shall hold for the purposes of this exercise, rather than a description of unquestioned palaeoanthropological facts. It is for this reason that I would reiterate the purpose of this Chapter: namely, to demonstrate that models in evolutionary psychology, which explain modern human behavioural tendencies in terms of Pleistocene adaptations, can (if sufficiently clearly specified) be subjected to testing by Palaeolithic archaeologists. In other words, I would defend not so much the low level assumptions of this particular attempt to solve the test, but the assertion that there is an in-principle-reasonableness to the archaeological project.

Specifying the 'prefrontal measures': lithics.

Review the summary of the role of prefrontal cortex in human behaviour (Figure 2.1). It is evident that there is a close parallel with the indices of technological complexity used by some recent stone tool analysts, deriving from Leroi-Gourhan's concept of the '*chaine operatoire*'. The *chaine operatoire* concept denotes the structured chain of manual gestures which are coordinated to produce a tool, and which are governed by a syntax which combines and recombines automatic, semi-automatic or mechanical, and lucid memory representations (there may be some analogy with the psychological distinction between procedural and declarative memory) (Schlanger 1990). Pelegrin (1990), describing the components of a *chaine operatoire* in elaborate knapping strategies, enunciates a series of components of the production model which are close to the terms used to describe the role of the prefrontal cortex in behaviour. His description is as follows:

> "we may distinguish (in an elaborate knapping activity) between two fundamental elements or 'ingredients', of distinct neuropsychological nature: knowledge (*connaissances*) and know-how (*savoir-faires*). This distinction corresponds to a subdivision of memory established between declarative and procedural memory (Squire 1986).
>
> As 'knowledge' can be classed the mental representations of forms and materials (concepts), and a register of action modalities (brief gesture sequences associated to their practical result). Referring to the memorisations and mental representations of objects and of facts, this knowledge ensues from a memory that is explicit and declarative in nature.
>
> Within 'know-hows', we may distinguish between an 'ideatory' time (evaluation, reflexion, decisions) and a motor time (programming and execution of the gesture).
>
> Ideational know-how corresponds to operations - spatial and sequential transformations, comparisons - undertaken on the mental representations. The artisan imagines (that is, constructs new mental representations of) the virtual state of the object according to the envisaged actions, and considers their respective advantages and risks.

> These mental operations are not only spatial (upon forms), but they are also organised chronologically and sequentially, as when a series of removals from different orientations needs to be ordained.
> It is evident that only practical experience can enable one to gradually refine estimations and to optimize reasonings, reasonings which are essentially subconscious" (Pelegrin 1990:118).

I propose that this account of the syntax and hierarchical structure of the *chaine operatoire* as it is entailed in flint tool production is close enough to the Goldman-Rakic account of the prefrontal area's role in behaviour to justify taking the *chaine operatoire* as the principle concept in formulating a lithic 'prefrontal index'. Goldman-Rakic proposes on the basis of her work with nonhuman primates that the prefrontal area in primate cerebral cortex is involved in working memory functions where there is regulation of motor behaviour by representational memory. She argues that the prefrontal area is not dedicated to a single behavioural domain or modality, but subserves a number of different functions. Thus with respect to manual behaviour in humans, the prefrontal area has a role both in manual behaviour regulated by verbal representational memory, and in manual behaviour regulated by visuospatial representational memory. One lithic 'prefrontal index' would be the working memory load entailed in organizing the gestural string which produces a certain type of artefact.

Another lithic 'prefrontal index' can be derived from work by Gibson, Greenfield and others on hierarchical constructional ability and its relationship with the activation of the frontal area in the human brain. Greenfield (1991) argues that language and object manipulation are homologous human behaviours which have their basis in the role of the prefrontal cortex in organizing hierachical, sequentially-ordered motor output (i.e., involving a hierarchy of subassemblies). In fact, Greenfield argues for a more specific localization of this hierachical sequence organizer within the prefrontal area, but this remains neurologically unproven.

The corollary of this is that a second lithic 'prefrontal measure' could be the depth of the hierarchy of subassemblies, and the degree of their differentiation, which have to be called to mind in the process of knapping a lithic artefact.

A further dimension of lithic technology which may tap prefrontal cortical workings has been proposed by Glyn Isaac as a language-marker (1976), and that is the extent of standardization of tool types and the diversity of tool assemblages associated with a particular timespan and fossil hominid morphology. This may be useful as a third lithic 'prefrontal index' if there is a relationship implied with generativity of different subassembly recombinations, and the individual artisan's mental and memory capacity to reproduce a wider range of standardised forms.

Specifying the prefrontal measures: spatial activity patterning.

Although spatial patterning in activity areas has been less frequently studied as an indicator of cognitive abilities, there is some theoretical rationale for such an endeavour. Spacing behaviour is a fundamental aspect of primate social life, at both the between-group and the within-group levels (cf Ibanez 1986). Brothers and Raleigh (1991) argue that primate social behaviour is governed by complex social rules in two domains - geometrical representations of spatial patterns of proximity, and categorical representations of social status (dominance rank, gender, reproductive status, kin relationship, amd age). They argue that the ability to parse social scenes in these terms and formulate spatial action patterns governed by the social rules which they embody produces complex behaviour which has an analogy with language comprehension, parsing and processing.

The concept of a syntax of spatial arrangements, based on the recombination of subassemblies, is familiar in social studies of human architecture. In principle, therefore, evidence of a patterning in the distribution of activity areas in hominid intrasite structure which presupposed a capacity to parse social relationships in a more complex way than the nonhuman primates could serve as a further 'prefrontal index' in hominid evolution.

Quantifying the 'prefrontal measures': a case for ordinal-scale ranking of qualitative data?

In conclusion to this Chapter, I shall itemize some sources of archaeological evidence which derive from the periods under review and which may be pertinent to the quantification of variation on a suite of 'prefrontal measures'.

For the purposes of this exercise, I shall assume that the Phase 1/Phase 2 contrast corresponds to the Oldowan/Acheulian assemblage contrast, such that we need to quantify prefrontal measures for these two different traditions. Again, this move masks real complexities in the discrete periodization of these traditions and in the association of traditions to hominid fossils. For the purpose of this exercise, we shall associate Oldowan (which Gowlett [1990] dates to c. 2.8 - 1.6 Myr BP) with *Homo* spp./*Homo habilis* (at least in its later stages), and Acheulian with *Homo erectus*, but we shall note also that justifying this move other than as a step in a methodological exercise would require a much more intensive survey of the dating, typology and contextual evidence for these traditions and their components.

With regard to the *chaine operatoire* and hierarchical construction as lithic prefrontal measures, Pelegrin (1990) argues that 'elaborate knapping activity' in the sense described in the quoted passage (above) appears only with the Acheulian, with symmetrical biface production and standardization of the debitage (implying a hierarchical organization of subassemblies of motor gestures). Gowlett (1990:94), also, argues this point with reference to his own work and to similar conclusions by other authorities, namely that Acheulian technology shows a much greater evidence of 'procedural templates' in the patterns of "imposed long axis in bifaces, bilateral symmmetry, and high correlation of dimensional relationships". However, and in contrast with Pelegrin, he interprets Oldowan core tools as also demonstrating (less clearcut) possible evidence of procedural templates and imposition of arbitrary form.

This would point to an increase in the lithic prefrontal measures from Phase 1 to Phase 2. Additionally, Isaac's (1976) diversity and standardization plots (reproduced in Figure 2.20) for the two periods and traditions would point to a greater generativity in the Acheulian - Isaac's juxtaposition of plot data for an Australian aborigine assemblage imply that he sees essentially human levels of ability emerging at this early stage of hominid evolution. However, the main control on interpretation of the cognitive complexity of knapping strategies has been experimental work replicating tool types, and this has thrown up some challenges to such conclusions. Specifically, Toth's experiments with naive knappers have shown that Oldowan core forms can emerge unintentionally in the process of flake production (Toth 1985, 1987, cited Gowlett 1990), while Davidson and Noble (1993) refer to an experimental lithics demonstration of biface production and attempt a similar argument for Acheulian bifaces, arguing that they may have served as curated cores for flake production (perhaps in combination with some use as core tools themselves). The importance of empirical control on interpretation has also been demonstrated in the case of the 'Levallois technique': Wenban-Smith (1990) argues that the appearance of the Levallois technique, which we may associate with archaic/transitional *Homo sapiens*, signals cognitive ability of essentially 'modern' levels, but also points out (pers. comm.) that refit studies show how a variety of methods can be used to arrive at a morphologically 'Levallois' tool, not all of which are of equal operational complexity (Marks and Volman 1987). This experimental work, refitting work, and parallel work in computer simulation, may represent the most useful future direction for developing prefrontal measures of hominid lithic technology, when it is coupled with allometric analysis of form regularities of archaeological artefact types in the manner practised by Gowlett.

With regard to the second proposed suite of 'prefrontal measures', spatial activity patterning, we may also note the need to exercise caution in interpretations of the archaeological record. The model of spatially segregated activity areas which was proposed by Whallon (1973, cited Johnson 1984) as the 'functional' approach to site structure has not been supported by ethnoarchaeological work. It has been found that in modern hunter-gatherer 'base camps', the spatial patterning of activity debris is shaped more by size-biased site maintenance activities and by social organization (clustered family units) than by activity segregation (cf Johnson 1984:78f). Equally, the temporal resolution for archaeological living floors is usually extremely coarse, making it hard to discriminate between signals of complex organization of activity during a single episode, and (at the opposite extreme) mosaics of activity of more than one visit by more than one species of animal, with further taphonomic disturbance attributable to physical processes. It is easy, but foolish, to disparage the rigour and caution which is now applied to the analysis and interpretation of hominid activity sites in an attempt to disambiguate these components of the site formation process.

Nevertheless, qualitative assessments have been made of the record of intrasite patterning in an attempt to derive behavioural inferences. Kroll and Isaac (1984) reported the results of their preliminary survey of potential contrasts between very early and later Pleistocene hominid sites, and suggested that while the archaeologically discernible differences may be fairly subtle, there are indications of contrasts which merit further investigation. These include increase in refuse density over time, increase in assemblage diversity within sites over time, the late appearance of recognizable hearths and of multiple spatial modules within sites, and the more recognizable presence of secondary refuse dumps and shelter components in the later sites (*ibid.*: 25-7). The difficulty is that for our purposes, these seem more the signs of a change in social system than a change in individual cognitive ability - at least for fairly direct inferences. Moreover, the contrasts Kroll and Isaac make are really between sites associated with pre-sapiens *Homo*, and sites associated with archaic/transitional *Homo sapiens* onwards, which lumps together the two phases we are trying to separate out. Thus while the spatial aspect of prefrontal measures has some promise, it needs to be more clearly specified in archaeologically meaningful terms for it to be used in this sort of test. Kroll and Isaac (1984) have made some very helpful suggestions as to the directions in which we might now look.

A second component of spatial patterning of activity which has been used as an index of 'planning ability' is artefact transport, particularly where there is transport of raw materials to a distant production or processing site. Wenban-Smith follows Roebroeks *et al.* (1988) in arguing this point, and concludes with a programmatic statement that "There are three quantifiable elements of technological organization which reflect the extent of the depth of forsight. Firstly, the extent to which an operational chain for lithic reduction is divided into distinct stages whose acomplishment is essential for success in the strategic aim. Secondly, the spatial distance by which different stages or parts of a reduction sequence are separated. And thirdly, the consistency with which the same parts of reduction sequences accumulate at the same sites (ie. the extent to which lithic production is logistically organized)." (1990:22). The problem with all these approaches, and the reason why I as a non-specialist in either lithics or spatial analysis am reduced to citing qualitative statements by recognized authorities, is that we are only just beginning to gather quantitative information of the order of sophistication which is necessary to derive indices such as those of a 'prefrontal measure'. Until such stable quantitative methodologies are agreed upon, however, Palaeolithic assemblage interpretation will retain its aura of a 'craft tradition' accumulating practical, often 'implicit' or unanalyzed knowledge rather than quantitative information.

It is for this reason that I asked rhetorically in this section's heading, whether there is a case for testing the two models of human brain evolution using ordinally ranked qualitative data. Clearly there is a strong basis in qualitative judgements of Oldowan versus Acheulian lithics for concluding that the latter involves more complex behaviours (in terms of motor output regulated by representational memory in the prefrontal cortical 'workspace'). However, it is only quantitative work such as Gowlett's length/breadth analyses of bifaces, or spatial analysis of patterning of lithic scatters integrated with refit work, that can firmly corroborate one or other of these contrasting models of human brain and language evolution.

PART FOUR

Discussion and concluding remarks.

In this Chapter I have advocated the use of archaeological evidence for testing the models of human evolution which are emerging into academic debate with the consolidation of a paradigm in 'evolutionary psychology'. Specifically, I have taken the prototype case of human language, described Deacon's model of its neuroanatomical correlates in the human brain and their evolution, and extrapolated on the basis of further analysis a testable hypothesis concerning the appearance of cognitive-motor analogues of language in the Lower Palaeolithic archaeological record. While this may seem fairly tame, at least insofar as we have dealt more with mechanisms than with their adaptive significance, such exercises are essential if archaeology is to be exploited as a control on speculation. After all, before we look for the correlates of language evolution predicted by adaptationist models (e.g. Dunbar and Aiello's group size hypothesis[1993]), we want to be sure of the periodisation of language evolution and of its morphological and artefactual correlates. Only when we have targeted the right phases of hominid evolution can we set to looking for falsifying evidence concerning the selective environment, such as evidence of change in social grouping strategies.

It is not unusual for sceptics to protest that the artefactual record only records minimum capabilities, and may not index the full cognitive resources used in language itself. I dispute this. Given the length of the period during which Acheulian assemblages predominate, had the capabilities of the craftspersons who made them exceeded this record, we might reasonably expect this to have carried over into lithic assemblage features. Indeed, such sceptics are not usually experimental flint knappers themselves: the latter generally go to the opposite extreme, sometimes proclaiming that the difficulty of biface production can tax even a brain of modern human proportions.

There is, however, another possible complication, and that is that artefacts may exceed the capabilities of their makers in a certain sense. Modern material culture is mostly based on highly modularised production processes with overall management only of global attributes of the assembly line. In this respect, individuals below the top level of production supervision are in effect sub-assemblies of skilled routines in a superorganic construction process. If artefacts in the archaeological record are similarly products of cooperative production in this way, then while individual artisanship indexes cognitive capacities, the assemblage composition and even the assembly of a single multi-component tool may presuppose social coordination of this kind. Lower Palaeolithic researchers on cognition tend to ignore this distinction, but it may require further consideration in future analyses of the kind given by Isaac (1976, see Figure 2.20).

CHAPTER THREE: PRIMATE SOCIAL SYSTEMS AND THE 'SOCIAL INTELLIGENCE' HYPOTHESIS: AN ANALYSIS.

INTRODUCTION.

Use of nonhuman primate models of hominid behavioural evolution is increasingly common, after a period when the social carnivores were favoured as closer analogues to an assumed suite of carnivorous hominid adaptations. Coles and Higgs (1969:68f), for example, had argued that "as man is a primate, the assumption has usually been made that primate behaviour studies are most likely to yield valuable results. However, man, with his extensive range of adaptability, has probably behaved in the manner of animals other than primates, where his food supply has been akin to those of non-primates."

In principle, there is no *a priori* reason why non-primate models of hominid social behaviour should be deemed inapt. Theoretical models of the socioecology of primate and of non-primate groups share many common features. In Figure 3.1 I have juxtaposed two such models, one a model of optimal herd size in ungulates derived from Focardi and Paveri-Fontana (1992), the other a model of optimal group size in primates from Terborgh and Janson (1986). In the Focardi and Paveri-Fontana model, optimal herd size is a function of predation pressure (A) and food distribution (G), where B = the amount of food consumed by each animal per day, E = energy level, and N = herd size. The zones of the graph delimited by the plotted curves are taken to correspond to classificatory categories used by Jarman in his description of the social organization of the African antelopes (1974). In the Terborgh and Janson model, primate group size is a function of predator pressure and of feeding competition, and thus indirectly of predator pressure and of available food energy per individual animal. The zones of the graph correspond to hypothetical categories of primate species classified by the size of their feeding resource. It will be seen that in both models, group size is modelled as a function of resource availability and predation pressure. At this basic level, mammalian socioecology can be reduced to a single set of predictive rules which derive social systems from environmental parameters.

However, there are major distinctions between the ungulates and the primates in terms of their dietary strategies and their life history strategies. In general, ungulates are adapted to feeding on poorer quality plant matter, while many of the primates are adapted to very high quality plant foods (fruits) or to omnivory including animal protein as a component. This may also impact on life history strategies, such as allocation of resources to growth and maintenance of different body organs. Relative brain size increase demands allocation of more of the animal's metabolic energy budget to this organ, with correlated increase in the demands placed on maternal energy investment (and thus dietary needs) during the offspring's gestation and postnatal growth. Mammalian brains grow at fairly constant rates (grams/day) across taxa, with relative body size and growth rates apparently more easily varied. Whereas the brains of an ungulate, *Sus scrofulus*, and of a primate, *Macaca mulatta*, grow at essentially the same rates (grams/day), their bodies are built at very different rates: for any given period of gestation the ungulate builds a body about nine times the size of the primate (Passingham 1985). Given the metabolic requirements of brain tissue, we may hypothesise a relationship between this order-by-order contrast, and the dietary quality of the niches. This constraint in turn has implications for cognitive ability, and thus for social behaviour involving complex social learning or social cognitions. Consequently, the evolutionary socioecology of the mammalian orders must also be differentiated according to the place of these taxonomic groupings in the overall ecological web and their phylogenetic history. There are major differences among the orders, and within the orders at lower taxonomic levels, which derive both from phylogenetic constraints and from ecological adaptations and which have consequences for social system evolution. The same points may be made in contrasting models of sociality in canids and felids with that of the primates. Wrangham, a primatologist, has noted that "Only occasional attempts have been made to compare primate socioecology directly with the socioecology of other animals ...Nevertheless, the processes governing primate social evolution appear broadly similar to those operating in other taxa" (1986:295). This assertion is somewhat undermined by the fact that while Wrangham asserts that one of the problems of such comparison is the occurrence of primate social system types "with no exact analogues in other taxa (e.g., female-bonded groups: Wrangham 1983)" (*ibid.*), he is capable of asserting on the next page that one of the similarities between primates and larger carnivores is that "female-bonded groups show defense of food resources (e.g., lions: Packer 1986)" (*op.cit.*:296). Assertions of analogy must be supported by more explicit and less confusing enumerations of the points of similarity between the two taxonomic classes being compared. In fact, the cited paper on the causes of sociality in female lions proposed a model in which the cause was *not* increased feeding efficiency pay-offs of pride size and group territoriality. Packer's model (1986) proposes that female natal philopatry and the permanent coexistence of female close kin in lion prides derives from the high population densities of lions (and the consequent costs of female dispersal, due to difficulty in establishing another territorial range); from the preference of lions for large prey species (in which the feeding costs of shared access to the resource are lower); and from the use by lions of an open habitat, in which scavenging opportunities are signalled to foraging lions across a wide area due to the aggregation of avian competitors (vultures). The felids are almost exclusively carnivorous: by contrast, in the (male kin-bonded) omnivorous chimpanzees, sharing of patchy, ephemeral and rich food resources involves complex social transactions entailing some sense of 'trade' or of reciprocity (de Waal 1989). The chimpanzees have evidently evolved a much richer repertoire of transactional and conciliatory behaviours which enable social relationships to persist among not just close kin male coalitions, but non-close kin male coalitions, female-male dyads, and female-female coalitions in multi-male, multi-female groups (and cf Blount 1990 for the case of bonobos).

We have seen that while models of the causal mechanisms selecting for ungulate and primate group sizes may use the same key variables, there remain fundamental distinctions between these orders in their life history strategies and cognitive abilities. The ungulates are terrestrial open country grazers, primarily on low quality plant matter. The primates, by contrast, are "typically arboreal inhabitants of tropical and sub-tropical forest ecosystems" (Martin 1986:16). Indeed, the order primates is characterized by a greater degree of encephalization (brain:body size ratio) than either the Carnivora or the Artiodactyla. This reflects different life history strategies, and different patterns of metabolic investment in growth of cerebral and other organs between members of each taxonomic order.

Rowell (1991:261f) has suggested that primate social groups have dynamics which are different from those of carnivores or ungulates: the latter can exhibit emergent group organization which is the outcome of complex interactions of each individual interacting with all other members of the group simultaneously, as in ram huddles or wolf greeting ceremonies, while primate groups show only dynamics which can be almost invariably be broken down into sequential pairwise interactions, a pattern of 'complication' which may permit greater elaboration and stability of social structure to emerge. The assumption can be made of a causal relationship between this capacity of social primates for elaboration of social structures through their combinations of pairwise interactions, and the greater degree of encephalization which also characterizes the order. There are likely also distinctions of this sort within the primate order: Whiten and Byrne (1988:57) show how primate social cognitions can vary qualitatively with the same group size, since prosimians (unlike anthropoid primates) may have no or limited capacity to engage in *tripartite* interactions (where there is a requirement to adjust behaviour simultaneously to that of two other individuals).

As a consequence, we may question the assertion of Coles and Higgs (1969) that nonprimate models of hominid behaviour are likely to be more relevant than primate models, not least because the evidence for a greater animal protein component in the hominid diet does not put hominids on a par with the almost exclusively carnivorous felids and canids. More recently, therefore, the value of primate behaviour studies for palaeoanthropology has been re-appraised. The reasons for this include recognition of the phylogenetic constraints of body-plan and brain organization on behaviour; the restriction to primates of cognitively complex forms of social learning paralleling early hominid culture; field evidence of the omnivory (including use of animal protein) of many primates, including chimpanzees; and recognition that the structured social systems of primates are probably a closer analogue for evolving human social behaviour than are the pack behaviours of social carnivores, or the foraging habits of asocial felids.

Modelling primate social systems in evolution.

Tooby and DeVore (1987) have argued that primate data should be used not in analogue modelling from a single extant reference species to extinct hominids, but in 'conceptual modelling' based on the extrapolation of general rules of primate behavioural evolution to the specific contexts of hominid behaviour. The distinction here is between models of some relatively inaccessible phenomenon which use some other single real phenomenon as the model (for instance, chimpanzee models of hominid social behaviour), and those which consist of a tightly integrated set of defined concepts or variables whose interrelationships are analytically specified, and from which an enormous range of phenomena can be deduced (*ibid.*:184f.).

However, more than one conceptual model of the evolution of primate social systems exists. The object of such models is to explain gross aspects of primate social system variation, particularly group size and adult sex ratio. Part of the reason for this is that some important aspects of primate social organization appear to depend on absolute group size (Terborgh and Janson 1986; Figure 3.2). Perhaps the most developed models are those which apply to primate multi-female groups (cf Wrangham 1987). One model, advanced by Moore (1984), posits that group living has no major costs or benefits to individual primates, and that even quite small marginal benefits from grouping are sufficient to explain primate social groups. Examples of such benefits would be the ability to benefit from the memory for food locations of old individuals; the ability to share the costs of locating hard-to-find foods; or the effect of reducing the speed of disease transmission. A second model, proposed by Wrangham (1980, 1987), posits that in species with female philopatry (where females remain with their natal groups) the benefits of grouping derive from the ability of larger groups to exclude smaller groups of conspecific animals from rare, economically defensible food patches which are likely to be fairly high quality (such as fruiting trees). The third model, supported by van Schaik (1983) and by Dunbar (1988), among others, posits that large groups occur as an adaptation against predation, because the benefits from increased survival of young outweigh the costs of increased feeding competition among group members (cf Figure 3.3).

It is only realistic to point out that these competing models are still being evaluated against the field data of primate observations, and that (given the extent of diversity in primate social systems and ecological niches) no single model may contain all the answers for every multi-female primate group. However, a number of partial tests of these competing models of primate social system evolution have already been carried out and published. Rodman (1988) has used primate group size data to test various versions of the hypothesis that primate grouping behaviour optimizes food-search routines, and concludes that most of the optimal foraging models of primate group sizes fail to explain the observed group size data. The importance or otherwise of predation risk for primate social strategies is a central issue in debates between Wrangham and advocates of predation pressure models: Cheney and Wrangham

(1986) have argued (without the benefit of the quantitative data used by Anderson [1986] to reach a diametrically opposed conclusion) that while there is scant quantitative evidence on predation levels, "there appears to be little relation between predation pressure and terrestriality, degree of sexual dimorphism, group size, mating system, or the number of males per group" (*ibid.*:239). Anderson (1986), by contrast, has reviewed the data on predation levels and primate social strategies at both the within species and between-species levels, and found correlations between elevated predation risk and a number of social variables: increased group size, more balanced adult sex ratios, changes in subgrouping strategy (changes in foraging party size and composition), sexual dimorphism, male defense, decreased frequency of solitary individuals, and male transfer (or female philopatry).

It is therefore desirable to continue evaluating competing models of primate social systems against the full database of living primates, before extending such models to the retrodiction of hominid adaptations. In evolutionary biology, such evaluation (hypothesis-testing) has usually taken the form of multiple regression analysis of covariances among ecological and life history variables, with correlation coefficients serving as measures of the adequacy of causal models linking different variables.

PART ONE: DUNBAR (1992).

One such model has recently been partially tested by Dunbar (1992), who has presented comparative analyses of primate anatomy and socioecology which support the 'social intellect' hypothesis - that primate neocortical evolution is driven primarily by the processing requirements of primate social networks. His analyses purport also to eliminate a number of factors other than *absolute group size* from the list of correlates of neocortex size which need to be considered in any causal model (Table 3.1). The implication is that, however the issue of the socioecological determinants of primate group sizes is resolved, group living *per se* imposes cognitive loads on individuals which scale to absolute primate group sizes, with consequent evolutionary selection pressures for a sufficient brain capacity to cope with such loads. In fact, Dunbar sees this as supporting the predation defence model of primate group size evolution: "The strong correlation between terrestriality, large neocortex size, large body size and large groups suggests that predation risk is the more likely of the alternatives, since it is difficult to see why large groups should be needed to defend the food resources of terrestrial species but not those of arboreal species. The resource defense hypothesis can only be entertained if it can be shown that arboreal species exploit resources that differ radically in either availabiliy or dispersion from those exploited by terrestrial species" (1992:490). This would be consistent with an interpretation of *hominid* brain evolution based on the socioecology of expanding hominid social groups in a high predation risk terrestrial foraging niche, as has been proposed by (among innumerable others) Steele (1989). Indeed, most recently Dunbar's (1992) analysis has been used as the basis for retrodictions of hominid group sizes on the basis of fossil brain case dimensions (Aiello and Dunbar 1993), and for developing a model of language evolution in which language is seen as an evolved adaptation to the problem of servicing large numbers of pairwise social relationships in very large social aggregations, under time constraints (*ibid.*).

Network size estimation.

Although Dunbar's analysis of primate group sizes and brain size and structures appears quite convincing, it leads to some puzzling predictions. For example, the regression equation which Dunbar derives for the relationship between group size and neocortex ratio (ratio of neocortex to rest of brain volume) yields expected group sizes for orang-utans and gorillas of, respectively, 60 and 67 individuals (Aiello and Dunbar 1993:189). Observed group sizes are of course much lower for these genera - gorilla median group size is [illegible], with the largest aggregation ever observed being 37 individuals, while orang-utan group sizes are considerably smaller than these, with the modal group size observation being of a single adult with infant. Inspection of the scatterplot of Dunbar's neocortex ratio and mean group size data suggests that his conclusion hides 'grade' effects distinguishing primate genera at the taxonomic level of the family (Fig 3.4). The prosimian group size data is corrupted by inclusion of some points which are for number of adults (i.e., a single female), rather than for total number of individuals in the maximal stable social unit. However, if these mistakes are rectified (and see below further), it is clear that the anthropoids are a cortical 'grade' higher than the prosimians for a given group size value.

In fact, it is also true that the rank order of anthropoid family mean values for cortex ratio and for body mass are identical, and also correspond to the rank order of standardized indices of variance in group size observations (for the three families for which this was calculated by Beauchamp and Cabana 1990) (see Tables 3.2 and 3.3). This suggests beyond the gross neocortex/group size correlation, a causal relationship between body size, cortex ratio, and the dispersion of group size observations about the species-mean in anthropoid primates - the latter perhaps as an adaptation to increased variance in range quality for large-bodied species. In fact, it is not clear that group size and group size variability are independent since it now seems that large groups may be inherently unstable and 'fissiparous' in a number of anthropoid genera (Beauchamp & Cabana 1990).

How significant is this variability in the cortex/group size relationship between anthropoid families? One simple statistical point should initially be considered in defence of Dunbar's reductionist hypothesis of 'not important at all'. Dunbar uses generic mean group size data to estimate generic mean social network complexity. The number of potential dyads scales as a power function of the number of individuals in a network (Fig. 3.5), so it is important that the estimator of generic mean network size is reliable. However, the use of mean group size for this purpose may *not* be reliable, since it is being used as an estimator of mean network size, which is the mean number of interactants in the social network of an individual primate in that taxonomic unit. As can be seen from the hypothetical examples (in Fig. 3.6) for which the mean group size and the mean number of interactants per individual have been calculated, the shape of the distribution of group size observations about the mean affects the reliability of mean group size as an estimator of the average individual's potential network complexity.

In Figures 3.7 - 3.9 I have calculated mean group sizes and mean numbers of interactants per individual for a number of primate datasets to illustrate this point empirically. We can see that these two mean figures can produce widely divergent results. For example, the group size observations for *Alouatta seniculus* and for *Ateles belzebuth* in Izawa (1976) yield mean group sizes of 5.4 and 6.7, but the MINS figures are 5.3 and 15.1. Again, the data on party sizes from the *Pan troglodytes* population at Mt Assirik, Senegal (Tutin *et al.* 1983) yield a mean party size of 5.3, but a mean number of interactants per individual of 11.1.

A more reliable index would therefore be Mean Individual Network Size (MINS), calculated using the following formula:

Summate [n X (n-1)] for each group size observation
Divide this sum by the sum of [n]s (i.e., $n_1+n_2+....n_x$).

Of course, this formula assumes parity across observations in terms of the temporal persistence of the grouping, a condition which may only apply for group size observations and higher levels of comparison, as opposed to party sizes in fission-fusion groups. In Table 3.4 I have worked out these indices for amalgamated group size observations at three levels of aggregation from chimpanzee field studies, to show the effect of the shape of a set of observations on the MINS for a real primate genus (mean group size and MINS are calculated for parties in the *Pan troglodytes* community at Mt Assirik, Senegal; for *Pan troglodytes* and for *Pan paniscus* community size observations; and for *Pan* generic means). Although the small sample size for *Pan paniscus* communities (n=2) rather detracts from its significance, this analysis does show that while the *Pan troglodytes* communities data yield a lower mean community size, the mean number of interactants per individual is closer to parity with bonobos due to the wider range of community size observations for the common chimpanzees.

So in view of the evidence for family-level differences in the shape of distributions of group sizes of primate species (Beauchamp and Cabana 1990), and the positive correlation between variability and mean cortex ratio across anthropoid families, we might predict that the mean group size index is systematically underestimating the social network sizes of Cercopithecids and (even more) Pongids, and that this bias may in itself explain the apparent 'grade' effects in the mean group size/ cortex ratio scatterplot for anthropoids (Fig. 3.4). To test this, we would need to convert Dunbar's mean group size data into generic MINS data.

Mean group size or MINS? Does it affect the analysis?

In order to convert Dunbar's mean group size data into MINS, it is necessary to know the shape of the distribution of group size observations from which each mean was computed. Unfortunately for this purpose, the source (Smuts *et al.* 1986) is a compendium of review articles which mostly contain only mean values for this index derived from synthesis of the primary literature. In some cases, the primary sources are unpublished Doctoral theses. While this should not preclude the investment of effort in calculating MINS from such primary sources, it is worth initially checking the premise that a simple index of network complexity is an adequate predictor of neocortex ratio in contemporary primate species, as Dunbar argues.

As a first proxy test of the effect of recalculating mean group size as MINS on the correlation coefficient of a regression against cortex ratio, I set out to take four of the pairs of anthropoid genera which have the most disparate cortex ratio scores relative to their mean group size scores, and to abstract MINS data from the published literature. The prediction is that in each such pair, conversion of mean group size into MINS will move the case with negative residual deviation from the regression line further to the left, and/or the case with positive residual deviation further to the right on the graph. The pairs which I chose were as follows:
Gorilla and *Cebuella* (Cr=2.65,1.43; mean group size=7,6); *Cercocebus* and *Nasalis* (Cr=2.38,1.75; mean group size=15.4,14.4); *Erythrocebus* and *Saimiri* (Cr=2.96,2.21; mean group size=28.1,32.5); and *Pan* and *Papio* (Cr=3.22,2.76; mean group size=53.5,51.2). Formally stated, the prediction is that Dunbar's hypothesis is supported if for any pair of cases, the conversion of mean group size (MGS) to MINS results in the case with the higher cortex ratio (Case 1) having a relatively higher score on this revised index of network complexity:

(MINS[case1]/MGS[case1]) > (MINS[case2]/MGS[case2])

At the outset it was decided to discount the disparity between *Cercocebus* and *Nasalis*, because the datum for *Nasalis*' cortex ratio given by Dunbar proved incorrect. Abstracting the correct value for this index from the data in Stephan *et al.* (1981) gives a cortex ratio value for this genus of 2.08, and not of 1.75. This decreases the apparent anomaly in the *Nasalis* cortex ratio/group size relationship to unremarkable propoportions. I was relieved by this, since the *Nasalis/Cercocebus* pairing was the only one which I had selected (on the basis of eyeballing the scatterplot for maximally vertically separated pairs of points) which compared members of the same family (the *Cercopithecidae*). As a point of information, checking Dunbar's data table revealed two other errors in calculation of cortex ratio: The figure for *Lemur* should be 1.15, the average for *Lemur fulvus* and *Lemur variegatus*, and not 1.23 (which is the value for *Lemur fulvus* alone); and the value for *Cebus* should be 2.26, not 2.36 (the value for neocortex volume for *Cheirogaleus* in Dunbar's table is also incorrect, but the value given for cortex ratio is accurate). I shall now describe the MINS data for the remaining three pairs of cases, and the fit of this data with my predictions derived from Dunbar's reductionist hypothesis. Consistent with Dunbar's analysis, I have derived generic MINS only from species for which volumetric data on brain components is given by Stephan *et al.* (1981).

For the pairing of *Gorilla* and *Cebuella*, the analysis of group sizes was hampered by the format in which the published gorilla data appears: Harcourt *et al.* (1981) give only some descriptive statistics on the shape of the distribution of gorilla group sizes in West and East Africa (minimum, maximum, median, upper and lower quartiles), which prevents calculation of the MINS datum accurately. Moreover, while the gorilla data was compiled from a number of study sites and showed regional variation in median and maximum group sizes, the *Cebuella* data is from a single study site (Soini 1982). In fact, more recently a bigger data set has become available on *Cebuella* which indicates a mean group size of 6.4 (range 1-15, n = 76) (Ferrari and Lopes-Ferrari 1989:140), compared with the gorilla figures of a median size of 9 (range 2-37, n = 64) for East Africa and a median size of 5 (range 2-12, n = 29) for West Africa (Harcourt *et al.* 1981). Dunbar's figure for *Gorilla* was presumably derived as the average of these two regional medians, but to attempt to draw any conclusions about differences in MINS betwen the two genera on this basis would seem unrealistic.

For the pairing of *Erythrocebus* and *Saimiri*, a survey of the relevant sources produced the following figures: *Erythrocebus*, mean group size = 26, MINS = 27 (sources: Hall 1965, Struhsaker and Gartlan 1970, Chism and Rowell 1988); *Saimiri*, mean group size = 39, MINS = 40 (sources: Klein and Klein 1975, Terborgh 1983, Bailey, pers. comm. in Robinson and Janson 1986). In this pairing, recalculation of mean group size as mean individual network size had no relevance for the relationship. What was significant was the difference in the calculated mean for *Saimiri* in Dunbar (1992) of 32.5, and the larger figure for the mean which I arrived at here. The source used by Dunbar (Robinson and Janson 1986) contains two tables giving group size data for *Saimiri sciureus* (the species for which we have cortex ratio data), one a summary of group size and range use data (p.71) and the other a summary of data from three troops on group composition by age and sex (p.79). As far as I can see, Dunbar's figure is the mean of the figure for *Saimiri oerstedii* and of all but the largest of the troop sizes for *S. sciureus* given in the former table. This is incorrect not just in the omission, but also in the inclusion of the low group size figure for *Saimiri oerstedii*, a species which was not sampled for the generic mean cortex ratio figure. I have calculated a mean of the group sizes in the group size table (Robinson and Janson 1986:71), using original sources when these were available, and have made some interpretations in order to do so. Specifically, Klein and Klein (1975) give figures for 3-6 groups of 25-35 independently locomoting individuals, which I have scored as 3 groups of 35 individuals (since other data are for total numbers of individuals including carried infants).

Finally, for the pairing of *Pan* and *Papio*, calculation of MINS was uncomplicated. The results were as follows: *Pan*, mean group size = 50, MINS = 62 (n = 10, source: Hiraiwa-Hasegawa *et al.* 1984); *Papio anubis*, mean group size = 50, MINS = 65 (n = 24, sources: Aldrich-Blake *et al.* 1971, Harding 1976, Rowell 1966, DeVore and Hall 1965). In both cases, the mean group size underestimates the average individual's network complexity, but by the same amount.

The conclusion to be drawn here would seem to be that while there are sound theoretical reasons for preferring MINS to mean group size in testing Dunbar's version of the 'social intellect hypothesis', there is no point in seeking such a level of precision unless one is also committed to scrutinizing the whole original compiled data set from scratch. Nevertheless, the analyses conducted using MINS transformation of mean group size data suggest that the vertical separation of anthropoid families shown in my replot of Dunbar's graph (Figure 3.4) cannot be explained by family-level differences in the extent of variability in observed group sizes. Thus it is the family-level variability in *body sizes* which we must now examine to account for this taxonomic effect.

Group size and sex ratio variation: life history strategy, dietary quality and neocortex size.

In fact, there is another major problem with the group size data used by Dunbar which cannot be corrected by the MINS recalculation I have just proposed. The mean group sizes for anthropoid genera, and a minority of the prosimian genera, are for total number of individuals. My understanding of the 'social intellect hypothesis' is that the cognitive load relates to the size of the stable adult group membership, but this cannot reliably be predicted from the mean group size data in Dunbar's paper. Theoretically,a mean group size of 10 and a mean number of females of 5 could leave us with 1 male and 4 immature or infants, or 4 males and one infant. This is of course implausible as an example, but the point is that taking total number of individuals as a basis of a mean group size datum leaves a wide margin for variation in age and sex composition which is very relevant to the hypothesis under review. In fact, it is well known that adult sex ratio bears little relationship to group size in primates. For instance, Clutton-Brock and Harvey (1977) give data for socionomic sex ratio (adult males:adult females per breeding group) and for mean feeding group size for a number of primate species. *Erythrocebus patas* has a socionomic sex ratio of 1:7, for *Cercocebus albigena* it is 1:2. Yet the mean feeding group sizes mask this difference, being (respectively) 20 and 17. If we combine this data set with some of the data from Dunbar (1992), we can derive some interesting results. If *Papio anubis* has a socionomic sex ratio of 1:2 (Clutton-Brock and Harvey 1977), a mean group size of 51.2 and a mean number of females of 11.4 (Dunbar 1992), that makes for 5-6 males and about 34 immature individuals (c. 3 per female) per group. Contrariwise, for *Pan troglodytes*, with a socionomic sex ratio of 1:1 (Clutton-Brock and Harvey 1977), mean group size of 53.5 and mean number of females of 13 (Dunbar 1992), we derive a mean adult group membership of 26 with 27-28 immature individuals (c. 2 per female). This in fact favours Dunbar's hypothesis, since *Pan* (mean group size = 53.5, expected mean adult group size = 26) has a significantly higher cortex ratio than *Papio* (mean group size = 51.2, expected mean adult group size = 17). The exercise should not be taken too seriously, since Clutton-Brock and Harvey were synthesizing a distinct set of available data to that used by Dunbar: nonetheless, it suggests that we should take account of group composition if we are to develop this analysis. I have not been able to correct for this in the analysis of anthropoid MINS, but it is clear that age and sex composition of groups cannot be ignored if we are seriously to test Dunbar's version of the 'social intellect hypothesis'.

Additionally, inspection of the partial correlations matrix for cortex ratio, mean group size, and mean number of females (Table 3.5) suggests, *contra* Dunbar 1992:485, that the effect of adult group composition on neocortical evolution should not be eliminated from causal models. Mean group sizes and mean numbers of females are correlated, but after taking account of the effects of mean group size, mean numbers of females accounts for more of the residual variance in cortex ratio than does the converse - mean group size with the female effects controlled for. The partial correlations matrix (least squares model) for group size, adult sex ratio, and ecological variables suggests a very marked *distinction* between the determinants of mean group size variance and the determinants of adult female numbers (Table 3.6), with a high concentration of females (controlled for group size effects) correlating with large body size and small range area. Thus residual variance in group size, controlled for number of females, day journey, and diet, correlates negatively with body mass and positively with home range area: the reverse is the case for residual variance in the mean number of females.

The data on dietary quality which Dunbar (1992) uses are very crude (percentage fruit in diet, derived from Richard [1985] and Clutton-Brock and Harvey [1977b]). For instance, while the fruit component in the diet of *Miopithecus* and *Cercopithecus* may imply a higher dietary quality for *Cercopithecus*, *Miopithecus* uses about twice the percentage of animal prey in its diet (Clutton-Brock and Harvey 1977b, Gautier-Hion 1988:262). In Table 3.7 and Figures 3.10 - 3.11 I have given some more representative data for the relationship between brain size, body size and dietary quality which suggest that dietary quality correlates with brain size (and by extension with neocortex size) after controlling for body size effects. The brain and body size data are from Harvey, Martin and Clutton Brock (1987); the dietary quality index is derived from Sailer *et al.* (1985)'s work on the dietary correlates of primate body weights, and uses the formula for weighting plant structural and reproductive matter and animal protein which these authors found to give the strongest (negative) correlation with body size across primate species. The partial correlations matrix in Table 3.8 shows that absolute brain size, controlled for body size effects, has a marked positive correlation with dietary quality in the primate order. Dunbar omits to point out that neocortex size scales very tightly to absolute brain size (Fig 2.5), with a positive slope steeper than isometry, such that we would expect cortex ratio to increase very precisely in step with total brain volume increase. This evidence of a correlation between absolute brain size and dietary quality, controlled for body mass, is therefore another piece of cautionary evidence against wholesale adoption of Dunbar's adaptationist interpretation of the social correlates of primate neocortical evolution.

Is there then the relationship which Dunbar asserts between network size and neocortex size, or is there rather a correlation between concentration of females (perhaps as controlled for group size effects), total brain size, and dietary quality (controlled for body size effects)?

In Figure 3.12 I have plotted data on dietary quality from the same source (and calculated using the same formula) (Sailer *et al.* 1985) against data on adult sex ratios, with point codes for predation levels (data from Anderson 1986), for a number of anthropoid species (n=22). There is some indication of a vertical separation of species with similar levels of dietary quality with the species with a higher male:female ratio (controlling for diet) also experiencing higher levels of predation. Indeed, if we return to Dunbar's original data set and (using simple linear least squares regression) regress mean group size on cortex ratio (both axes unlogged), we find that the correlation coefficient (r^2) is 58.93 (all primates) or 47.96 (anthropoids only), whereas the corresponding coefficients for regression of cortex ratio on mean number of females (both unlogged) are 62.17 and 50.64 (all significant at p=.001).

Thus in contrast with Dunbar's model, we might propose an alternative hypothesis positively linking body size, dietary quality, number of females in the average group, and low predation risk in primates, with variables such as home range area or relative neocortex size covarying as functions of these sociecological relationships. In this model the correlation of cortex ratio with mean group size would be the result of shared effects of a latent variable, niche quality, which is a compound of high dietary quality and low predation risk. In this alternative hypothesis, neocortical evolution would be seen as the result of evolutionary decrease in the energetic constraints on brain size evolution, rather than as an adaptive response to the behavioural complexity of group living in predator-dense ecological niches. We may also note that cortex ratio/group size correlation need not in fact imply direct causal linkages between social network size and cognitive capacity, since group size also affects levels of feeding competition and thus birth rates (van Schaik 1983), and in mammals brain size is related to birth rate parameters (gestation length and litter size). Clearly there is more to this issue, and to Dunbar's data set, than his own initial analysis suggested.

PART TWO: BEYOND DUNBAR (1992).

Methodology.

In the remainder of this Chapter I report a further attempt to test two causal models of the evolution of primate social systems, using the statistical methods of path analysis and multiple regression. Path analysis is an increasingly popular statistical tool used in biology to test causal interpretations of observational data in which there are many variables and many observed correlations among the variables. The method entails construction of a causal model in the form of a 'path diagram', where arrows indicate the permitted relationships between members of a set of variables, and the 'paths' so defined are translated into a set of linear equations which are solved using multiple regression techniques (Mitchell 1992). This procedure also yields a residual term for the amount of variance in each variable which is not accounted for by the relationships stipulated in the causal model. Recently, methods have also become available for statistically comparing two such models for their goodness-of-fit to the observational data. In a situation where there is a complex dataset with many possible relationships to be explored, this approach is far preferrable to *ad hoc* use of bivariate regression analysis or limited use of partial regression analysis without any overall path representation of the causal model under review.

The basic procedures of path analysis are reviewed in a number of handbooks, such as Herbert Asher's *Causal Modeling* (1976). The method has also recently been reviewed concisely by Li (1991).

Data: some revisions.

This analysis of the data used by Dunbar (1992) to explore the hypothesis of an adaptive relationship between cortical capacity and group size in primates has brought to light some limitations both in the compilation and in the statistical analysis. In fact, further analysis suggests that the data may also be consistent with a dietary constraints hypothesis, which is what has been argued for the relationship between primate brain size and dietary strategy by Martin (e.g. 1985), among others. In order to test these two models of primate brain-social system coevolution, I have essentially recompiled a different version of Dunbar's dataset for analysis using the methods of path analysis (Mitchell 1992) and multiple regression.

Table 3.9 gives the data which I have used to reexamine Dunbar's conclusions. It is important to take care when compiling data sets of this sort, since they are so useful that they are bound to be taken up and used by other workers in the field either for their own research or as an illustrative teaching tool. For example, I have changed the data on body weight given by Dunbar, which he misattributes to Harvey, Martin and Clutton Brock (1987) as the averages of their figures for adult male and female body weight. In fact, these data are the body weight data given by Stephan *et al.* (1981) for the individuals used in their brain volume estimation. There is a potential problem here in that the body weights of the Stephan *et al.* data are mostly for individuals which had lived in captivity, provisioned and thus with larger body weights than would be the norm in the wild. Furthermore, there is no control in the Stephan *et al.* (1981) data for sexually dimorphic variation either in body weight or in the volumes of brain structures. I have changed the body weight data used by Dunbar for my own analysis, since the comparison is with a ratio of neocortex to the rest of the brain rather than to absolute brain sizes, and the ratio may be assumed to be a species trait independent of absolute brain size or sexual dimorphism. The Harvey *et al.* body weight data, from wild populations, are therefore more reliable indicators of the modal scores for this trait.

The data for total brain volume and for cortex ratio are taken from the source used by Dunbar (i.e. Stephan *et al.* 1981), but I have not used Dunbar's procedure for calculating cortex ratio. Dunbar took the product of neocortex divided by rest of brain, and logged that product for his regression analyses. This seems the wrong way round, and I have therefore instead logged the original variables (neocortex and rest of brain volume) and then used the unlogged product of their division in my own regression analyses. It is this figure which is given as the cortex ratio in Table 3.9. This does make a difference: for instance, Dunbar's procedure results in a higher cortex ratio for *Pan* than *Erythrocebus*, while the reverse is the case with the formula which I have used here.

I have compiled new data for two group size variables, Mean Adult Group Size and Mean Number of Adult Females, extracting this data from the same compilation used by Dunbar, Smuts *et al.* (1986) *Primate Societies.* The reason for this is that Dunbar's figures were in some cases for total number of individuals, in other cases for total number of adults, and in some cases were also incorrectly extracted by Dunbar from the source book (see my comments above). I felt that using figures for the adult membership and sex composition of groups was more appropriate to the hypotheses under review. This resulted in some loss of sample size, since there are many more group size observations for primate societies than there are fully specified breakdowns of age and sex composition of particular groups. Some sampling error is likely to have crept in as a result, and the representativeness of these figures as means for the genera concerned should be accepted as provisional until a fuller database becomes available.

I have given new data on dietary quality, using a formula developed by Sailer *et al.* (1985) which weights the major components of primate diet as follows: 1 x (plant structural matter) + 2 x (plant reproductive matter) + 3.5 x (animal matter).

Finally, for the analyses which I have undertaken I used only data on anthropoid primates. This is because of the large number of adult group size observations among prosimians which are single individual groups: including the prosimians skews the distribution of these two variables to the extent that their shape obviously violates the regression assumption of normality, and logging does not correct this problem. However, the anthropoid data alone do not show this skewed distributional shape.

Path analysis and multiple regression analysis of the revised dataset.

In Figure 3.13 I have drawn a path diagram of the two models which I wish to test using this new dataset. In the first simple path diagram, cortex ratio is assumed to correlate with mean adult group size, with mean number of adult females dependent on mean adult group size and independent of cortex ratio except through this indirect effect on adult group size.

In the second path diagram, I have suggested a more complex pattern of causal relationships between traits, with three exogenous independent variables (dietary quality, body size, and mean number of adult females) causing variation in both total brain size and mean adult group size, and cortex ratio covarying with total brain size.

Figure 3.14 gives the path coefficients for the paths specified in the two causal models. These are raw partial correlation coefficients. It will be seen that Dunbar's model is not supported by the analysis of my new dataset: mean adult group size, after controlling for the effect of number of adult females, has an insignificant but negative correlation with cortex ratio. Partial correlation analysis (also given in Figure 3.14) shows that by contrast, mean number of adult females accounts for over half of the sizeable residual variation in cortex ratio after controlling for mean adult group size, confirming that it is mean number of adult females which is the group size variable which we should be interested in.

The results for the second model are less conclusive. Dietary quality appears to play little independent role as a determinant of group size or brain volume, but body size seems strongly related to total brain volume and thus to cortex ratio. However, partial correlation analysis also suggests that residual variation in cortex ratio (after controlling for total brain size effects) is largely accounted for by variation in adult group sizes (whether all adults or adult females only), suggesting that the second model is insufficient to explain all variation in primate generic cortex ratios (Figure 3.14).

Part of the limitation of this analysis is that the use of raw partials as path coefficients does not allow one to calculate the absolute magnitude of the effects of one variable on another for any one pair, since the partials are indexes of the amount of residual variation accounted for by a specific bivariate relationship controlled for the effects of all other variables, and we do not know the size of the residual variation as a percentage of total variation in one or other variable. It is here that multiple regression analysis plays a vital supporting role. In Figure 3.14 I have attempted to quantify the independent effects of the bivariate relationships specified in the path models on the dependent variables by multiplying the raw partials by (1 - the multiple r-sq. of the remaining variables in the model). It will be seen that this shows how little of the variation in this dataset can be accounted for by any single bivariate relationship (the salient relationships are shown to be body weight-total brain volume, mean adult female group size-mean adult group size, and dietary quality-body weight). By contrast, I have also noted the multiple r-sq. coefficients for the compound relationships specified in the model, and it will be seen that these do account for a lot of the variation in the dependent variables. For instance, 95% of variation in total brain volume and 98% of variation in adult group size are accounted for by the compound effects of dietary quality, body weight, and mean adult female group size. What we need to do now is quantify the relative importance of these exogenous variables for this result.

In Tables 3.10-3.15 I have given a series of results of regression analysis of these variables in an attempt to clarify the nature of the causal relationships which structure the observations in these primate data sets. In Table 3.10 we see that 93% of variation in total brain volume across anthropoid genera is accounted for by positive correlated variation in body weight: bigger primates have bigger brains. Adding dietary quality and mean number of adult females to the regression only accounts for a further 2% or less of this variation in total brain volume.

In Table 3.11 we see that 54% of variation in cortex ratio is accounted for by variation in total brain volume. 49% of the residual variation in cortex ratio is then accounted for by variation in adult female group size, and a further 19% by dietary quality (Table 3.12). The combined effect of mean number of adult females and dietary quality on residual variation in cortex ratio (controlled for total brain size effects) is to account for 66% of that residual variation, or 31% of all variation in cortex ratio. It is clear from Table 3.13 that as we
would expect, there is consequently a correlation between cortex ratio and body weight (36%), with the group size variables accounting for a further 44% of variation in cortex ratio after controlling for this body size relationship. We see from Tables 3.14-15 that variation in the group size data is largely independent of body weights and dietary quality (together, they account for only 15% of the variation in adult female group size, or 12% of variation in adult group size).

Thus we see that cortex ratio varies as a compound function of two separate clusters of variables, the one being body weight and total brain weight, and the other being mean number of adult females in a group and dietary quality. The relationship simply cannot be reduced to a bivariate relationship between cortex ratio and group size. It is the exclusion of absolute body and brain size as exogenous variables that leads to such nonsenses as the predicted group size mean of 60 for *Pongo* and 70 for *Gorilla.*

It is also necessary to point out that the reasons for this pattern of correlation remain unclear, not least because of the lack of any obvious explanation for the adaptive significance of variation in cortex ratio (as opposed to variation in absolute neocortex size). Quite why cortex ratio has some covariation with the mean size of the adult female membership of social groups in anthropoid primates requires further investigation. One possibility which should not be discounted at this stage is simply that this is a statistical artefact of the method used. Cortex ratio has some degree of correlation with body size, and if the least squares model were underestimating the steepness of the regression slopes in the partial correlation analysis, then this residual correlation could be an artefact of correlated error in the multiple regression residuals from which the partial is derived. There is some evidence that biological distributions of this kind may produce such errors in allometric line-fitting using the least-squares regression technique.

CONCLUSION.

The conclusion from this analysis is therefore as follows: anthropoid primate cortex ratios are significantly determined by total brain size, and this correlates strongly with body sizes. Larger bodied primates have larger brains, and thus higher cortex ratios, and there is no guarantee that this is adaptive variation as opposed to the results of developmental constraints on brain organization under selection for absolute size increase in the body-brain complex.

However, significant residual variation in cortex ratio does appear to have a positive correlation with adult female group size and with adult group size, and it is suggested that of these two it is the former (adult female group membership) which is the relevant social system variable.

Although Dunbar argued for a strong adaptationist interpretation of the cortex ratio/group size relationship, we can see that the relationship (once the data are recompiled to eliminate some defects in the original compilation) is not so strong. In fact, the evidence for a strong cortex ratio/body weight relationship seems more consistent with observed group sizes for the apes (gibbon, gorilla, orang) than Dunbar's model, since the latter are large bodied, correspondingly large brained, have high cortex ratio, and live in small social groups.

Despite this, the significant contribution of group size to residual variation in cortex ratio should not be discounted. Clearly this needs further work if we are to extend this research to the modelling of evolving hominid socioecology. While Dunbar's hypothesis may fit this aspect of the reanalysis, we should also consider the possibility that in large aggregations of reproductive females there may be selection for reduction in birth rates, to decrease feeding competition, and that the evolution of cortex ratios may be acting as a life-historical brake on this parameter, rather than being a sign of selection for 'smart primates'.

In this analysis my emphasis has been on data compilation and on the advantages of multivariate, as opposed to bivariate analysis of constellations of data of this kind. As a consequence, I have omitted to consider the recent debate on which regression models are appropriate to such analyses, and it is possible that my use of the least squares as opposed to the reduced major axis regression model has distorted some of these results.

Nonetheless, the exercise has been instructive insofar as it shows that Palaeolithic archaeologists should be wary of consuming uncritically the models of hominid social system evolution which are generated by biological anthropologists. If we follow Aiello and Dunbar (1993), we will look for signs of group size increase in hominid evolution and place less emphasis on the socioecology of body size increase and dietary niche definition. Yet this reanalysis suggests that such a strategy would be flawed, and that retrodiction of hominid group sizes from total brain volume is by no means as straightforward an exercise as Aiello and Dunbar (1993) imply.

In many ways this is an unsatisfactory conclusion, since group sizes and group composition are clearly important aspects of hominid socioecology, and we need to have some idea of the scale of the stable groups and the wider networks which existed at various places and at various points in time during the Palaeolithic. This reanalysis has not eliminated the evidence of a group size-neocortex size relationship, but it has qualified Dunbar's simple bivariate model of the relationship and his interpretation of it sufficiently for us to doubt the use of the predictions derived by Aiello and Dunbar (1993) from the earlier analysis (Dunbar 1992). Thus if we are to continue attempting to make quantitative estimates of hominid social systems on the basis of cognitive and life history parameters, then we will need first to develop a more sophisticated approach to multivariate analysis in order to bring out the relevant relationships in the living primate record.

The implication of this is that while (as I argued in the introduction to this Chapter) we should learn from primate models of hominid social systems, this does not mean that we should use them as passive and grateful consumers. Palaeoanthropology and Palaeolithic archaeology share an interest in living primates which is biased towards analysis which answers certain sorts of questions, and these questions are less relevant to primatologists themselves (who are looking for patterns of variation in the living primate order, not for bases for inference about the characteristics of extinct outlier species of hominid). There is therefore a case, I would argue, for analysis of primate data by archaeologists asking archaeological questions, and it is as part of that case that I have presented the results of my reanalysis of Robin Dunbar's findings.

CHAPTER FOUR: NETWORK MODELS OF CULTURAL DIFFUSION IN THE LOWER PALAEOLITHIC.

Introduction

Primate models of hominid social systems have been in circulation for many years. However, Palaeolithic archaeology has yet to make full use of these comparative data sets as a resource in modelling. The reasons for this may lie as much with the divisions of disciplinary culture and affiliation which separate biological anthropology from cultural anthropology and archaeology, as with the applicability of primate models to the Palaeolithic record.

One of the most frequently cited models of the social behaviour of hominids (early *Homo*, associated with Oldowan and Acheulian technologies) is the late Glyn Isaac's 'home base' or central place foraging model. Isaac came to prefer the latter term as a neutral descriptor of his model, given the semantic load of the concept of a 'home'. In Table 4.1 I have summarized the main components of the home base model from Isaac (1978). The model works by extrapolating the contrasts between modern hunter gatherers and living nonhuman primates back into the interpretation of Palaeolithic archaeology. However, it is clear both that these traits have not evolved as a functionally integrated package, and that the underlying model of the importance of the household unit and of a sexual division of labour maintained by food-sharing contains questionable assumptions.

I shall review the components in the model sequentially following the order in Table 4.1. *Bidepalism* has evolved gradually: early hominid locomotor adaptations (*A. afarensis* and *A. africanus*) may have been a persisting "compromise adaptation" retaining a significant amount of arboreal positional behaviour (Hill 1987, Rose 1984, McHenry, 1986), while *H. erectus* morphology is characterized by enlarged hindlimb joints and elongated lower extremity, interpreted as an adaptive shift connected to longer distance travel and "prolonged repetitive loading of the hindlimb joints" (Jungers, 1988:264). According to Baba (1993), the bipedal locomotion of *Australopithecus* was characterized by some retained anterior tilting of the pelvis, dorsal bending of the lumbar, and rearward placement of the thorax, such that "we acquired true human-like body structure and bipedal walking in the Homo erectus stage" (*ibid.*:S34).

Spoken language evidently may have existed in the form of intentionally controlled vocalization at least from the Old World anthropoid common ancestor, but the pathway of evolution of complex human language remains unclear: debate still continues on the importance of, and evolution of, central brain structures and peripheral speech generating musculature. However, the uses of spoken language in information exchange and social regulation do not appear in themselves to imply anything about the importance of the household unit in hominid evolution.

Active food sharing is problematic. De Waal (1989) has shown that passive food sharing occurs among adult and immature group members in common chimpanzees, appears to entail cognitive assessment of reciprocity, and involves "special behavior to share information about food, beg for food, reduce acute competition, and regulate the interindividual transfer of food items" (*ibid.*:455). Hawkes (1991) has argued on the basis of data from the Ache hunter gatherers of Eastern Paraguay that human male hunting strategies are not ruled by the principle of optimizing returns for the household unit, but by the principle of 'showing off' - targeting resources which are more widely shared, and likely to be consumed outside their own nuclear families. The implication is that reciprocity in hominid food sharing transactions, and the evolution of gender-specific hunting strategies, cannot be understood as qualitatively distinct from the dynamics of social relationships and status negotiation in nonhuman primate social groups such as those of the chimpanzee species.

The *home base* concept is also problematic as an explanation of spatial artefact clusters in the Lower Palaeolithic record. Potts (1987) has argued that stone tool clusters may represent caches of tools for special purpose activities, such as butchery, rather than 'home bases', while bone concentrations may represent accumulation over periods of years, perhaps due to a variety of processes (of which some at least did not involve hominid agency). This ambiguity therefore also extends to the component of the model which is '*deferred consumption of gathered items at home base*'.

The dietary focus on *middle to large animal prey* is also a modern hunter gatherer trait which it is hard to trace back into the Lower Palaeolithic record. Modern hunter gatherer studies would suggest that plant food was more important a component in an omnivorous diet, and that large mammals may have been scavenged as often as they were actively hunted, while taphonomic evidence from the Palaeolithic record is ambiguous as to the importance of meat in hominid diets. One recent bone strontium study of hominid fossils found that isotopic concentrations indicated (in contrast to received wisdom) a higher level of dependence on plant foods for an early *Homo* sample than for the Swartkrans *Paranthropus robustus* sample (Gibbons 1992).

Intensive food preparation and *complex foraging toolkits* are stipulates of the model which relate to technology. With regard to the first, the evidence for controlled use of fire in food preparation prior to *Homo sapiens* is restricted to ambiguous evidence from Oldowan contexts, and reliable evidence from quite young hominid contexts (notably Zhoukoudian, c. 0.5 Myr BP). With regard to the complexity of foraging toolkits, the emphasis on complexity distracts attention from some of the most challenging aspects of the pre-*H. sapiens* lithic record, namely the persistence of assemblage elements such as the Acheulian biface.

Thus the components of the 'home base' model which relate to primary subsistence adaptations are only clearly in place with *Homo sapiens*: the subsistence strategies of

H. erectus, or of early *Homo* remain poorly resolved. This is particularly unfortunate since the model was designed to provide an account of the subsistence transitions which accompanied the evolution of hominids and the appearance of the activity remains of *Homo* spp. in the Lower Palaeolithic record.

The other two elements of Isaac's model relate to social organizational adaptations. *Long term mating bonds* are not unique to humans: gibbons, for example, are monogamous. Indeed, van Schaik and Dunbar have recently developed a model to account both for gibbon monogamous pairing (in a niche which would support a multi-female harem system), and for human monogamy (given evidence for a marked predisposition for male violence towards stepchildren), which holds that monogamy and increased male parental investment is a necessary strategy to avoid infanticide in species with long life spans and long periods of infant dependence during development (reported in *The Independent* 27.4.1992).

Regulation of social relationships by explicit kinship categories and rules is also problematic as a distinguishing human trait. Not only is it clear that other primates may recognize kin and non-kin, and regulate their transactions by some notion of trade or reciprocity (as De Waal [1989] has argued for common chimpanzees); it also appears that human social cognition and categorization may originate in memory for long-term stable patterns of social interaction, and that by implication explicit categories may represent the 'fossilized' descriptors of such interaction constants (cf Freeman *et al.* 1988). Thus while the primary subsistence components of the home base model do not unambiguously explain the subsistence activities of pre-*sapiens Homo*, the social organization components in the model are not sufficiently human-specific to constitute distinguishing traits of an evolved hominid adaptation.

The home base concept (the term presumably denotes the baseball fix-point, which is the origin and terminus of a 'home run') does incidentally encapsulate many of the behavioural assumptions about household structure and division of labour which have made Isaac's model both so often cited and so controversial. But Isaac's model has not proved an unqualified success in explaining the archaeology of *Homo erectus* or other pre-*sapiens* hominid taxa. Moreover, in focussing attention on the nuclear family group and its economy, the model has obscured issues concerning the larger groups and the intergroup relationships of these hominids. I shall next examine primatological work which uses the notion of role structures and household units to analyze nonhuman primate subgroups, and the location of such units in a hierarchy of social units of increasing inclusiveness. I shall then look at the way in which the structure of hominid social networks can be modelled as a determining cause of Palaeolithic artefact distributions and rates of typological change, following ideas proposed by Isaac in an early paper in 1972.

The idea of home.

The idea of 'home' was the subject of a recent special topic issue of the journal *Social Research* (58[1], 1991). The contributors, from a wide range of backgrounds, identify many of the evocations of that idea which make it so central also to archaeological interpretations of the ancestral human social environment. Douglas (1991) observes that the home is the prototype instance of a voluntarily maintained solidaristic association, in which people associate in order to produce joint 'public goods' and accept a discipline of social coordination of individual members' intentions and preferences as the cost of such a strategy. Hareven (1991) discusses the social history of the household as an economic unit, and notes the recent origin of the isolated middle class nuclear unit: in preindustrial Western society, the home was not a private retreat from the outside world but a sociable domain of multiple activities, some public and economic, some involving extended kin and non-kin. Rykwert (1991) notes that a home need consist of little more than a hearth or other focus point (the Latin word *focus* meant 'hearth' or 'fireplace' [Hollander 1991]). The Roman concept of home, *domus*, derived from an Indo-European root word *dem*, family. In Greek, *domos* was a building, and *oikos* a home; to build the material fabric of a home was *oikodomein*. *Oikos* derives from a (hypothetical) Indo-European root **weik*, a clan or social unit above the level of the household (Hollander 1991). In other words, the concepts of 'home', of spatial fix-point or focus, and of family or other solidaristic kinship unit, are etymologically intertwined. Equally, the home is primarily a site of 'primary sociability'. Indeed, the parlour was the residual sign of this sociability function in the later nineteenth century home, deriving as it does from the rooms which are denoted by the French *parloir*, places for talking. Unfortunately modern studies of the ways in which the built environment facilitates or inhibits mood regulation and social interaction regulation are rare, even though it is evident that the methods do exist for conducting research on this aspect of the social context of subjective experience (Brown 1992).

Primate social organization and household models.

Part of the concept of a home is the notion of a *spatial* organization of the activities of the household unit. Although it has not been a major focus of attention in primatology, it is clear that nonhuman primate social organization has correlates in the spatial dimensions of social interaction, which can serve to reinforce distinctions based on dominance rank and affiliative bonds. One recent study which confirms this point is Blount's observational study of a small group of five bonobos, one male, three adult and one juvenile female, at Yerkes Primate Research Center in Georgia (1990). Blount's study shows that the patterns of affiliation and of dominance were expressed not just in overt aggressive acts (which were very infrequent) but also in the spatial distribution of these animals in their preferred locations within their caged enclosure: the spatial separation between the male and the other members of this group were interpreted as "a buffer to true dominance (i.e., patterned directionality of aggression)" (*ibid.*:430), while the affiliative contacts between the adult females were reflected in their shared preferences for specific parts of the cage space.

Equally, while primate social systems have been most intensively studied in comparative socioecology on the basis of group-level traits such as group size, adult sex ratio, or reproductive systems, there is a strong tradition of work on primate subgroups which are analogues of the human household unit. For an example of a specific application of household analysis to nonhuman primates, Quiatt (1986) has outlined an approach to rhesus monkey subgroups based on analysis of the effect of a hypothesised age and sex-based role structure on interaction patterns: he observed stable sociospatial groupings which correspond to the notions of simple and extended family households (one subgroup consisting of a juvenile female, two sisters, and mother; the other consisting of a juvenile male, two brothers, mother, and mother's younger brother).

Kummer's (1968) model of the social organization of Hamadryas baboons was a major advance in this respect, with his demonstration that baboon groups have a structure made up of a nested hierarchy of interacting units, with the family group (one adult male, one or two adult females, and their dependent offspring) as the smallest such unit (see Figure 4.1). Hinde's model (1975) of the hierarchical nature of primate social organization, based on the emergence of relationships out of the repeated patterns of interactions among individuals, and on the emergence of group structure out of the compromises between the multiple relationships of each animal in the group, was another step in this direction (Figure 4.1).

On the comparative level, Maryanski and Ishii-Kuntz (1991) have recently diverged from the familiar procedures for categorizing primate social systems, in their attempts to apply social network theories of role segregation in human households to nonhuman primate cases. Their starting point is Bott's theory of the social network characteristics which give rise to clear role segregation in some human marriage partnerships. Bott (1957) argued that the stronger role segregation observed in working class households reflected the strong ties which both partners retain to members of their separate premarriage social networks, given a tendency for densely connected, stable networks to exert pressures for conformity to collective norms from their members. Maryanski and Ishii-Kuntz (*ibid.*:406) formalize this model by isolating five variables: "(1) degree of overlap or separateness in the networks of individuals; (2) degree of density of networks available to actors; (3) degree of social support provided by networks to individuals; (4) degree of normative elaboration of obligations for social support among those embedded in networks; and (5) degree of segregation in the activities of individuals." They graph the model as a path diagram giving the sign (positive/negative) of the effects of each variable upon its dependent variables (Fig. 1, reproduced as Figure 4.2). They then use primate data to test the hypothesis that variation between species in the characteristic patterns of affiliative bonding and coalitional behaviour can be explained by this model, abstracted from its human sociological context, as a comparative model of the effects of network structure on role relationships. I have tabulated some of their results in Figure 4.3. Their conclusion is that network density and role segregation (as indexed by patterns of affiliative bonding and by extent of overlap between the activity profiles of male and female mating partners) are related, and reflect the importance of dispersal patterns for patterns of same-sex bonding. "When males leave home, close-knit female networks prevail; when females leave home, close-knit or medium-knit male networks prevail; and when both leave home, loose-knit networks for both males and females prevail" (*ibid.*:417). This is a particularly pertinent point for the student of human evolution, since the implication is that a marked division of labour (a central component of the home base model) follows from role segregation, and that role segregation in turn follows on from the prevailing pattern of dispersal and philopatry: an individual remaining in his or her natal group and with a dense social support network is less likely to enter into undifferentiated role relationships with partners transferring in from outside that group. Thus the structure of the domestic 'household' unit cannot be separated from the larger scale dynamics of group composition and intergroup or population-level mobility.

Maryanski and Ishii-Kuntz also diverge from much biological thinking in presenting their model of role segregation as a model of the properties of social networks, rather than as a model of the sociobiology of innate dispositions to form certain kinds of affiliative bonds. This is therefore in contrast with the 'finite social space model' of Foley and Lee (1989, cf Foley 1989), in which it is argued that the evolution of social systems in savannah-living hominids was phylogenetically constrained by a hominoid pattern of sociality based on male-male affiliative bonds. According to Foley (1989), whereas papionine (baboon) sociality in a similar open habitat has been constrained by a pattern of male out-transfer and female matrilineal kin-bonding, this pattern would not be transferrable to a hominid analogue due to phylogenetic constraints. Thus according to Foley's cladistic analysis, hominid social behaviour is grounded ancestrally in male-male affiliative bonds, with subsequent accretion of stronger male-female affiliative bonds and female-female bonds. This model appears to be contradicted by the strength of the female-female bonds in bonobos. Moreover, there is a clear tendency for male out-transfer to occur in habitats where there is a high predation risk (Anderson 1986). In fact, in the common chimpanzee study population at Mt Assirik, Senegal, the study population of common chimpanzees which has the highest predation risk a large community size, there is a clear pattern of differences in sub-group composition and mobility according to the micro-habitat type being traversed, with very few mother-infant or female isolate subgroups occurring in the more open and exposed sectors of the habitat (Tutin *et al.* 1983). Contrariwise, for papionines, where there is low predation risk, female transfer appears to become much more common in chacma baboons (Anderson 1987). It therefore seems equally plausible to think that early *Homo* had a pattern of larger mean group sizes, male dispersal and female bonding, due to the higher predation risk of a savannah-woodland niche, and that any hypothesis of the evolution of sex-role segregation in hominid household units should take this into account.

These models place the primate analogue of the domestic or household unit in the context of a hierarchy of levels of social structures, most notably in the context of the dynamics of the primate social group. This point has been made by Rowell (1991), who notes also that the group level may not be the most inclusive level of primate social organization, since there are also intergroup interactions (most frequently observed in agonistic and spacing behaviour) and possibly population-level social structure. This last point is very suggestive. Rowell (*ibid.*:266) notes that dispersal of members of one sex from their natal troop is a linking mechanism between troops, but one which can rarely be monitored by field observation: "We are limited, by practicality, to trying to understand a small corner of an open system whose extent we cannot determine. One possibility [in the case of Rowell's own wild study-population of blue monkeys] is that there is a closed group of perhaps a dozen subgroups, within which the males circulate but which they rarely leave; another that the system is really open, and knows no barriers other than distance and no limits other than the extent of suitable habitat. This last corresponds, I think, to the Japanese workers' concept of a species-wide social system, or specia ... A combination of experience and anecdotes of several species of African monkeys (baboons, patas, colobus, deBrazzas, blue monkeys and redtails) suggests to me that adult males might have something like a Poisson distribution of travel lengths, with most males mostly making short moves within a study area, some moving longer distances within an area, while occasional males are encountered far from others of the species, apparently moving between suitable habitats".

The indication, therefore, is that the central focus of the home base model on the domestic unit and the sexual division of labour is distracting our attention from the importance of larger scale social units in hominid evolution. Indeed, there are reasons to link the occurrence of sexual divisions of labour (or at least role segregation) with the causal influence of patterns of dispersal and philopatry which involve precisely the supra-group level social structures which Rowell discussed.

Social network models of Upper Palaeolithic social systems.

In a previous Chapter, I have discussed the limitations of models of hominid social systems which use the social carnivores as a reference group, and have examined work which suggests a link between the evolution of relative neocortex size and the complexity of the typical social network of a primate species. Given the increased predation risk of a shift to the open habitat of a savannah-woodland niche, and the phylogenetic constraint of a heavily K-selected hominoid reproductive strategy (which makes the cost to the parents of any one predation event so much the greater), it seems realistic to retrodict large group sizes (at the community level) and subgrouping strategies which were sensitive to the ranging area as a predation 'risk surface' for hominids of pre-*sapiens Homo* taxa. In the first part of this Chapter, I have outlined some of the limitations of Isaac's home base model, and emphasized the way in which analysis of primate data suggests a causal relationship between role segregation in the minimal reproductive unit, and the pattern of dispersal and mobility at the intergroup or population level. The expectation for *Homo erectus* would therefore be of a community-level organization intermediate between the chimpanzee community and the modern human hunter-gatherer 'maximal band', with wider population-level structure emerging on the basis of male dispersal between groups if there was a sufficient basis in individual long-term memory for patterns of behaviour to be transferrable between groups at this level. Rowell (1991:266) suggests that this level of interaction within populations (as defined by circumscribed resource distributions) could "add up to something so organized as to be recognisable as a population-wide element of social structure" only if individuals have the ability to "recognize others and remember them between infrequent encounters, and [have] the longevity which can allow a network of acquaintance to build up. For the elephant, fabled both for its good memory and its longevity, Moss & Poole (1983) have suggested that such a population-wide system is indeed a reality".

The paradox is that this continuity between the large, complex communities of chimpanzees and the regionally integrated bands of modern human hunter-gatherers is implicitly denied in much conventional thinking about the social systems of earlier *Homo*, which has been dominated by the concept of the nuclear family or domestic household unit (following Isaac's work, and also Lovejoy's (1981) model of the evolution of hominid social strategies). Yet when one turns to recent work on the social systems of Upper Palaeolithic foraging bands, complexity and network extension are the focal issues. Indeed, this bias in Upper Palaeolithic studies is in many ways the converse of that of Lower Palaeolithic studies, since it pays relatively scant attention to the issues of household composition and sex role segregation.

Mueller-Wille and Dickson (1991) have reviewed some models of Late Pleistocene society in Southwestern Europe to specify the issues which predominate in such model-building. They show how theory has moved away from the 'basic model' of hunter-gatherer strategies, which derived from the *Man the Hunter* symposium and which was characterised by the following components: "(1) a simple technology, (2) subsistence systems capable of producing relatively low levels of food energy, (3) a diet in which plants contribute a greater percentage of the calories than animals, (4) little emphasis on accumulation of wealth, food or other kinds of surplus, (5) a low density of population per square kilometer, (6) dependence upon wild food resources which tend to be spatially dispersed and to fluctuate (often either seasonally or over the long run), (7) a population size determined by the amount of wild foodstuffs collectable during the season of minimum availability, (8) a band level of social organization, (9) reliance upon kinship as the most important principle of social organization, (10) economic distribution and exchange based on reciprocity, (11) bands as corporate groups holding land resources in common but granting unrestricted access to these resources to all members of the band, (12) an absence of full time specialization beyond that based on the sexual division of labour, (13) an absence of ascribed statuses and roles beyond those of age and sex, and (14) feuding but no true warfare" (*ibid.*:26). The new models of Upper Palaeolithic social systems in southwestern Europe depart from that basic model in viewing hunter-gatherers of that period not as members of such tiny and isolated 'band' formations, but as "integrated into vast regional networks, emphasizing marriage ties, information exchange, and social and religious interaction. In such networks, the existence of full time specialists beyond those social categories defined by sex and age appears a real possibility. By facilitating the sharing of both information and risk, these regional networks are seen as contributing directly to the adaptive success of the peoples of southwestern Europe (see also Soffer 1985 for eastern Europe)" (*ibid.*:48).

However, models of Lower and Middle Palaeolithic social systems remain in the 'basic model' paradigm. In the remainder of this Chapter, I shall present a simulation model of information transfer through structured social networks which could stimulate us to modify this assumption.

Social network models and cultural evolution in the Lower Palaeolithic.

The starting point for this section is an early paper by Glyn Isaac on modelling hominid social behaviour in the Lower Palaeolithic (Isaac 1972). Isaac was writing at the time when the clash between the culture historical and the functionalist paradigms in lithic analysis was becoming established, and his paper explores both the importance of moving beyond artefact-classification studies to site structure analysis and behavioural modelling, and also the need for models of lithic variability which take into account stochastic factors of 'cultural drift'. Isaac argued specifically that the pattern of Acheulian artefact variability, with a consistent broad band of tolerated variation in metric traits of bifaces constrained by an overall conservatism in the template for their production, could reflect neither the inertia of different 'craft traditions' (since such variability is synchronic and spatially localized) nor the influence of functional considerations (since this remains undemonstrated by anything other than circular reasoning). He suggests that the variability and the overall conservatism seen in biface metric traits could be explained by an 'equilibrium basin' model in which local micro-traditions may evolve over several generations through cultural drift (a stochastic process), but in which such variability could never become fixed over the longer term as a way of generating true cultural innovation due to the characteristics of Lower Palaeolithic social networks ("A simple mechanical analogy for the pattern would be the trajectory of a ball-bearing in a bowl being tilted or vibrated in a random fashion" [*ibid.*:186]).

Isaac then proceeds to outline a model of the social network characteristics which might give rise to such 'equilibrium basin' effects. He suggests that if inter-band or inter-community relations are treated as a communication system, then "it is conceivable that a widespread low density network lacking in mechanisms for preventing the equalization of information content between neighbouring nodes would have great inertia to fundamental changes (cf Owen, 1965), while a more tightly knit network involving culturally determined differentials in the rate of information exchange might engender localized partial isolates, which, on occasions, might be more prone to the acceptance and exploitation of innovations ... This process may have the same kind of importance for cultural change as isolating mechanisms have in genetic evolution" (*loc.cit.*). This contrast between two model regional social network types is shown by Isaac's diagrammatic representation, reproduced as Figure 4.4.

Isaac further suggests that language could serve as the mechanism of such isolation of regional populations in the Upper Palaeolithic, which, provided that they were stable for at least several generations, and involved reasonably dense and populous sets of people, "may have constituted a mechanism for readier development and establishment of innovations, which might have been lost or rejected in a more diffuse situation" (*ibid.*:187).

This model of the effects of linguistic barriers would appear to be incompatible with the extended network models of Upper Palaeolithic society, although Isaac is sufficiently vague as to the scale of regional linguistic integration for this to remain open. It is unclear how languages would have diversified in this stage of human prehistory, whether, for example, by some simple distance-decay process, or by active reinforcement of in-group/out-group boundaries and within-group standardization analogous to the effects of modern nation-state 'standard language' policies. Perhaps more seriously, the model assumes a free exchange of information through an open, low-density social network in Acheulian times, even though cooperative exchange transactions of this sort have been shown to depend on quite complex mechanisms for assessment and enforcement of reciprocity in games theoretical modelling. Nonetheless, it is sufficiently abstract and well-specified to justify further exploration.

Simulation modelling.

As a first approach to testing this model, I have designed a simulation experiment which takes model social networks analogous to those of Isaac's two types and treats their connections as channels for cultural transmission. The design was implemented in a specially written program by David Wheatley (Dept of Archaeology, University of Southampton) using the Clipper compiled Dbase programming language, and I am happy to acknowledge his fundamental contribution.

Simulation in this sense is designed not to provide an analogue representation of complex multivariate real world processes, but rather to formalize and experimentally manipulate the conditions of a simple system with some properties assumed shared by the real world processes being explained. It is thus *part* of an explanatory strategy, and not a substitute for other forms of explanation or interpretation. In this case, and following Isaac (1972), it is assumed that cultural diffusion processes track pathways of interaction between nodes in a network (analogues of groups or other semi-closed social units), such that the spread of traits is a function of the connectivity of the total network. To understand the conditions of saturation of a total network by a single trait or trait complex (analogous to the spatial and temporal homogeneity of Acheulian bifaces), we shall assume further that two competing traits are introduced into the network, and spread as a function of the set of shortest paths linking their initial distribution points to all other points in the network. The simulation experiment therefore addresses the question, 'Under what conditions does the diffusion of traits through Isaac's two model networks result in an equilibrium distribution of a single trait throughout the network, rather than an equilibrium or non-equilibrium distribution of both competing traits in a spatially segregated distribution pattern?' Isaac's own intuitive arguments lead us to expect a tendency for the low-density network to lead to homogenous single-trait distribution patterns, and for the clustered network to lead to spatially segregated equilibrium distributions of both traits.

Methods.

First set of experiments.

Two model social networks are described as closed arrays of 90 nodes connected by lines. The networks are closed by the device of coding their two-dimensional representation as the surface of a torus (thereby preventing edge effects in the simulation). The networks are first plotted on isometric graph paper (for consistency with the lattices in Isaac's original model), and the nodes assigned identifying point labels. In the case of Network 1, the lattice is homogenous and each node has the same level of local and global connectivity as every other node. In the case of Network 2, two densely interconnected groups are superimposed onto the background lattice of Network 1, by the device of connecting each member of the group to each other member of the same group. These two Networks are represented in Figures 4.5 and 4.6, with their point labels.

The Networks are then described in a square adjacency matrix in which the point labels are both the row and the column variables, each cell represents a relationship between a pair of nodes, and each possible pairing of nodes in the network is represented by two cells (symmetrically reflected about the diagonal). The cell values are 0 or 1 depending on whether or not a direct line exists linking the relevant pair of nodes.

Each point or node is then allocated a 'trait state', denoting a specific attribute state of that node. The initial 'trait state' at the outset of a simulation is 0, representing the absence of a score for this attribute. The simulation is designed to propagate two traits through the network, "1" and "2", which represent mutually exclusive attribute states for a node. Thus a node may have the trait or attribute "0", "1", or "2", but may not have more than one of these attributes or 'trait states' simultaneously.

The nodes change their 'trait state' as a function of the trait states of the nodes to which they are directly connected. For this simulation experiment, the rules are specified as follows: If a node has trait state "0" and one or more of its contacts has a trait state of "1" or "2", then the node changes its own trait state to that of the adjacent node - either "1" or "2". If a node is adjacent to two or more nodes with non-"0" trait states, and these nodes do not all have the same trait state (all "1"s or all "2"s), then the node adopts the trait state which is most frequent among its contacts (or, optionally, as a weighted function of the ratio of "1"s to "2"s). Where there is no dominant trait state in the node's immediate network (but there are nonetheless non-zero states in adjacent nodes), a new state is randomly allocated (either "1" or "2"). For each iteration, the program calculates the new trait state for each node as a function of the summated trait states of all its contacts (as these were at the end of the previous iteration). The object is to see what factors affect the ultimate distribution of trait states among the nodes in the Networks after all nodes have acquired a new trait state (either "1" or "2"), and after the initial propagation process has reached a competitive equilibrium.

The first sets of experiments involved running two separate sets of fifty different random seedings of nodes with the "1" and "2" traits, one set for each model network (Network 1 and Network 2), for each of three different conditions.

In *Condition 1*, the traits "1" and "2" are equally weighted.

In *Condition 2*, trait "1" is weighted against by the device of stipulating that a node acquires whichever trait state is most prevalent in its network, such that the number of "2"s is greater than [the number of "1"s divided by 1.2]. In effect, this means that where a node has 3 contacts with state "2" and three with state "1", the node acquires state "2", but where the distribution is (say) 7 "2"s and 9"1"s, the reverse is true.

Finally, in *Condition 3* the weighting factor is increased to further favour the propagation of trait "2", by making the decision rule a function of whether or nor the number of contacts which are "2"s exceeds [the number which are "1"s divided by 1.5].

Second set of experiments.

In a further set of experiments, a third model network was coded with characteristics distinct from those of Isaac (1972), but consistent with Rowell's model of dispersal patterns in African monkeys. Each node is directly linked to six nearest neighbours as in Isaac's low-density lattice (Model Network 1), but also to two nodes which are at two steps distant, and one node which is three steps distant. These are selected randomly from the set of nodes which are two (or three) steps distant from the focal node, for each of the ninety nodes in the model network. This simulates the Poisson distribution of travel distances for male dispersal in Rowell's model of the population structure of African monkeys. Because of the random element in this model network, there are irregularities which would not be replicated in a subsequent sample of the possible networks which follow these rules of connectivity. However, due to the processing time involved it was possible only to use the one version of Model Network 3 (Poisson) (Figure 4.7), with fifty different random seedings of Traits One and Two (the same fifty seedings as used for Model Network 1), each run for twenty iterations.

Results.

The objective was to run each simulation for as many iterations as it took for the network to reach an equilibrium distribution of trait states. However in the experiments with Model Networks 1 and 2, while this has essentially been accomplished in the second series of runs, the first series in particular did not reach an equilibrium distribution for all cases. In the first series, all runs were of 10 iterations; in the second series, all were of 20 iterations. Network 3 proved to have the most complex dynamics of all, and had not stabilized in all cases even after twenty iterations. As a technical note, it was evident that the program made intensive use of processing time, due not to the program's computational complexity (which is not great), but to the highly iterative nature of the calculations required to propagate the traits through these model networks. Thus these results represent a total CPU time of well over one week of continuous running on a 486dx 33Mhz machine. It is possible that this processing time requirement could be drastically reduced by using more efficient read/write routines in subsequent updates of the program (Dave Wheatley, pers. comm.).

Figures 4.8, 4.9 and 4.10 contain the results of these experiments in the form of frequency histograms for the numbers of trait "1" remaining in the network at the end of each of the 50 simulations, for each of the three conditions and for each of the three model networks. It will be seen that in Network 1 (low density) the traits trended very strongly indeed towards an equilibrium of half of each, where there was no weighting factor. With weighting, the distribution moved towards an increasing preponderance of "2"s as a function of the strength of the weight. For Network 2 (low background density with two dense groups), the unweighted condition led to a similar distribution shape but with more outlier results of either all or no "1"s at the end of the run. However, with weightings, the distribution moved towards a preponderance of "2"s but with the modal distribution of "1"s stabilized at 19 nodes (i.e., the membership of one of the dense groups). In contrast with Network 1, there were relatively few scores of saturation (no "1"s) under the weighted conditions. Finally, Network 3 (Poisson distribution of ties) showed a more erratic pattern in the unweighted condition, but the strongest convergence on a complete saturation of the network with "2"s in both of the weighted conditions. Indeed, under condition 3 (with a fairly strong weighting against trait 1) all 50 simulations resulted in such a saturation (no "1"s at all), although the random seedings were of the same pairs of nodes as those of the Network 1 simulations.

Figures 4.11-4.14 show the results of some analyses of the initial conditions of each simulation and their effect on the outcome distributions of traits. These analyses were run using the *UCINET IV* social network analysis software (Borgatti, Everett, and Freeman 1992). I would like to acknowledge the usefulness of a SERC funded place on Martin Everett's Social Network Analysis day school at Surrey University in 1993, for the design of this analysis of the simulation results.

I first looked for effects of distance between seed nodes on the resultant distribution. 'Distance' in graph theory means the length of the shortest path connecting the two points, where a path length is measured by the number of lines between nodes which must be traversed to connect the nodes. It will be seen from the scatterplots that distance appeared to have no discernible effect on the outcome of the simulations. For the low density Network, this implies that the random term in the simulation program may have been the most important determinant of the simulation outcomes.

For Networks 2 and 3, which are irregular in the sense that not each node is equally central relative to other nodes in the whole network, it was possible to compute some-further measures of the initial conditions which may have affected the outcomes of the simulations. I computed the differences between the scores for each member of a pair, for each seed pair, for a number of measures of centrality. 'Centrality' is a term used to indicate how 'well connected' a node is to all the other nodes in the network. The following measures of centrality were used, derived from the work of Freeman (1979) and incorporated in the *UCINET IV* analysis package: 'Degree' (the number of ties connecting a node directly to another node); 'Closeness' (an index of the sum distance of the node to every other node in the network); and 'Betweenness' (an index of the frequency with which a node lies on the shortest path conecting other pairs of nodes, as in a 'gatekeeper' role). For Network 2, it appears from the scatterplots that the relative 'closeness centrality' of one of the seed nodes relative to its counterpart had a marked effect on the oputcome of the simulation, for all weight conditions. For Network 3, a 'directed graph' (in which ties were not all bidirectional), the differences in 'in-degree' (numbers of ties converging on a node) were computed, and the differences in betweenness centrality were also compiled. It is evident from the scatterplots that these indices were relatively poor predictors of the outcome distributions of the simulations, suggesting that the dynamics of the propagation through Network 3 were the most complex of all these models.

Discussion.

I have discussed Isaac's 'home base' model and its limitations, and have noted work in primatology which links household structure (and role segregation) to the patterns of sex-based dispersal and philopatry. I have noted also Rowell's suggestion that monkey social structure may persist at the regional population level as a consequence of dispersal patterns, given a capacity for long term memory for information to span groups using dispersing individuals as carriers. I then discussed Isaac's models of regional interaction networks as communication networks, and the effects of their structure on innovation rates in material culture.

The simulations explored the properties of these and a further network structure. It was found that the Network which was an analogue of the population structure proposed for monkeys by Rowell (Network 3, taking dispersal to be the mechanism of communication between groups, and with a Poisson distribution of travel distances from each node) was most efficient at propagating a trait in situations of competition with some single other less adaptive trait (where adaptiveness was simulated by the propensity of nodes to adopt that trait in relation to the frequency at which it was encountered among the node's 'contacts'). In both of Isaac's networks, when there was no weighting, the modal distribution was of half the population having trait "1" and half having trait "2", which does not really correspond to the picture we have of Acheulian biface distributions. Furthermore, the network with two dense groups (Network 2) proved the least efficient at propagating an adaptive trait in the strongly weighted condition, due to the inability of 'super-group' members to pay attention to what was going on outside their group once they had all acquired the less adaptive trait.

It is conventional to dismiss speculations about the functional adaptedness of Acheulian bifaces. However, a number of speculative explanations do exist, including Calvin's projectile model (Calvin 1993) and a model of bifaces as curated cores (Davidson and Noble 1993). I am predisposed to believe that hominid networks evolved as a function of dispersal mechanisms and the individuals' longevity and memory capabilities, since this is the most parsimonious explanation of evidence of regional interaction networks and the only one which is consistent with what is seen among nonhuman primates. Quite possibly this model might apply also to the 'regional interaction networks' which have been postulated for the Upper Palaeolithic in Europe. Given these biases, and the evidence of the simulation studies for total saturation of the 'Rowell' network with the more adaptive trait under weighted conditions, I am inclined to give greater credence to these speculations about the functional adaptedness of these tools than is conventional.

The simulations of the dynamics of Network 3 as a matrix for information propagation showed that under conditions of zero selection pressure, outcome distributions appeared to be very variable and unpredictable. However, under conditions of positive selection pressure for one of the two competing traits, there was a powerful tendency towards an equilibrium distribution made up entirely of the 'dominant' trait. This would appear effectively to mimic the two processes discussed by Isaac (1972): random-walk variation in biface morphology, and a strong tendency to revert to the prototypical biface morphology once the limits to such variability have been reached or exceeded. If these limits represented real constraints on functionality for these still poorly understood artefact types, then the Network 3 (dispersal) model would offer a plausible and sufficient communication mechanism for the variation and the equilibrium basin effects which Isaac took as his point of departure.

Dispersal patterns are a fundamental aspect of primate social systems. Pusey and Packer (1986) note that whereas early field workers were impressed enough by the persistence of primate social groups to see these as closed genetic units, evidence has since mounted that primates like other mammals show high rates of dispersal by one or both sexes from the natal group, and that this has the ultimate evolutionary function of adapting to intrasexual competition and avoiding inbreeding depression of the gene pool. This mechanism evidently exerts a powerful force on primate reproductive strategies, since "dispersing animals are likely to face increased risk of mortality from predation, starvation, or hostility from strange conspecifics" (*ibid.*:250). What if dispersing hominids were (as a function of their evolved life history strategy) sufficiently intelligent and long-lived to retain cultural traits acquired in their natal group, after dispersal to another social unit? Is it possible that all evidence of pre-*Homo sapiens sapiens* regional interaction simply reflects this behaviour pattern, and that large scale networks in the Upper Palaeolithic were simply explicit realisations of communication networks which were always latent in the dispersal patterns of the hominid ancestors?

Wobst's (1974, 1976) simulation model of mating network size in an optimally packed hexagonal lattice (analogous to that of the simulations reported here) produced predictions of a minimum viable mating network of 175-475 individuals (depending on the extent of cultural mate selection rules). As Mandryk (1993) notes, the hexagonal packing is a realistic analogue of the regional spatial structure of human hunter-gatherer bands (which average 5.4 - 5.9 neighbours, Gamble 1986), and the viability of a mating network will depend on the size of the minimal bands and the distance between them (as this impacts on travel costs). Mandryk follows analysts of modern hunter-gatherer regional social systems in arguing that maximal band networks play an adaptive risk-buffering role, and suggests that the cost of maintaining a viable mating network/regionally integrated maximal band can be calculated as "the total distance travelled to allow one round-trip to each of the other bands within the network" (1993: 63).

This mating network model differs from my model of Poisson distributions of dispersal distances outward from each node (or minimal band) in that it assumes the existence of regionally bounded large scale social units. One further application of my model would be to calculate the minimum local group sizes needed to maintain viably low coefficients of relatedness between mating pairs in each group, given 100% out-migration by one sex and a Poisson distribution of dispersal distances to other groups (randomly selected for each dispersing individual, subject to the constraint of a target Poisson distribution of travel distances for the total of emigrants from each group). My expectation would be that under such a 'mixing' regime, smaller groups would remain viable than would be the case in the closed regional networks envisaged for the Upper

Palaeolithic of Europe and elsewhere, which may be closer analogues of Isaac's (1972) linguistic isolates.

In sum, my contention in this Chapter is simply that once again, closer study of primate social systems suggests that apparently exotic patterns of activity residual in the archaeological record may have very unremarkable underlying causes.

CHAPTER FIVE: ETHOLOGICAL ASPECTS OF LANGUAGE AND ITS EVOLUTION

Introduction.

Palaeolithic archaeology is hardly a stranger to model-building: one of the archetypal clashes between archaeology in the culture history paradigm, and archaeology in the functionalist paradigm of the New Archaeology, was that between Francois Bordes and Lewis Binford over the interpretation of assemblage variability in the Mousterian of Western Europe. Nonetheless, many aspects of the behaviour of hominids and of the first modern humans remain poorly understood, and the development of coherent models of hominid behaviour which can account for the observed patterning of the Palaeolithic archaeological record continues apace. Some of the most promising current work involves dialogue between archaeologists and primatologists working on the determinants of social systems and of cultural traditions: other directions are being followed which lead to a greater integration of archaeology with cognitive and comparative psychology.

In this Chapter, I shall point to the need for clearly articulated models of the adaptive function of language in *Homo sapiens*, if we are to understand the causal relatyionships between its appearance and the socioecology of early modern *Homo sapiens sapiens*. Specifically, I shall critique the model of language which I believe to be central to postprocessual archaeology, offer an alternative ethological model of language as 'vocal grooming', and finally show how recent work on dominance style in primate species can lead us to a new model of the evolution of language as an adaptation. This is a model for early modern *Homo sapiens sapiens* which sees language and global colonization, not as causally related in the sense of the latter depending on the former, but rather as both manifestations of a relaxation of dispersal costs for members of early human social groups.

Recently there has been a resurgence of interest in the origins of modern humans, and in the behavioural adaptations associated with their apppearance and spread. The 'Out of Africa 2' model, which postulates a replacement wave of global recolonization from a genetic hearth in southern Africa c. 100,000 years BP, remains the most coherent and well-supported single model of this process currently available, although the limitaions of the more simplistic versions of 'Out of Africa 2' are now being brought to light. In Palaeolithic archaeology, the trend has been caught in a pair of recent books edited by Paul Mellars (an archaeologist who sees marked discontinuities in the cognitive abilities of modern and pre-modern *Homo*) and Chris Stringer (a biological anthropologist who is one of the principal advocates of the 'Out of Africa 2' scenario for modern humans' appearance and spread) (Mellars and Stringer 1989,1990). Implicit, and at times explicit, in this work is the assumption that modern humans were characterized by behavioural and cognitive abilities which distinguished them from their morphological predecessors; and the primary candidate for this distinction is the appearance of a full language capability.

This assumption merits further examination, and I have examined some of the issues in an earlier Chapter on Deacon's work and its application in Palaeolithic archaeological interpretation. Much of the work associated with the 'Out of Africa 2' scenario focusses more, however, on reconstructions of the peripheral speech apparatus and its evolution in *Homo sapiens* (e.g. Lieberman 1991). The contribution of the evolutionary anatomy of the hominid *vocal tract* to language capabilities remains controversial. Aiello and Dean (1990) discount all arguments from vocal tract morphology to linguistic production capabilities, evidently on the grounds that this confounds two distinct levels of computational complexity, the one to do with speech motor control, the other to do with integrated language generation involving syntactic, semantic and pragmatic strategies. Certainly, speculative claims about neanderthal linguistic deficits based on pharyngeal reconstructions face considerable and diverse counter-evidence. More generally, in morphogenetic terms, unique aspects of the human vocal tract (low position of larynx, greatly expanded oropharynx) may be the secondary outcome of selection for an expanded brain in our hominid ancestors, since the related modification of the cranial vault appears to have architectural and mechanical relationships with increased basicranial flexion and low position of the laryngeal soft tissue (by inference from the effects of surgical intervention on cranial development in rats) (Reidenberg & Laitman 1990). Characteristic developmental changes in the composition of the infrahyoidal and pharyngeal inferior constrictor musculature may also reflect primarily the evolution of the human cranial vault (cf Herr *et al.* 1990). Cranial morphology constrains not only the potential range of phonation, but also that of articulation. Thus tongue position in the oral cavity is determined by palatal and by mandibular length, and by relative height of the hyoid bone (Duchin 1990). In modern *Homo* the increased potential range of articulation is therefore a product of evolved facial orthognathism. Thus although the human speech-related musculature may (exaptively) *enable* more complex acoustic signal production and comprehension, this has not necessarily been the main driving force in human brain evolution, nor has it been sufficient for the generation of more flexible and informationally complex speech signals.

However, the brain evolution evidence does, whatever the case for speech motor muscles, point to a late increase in language capability, on the basis of the late expansion of absolute and relative brain sizes (following the arguments of the two models presented earlier). In humans, language is not modality-specific: congenitally-deaf signers develop signing behaviours in a parallel sequence of stages to audiovocal language users, and with similar patterns of cerebral laterality of control (Poizner *et al.* 1990). While the marked tendency to left hemisphere dominance for speech is peculiar to humans, monkey vocal comprehension is also lateralized to the left hemisphere, while other affiliative-approach behaviours share this lateral bias in primates, including self-calming behaviours in infant chimpanzees (Bard *et al.* 1990). This may reflect conserved neurochemical asymmetries in the motivational systems which selectively activate functionally-differentiated areas of the mammalian neocortex (cf Tucker and Williamson 1984). However, lateralization and complex hierachical constructions appear to relate to neocortical size, as I have already discusses.

Despite these quantitative discontinuities, in terms of brain circuitry for speech comprehension and motor output there is basic continuity between human and nonhuman primate vocalization circuitry and physiology. In monkeys, the Broca area homologue subserves multi-movement orofacial actions, and incorporates a projection from the larynx (O'Brien *et al.* 1971). The Wernicke area homologue in macaques is involved in vocal comprehension tasks beyond simple audition (Heffner and Heffner 1989). The arcuate fasciculus, the fiber tract linking the Broca and Wernicke areas in humans (and subserving gestural rehearsal of incoming speech signals in speech comprehension), is a conserved trait present in macaques (Deacon 1988a). Monkey vocal gestures involve manipulation of the tongue and lips paralleling human speech articulation (Brown and Hauser 1990); phonological evidence shows that monkeys use acoustic patterns in vocal communication which are common to human language phonology (frequency modulation, changes in power spectrum, amplitude modulation and call duration) (Maurus *et al.*, 1988). This raises the issue of whether we should understand human language as functionally related to monkey or ape vocalizations, or whether the circuitry has been 'exapted' for some other set of functions which are found only as secondary or latent aspects of nonhuman primate vocal behaviour.

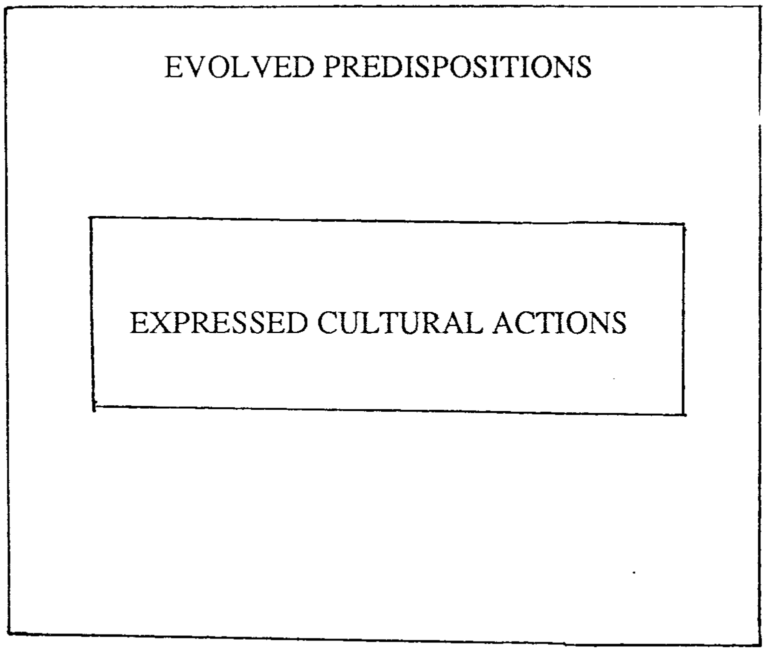
Palaeolithic archaeology and models of language adaptation.

Postprocessual archaeology has been called a movement to examine the implications of the fact that people talk to each other. Yet despite the importance of language origins research in Palaeolithic archaeology, that field has remained largely impervious to the theories of the post-processual school. While some hold that this reflects the conservatism of Palaeolithic archaeologists, others hold that this reflects rather the limitations of the theory informing the postprocessual paradigm. Palaeolithic archaeologists are forced to confront the issues of biological and cultural evolution directly, and this may make them more aware of the need for a model of hominid and human behaviour which is consistent with evolutionary biology. In this Chapter, I shall review some of the limitations of the structuralist assumptions which postprocessualism reproduces, before continuing in subsequent Chapters to outline a more substantial approach to the reconstruction of evolving patterns of human cultural transmission and agency.

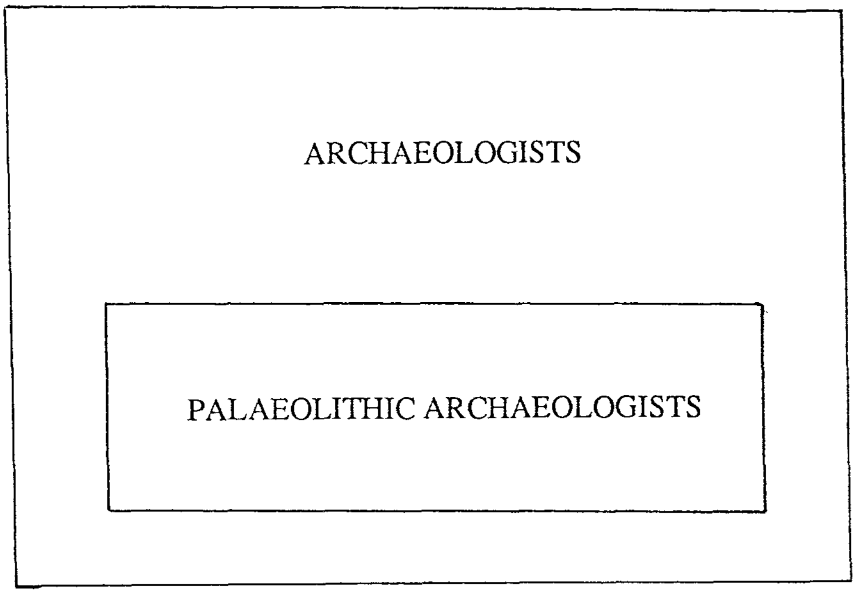
Stereotypically, the natural sciences are assumed to deal with causal inference of a mechanistic order (as in Newtonian mechanics, or, with allowance for observational limitations, in statistical mechanics). The social sciences, by contrast, are assumed to deal with the self-directed agency of human beings with their own internal cognitive mechanisms of motivational adaptation. Social scientists therefore share a central theoretical and methodological concern with the reliable attribution of intentions to social actors, usually through some overall framework articulating a basal model of individual motivation and cognitive and communicative competence with a hierarchical model of the more powerful macro-scale factors constraining individual actions (whether seen as the statistical aggregation of a host of individual acts, or as the product of ideological shaping of individuals' perceptions and goals). Finally, the humanities disciplines deal with the evaluation of human actions and their products in terms of these intentional and unintended processes and consequences.

Now from one point of view (e.g. Hempel), while these different knowledge domains each impose different explanatory strategies on researchers, there is nonetheless an underlying unity in all such fields of enquiry, which all require causal explanation in terms of empirically verifiable general laws and theories. From a different viewpoint (e.g. Gadamer), method in the social sciences differs dramatically from that of the natural sciences because of the need to understand the rationality of human behaviour in terms of both subjective intentions and cultural traditions. This 'interpretive' dimension entails attribution of knowledge-structures to actors in any given situation or social collectivity, structures which may be inaccessible to direct observation. Apel (1984) has argued that neither of these viewpoints is adequate in itself, since while social scientists must be aware of the purposes or reasons behind an action, this takes no account of the unintended consequences and unrecognized causal connections of an agent's actions. He therefore argues for a 'complementarity' between the need for 'understanding' of a tradition, and that for explanation of the causal forces which may remain unincorporated into that knowledge base.

Because of these differences between the social and natural sciences, the relationship between archaeologists and evolutionary biologists is often a problematic one. On the one hand, evolutionary studies are concerned with the evolution of the set of cognitive and behavioural capacities which generate as a sub-set those realised cultural actions which archaeologists recover in the field. This relationship can be represented as:

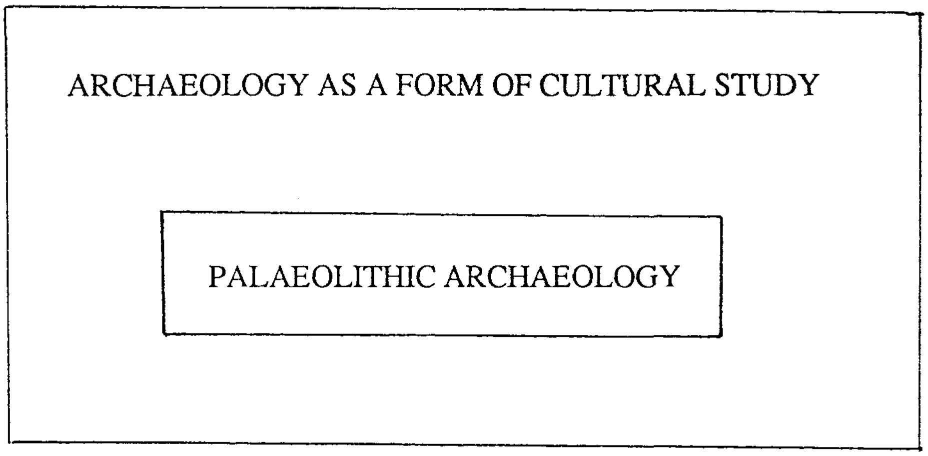


However, the same relationship can be represented inversely, in relation to the quantity of material and the numbers of scholars involved in each field - for example,

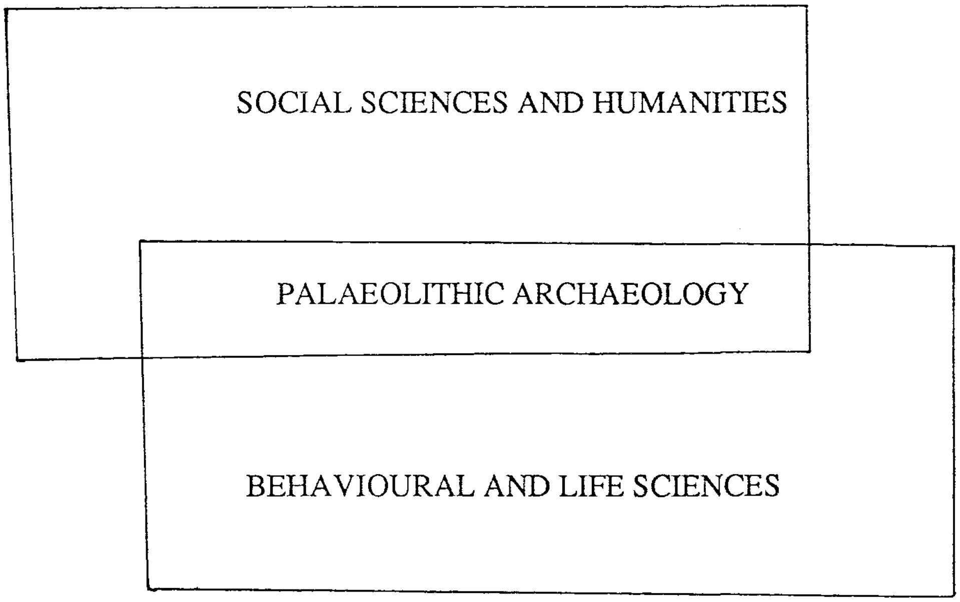


Depending on how our perceptions are 'weighted', we can see the relationship of dependence or subordination going in either direction.

In addition, there are divides of disciplinary culture which render this relationship problematic. Most archaeologists are concerned with cultural variation, and take some construal of the baseline human capabilities as a 'given' factor. There is an increasing tendency to distance the field from evolutionary issues, and to relate the archaeological study of human culture to the traditions of the humanities and human sciences. On the other hand, *palaeoanthropology* is the field in which this baseline is constantly redrawn, now earlier, now later, now based on hard distinctions between humans and other animals, now based on comparison and analogy with other species' anatomies, physiologies, and behavioural repertoires. The place of palaeolithic archaeology in this network is problematic. Should we see the picture as:



or should we see it like this:



Part of the problem lies in the ideological differences between practitioners of the biological and social sciences. This can be seen in extreme form not just in some of the early sociobiological assertions about genetic determination of human social behaviour, but also in some humanist responses to attempts to dissolve the barrier between the perceived cognitive abilities of humans and other animals. G.E. Allen (1987) exemplifies this response:

> "Sociobiologists and students of animal awareness, though coming from different directions, arrive at the same end: they blur the distinction between animals and humans by setting up an evolutionary continuum [...] students of animal awareness see fully developed human awareness existing in rudimentary form in lower animals [...] To blur the distinction between animal and human especially by distorting the biological reality (or by claiming for the biological reality more than it can offer), is to play into the hands of a political mood that leads ultimately to fascism [...] Blurring the distinction between animals and humans, whether by evolutionary, genetic, or neurobiological arguments, paves the way for relegating some people to the sub-human category on the basis of their biology. Once there, the usual moral restraints and considerations cease to apply, and fascism has arrived" (quoted Griffin 1990:*xvii*).

Further light on this pattern of acceptance or rejection of sociobiological concepts can be found in a study by Lieberman *et al.* (1992) which found that among academics, familiarity with the concepts of human sociobiology was a poorer predictor of their acceptance or rejection than disciplinary affiliation, and that the affiliation of disciplines to either the social or the natural sciences was a probable explanation of the attitude of the academic to human sociobiological concepts. Notably, whereas biological anthropologists were inclined to favour such concepts as useful for research, the reverse was the case among cultural anthropologists .

Post-processualism and biological anthropology.

Despite these rifts, it is clear that there are weaknesses in social scientific theories of human culture and social behaviour which deny any role to biologically-constrained motivations or dispositions. A clear example of this is the postprocessual approach to human social communication. It has been suggested that the appearance of the 'post-processualist' critique in archaeology in the early 1980s represented a body of new work adressing the implications of the observation that *people talk to each other*, in contrast to the work of the New Archaeology group (which had derived from the observation that people must eat, and that there is no such thing as a free lunch). Now, through the 1960s and 70s, Anglophone cognitive psychology in association with artificial intelligence had consolidated a cognitive framework for understanding language and decision-making, one which developed from an initial critique of a model of behaviour as driven by environmental contingencies, and a move to put the mind, intentions, and internal representations or symbolic processes back in the driving seat (famously in Chomsky's critique of B.F. Skinner), to a more rationalistic, formalist focus on postulated innate, context-independent procedural rules for information-processing, decision-making, and linguistic competence. In archaeology, the post-processual group has *rejected* adaptational models of information processing and decision making in favour of the structuralist and poststructuralist corpus, largely because of a sense of the failure of the New Archaeology to take account of the role of subjective intentions and cultural traditions in human behaviour.

Although this post-processualist critique has achieved some considerable impact, it remains vulnerable to the response that it ignores the shaping role of the external environment on human social behaviour, and that it is structured by only a superficial understanding of theoretical work in linguistics and the social sciences relating to the organization of human cultural behaviour. The post-processual group's structuralist roots suggest that in a postprocessual Palaeolithic archaeology we would be talking in part about the origins of the Saussurean sign, but this has not been the focus of much research in evolutionary or palaeoanthropological debate (one exception is Hurford 1989). Most theory-led work on the evolution of the human brain and the capacity for language draws either on Chomsky's ideas about language, or on Piagetian schemes for general cognitive capabilities. More empirical work is focused on the comparative anatomy and physiology of brains and of vocalization and speech in primates, with its associated neural circuitry. Yet as a research tradition, post-processualism seems to be moving more and more into the realm of 'humanities-babble'. This is part of a general trend in the social sciences. As Turner (1992:126) puts it, "the social sciences, particularly sociology and anthropology, have lost their early vision. They seem afraid to assert that there are universal and generic patterns of human behavior and organization that can be described and understood with concepts, models and propositions. [...] In all of this new 'discourse' - to use a favourite word of humanities-babblers - relativism reigns supreme. *Realism*, *positivism*, and *naturalism* are dirty words, because everything is relative, and, as a result, the only real things are text and talk." But palaeolithic archaeology, and palaeoanthropology, are focussed on discovering precisely such universal and generic patterns of human behaviour - 'evolved predispositions'. The study of 'human universals' is currently undergoing a renaissance, and much of the impetus comes from this evolutionary research field (cf Cosmides and Tooby 1989, Brown 1991, Fiske 1991). And *talking* is the central universal of human behaviour in this sense.

Debate in palaeoanthropology has recently turned explicitly to questioning definitions of 'human uniqueness' which have a direct bearing on these theoretical differences. Foley, in his book *Another Unique Species* (1987) and elsewhere, has demonstrated how much could be gained by taking a comparative zoological and ecological perspective on human evolutionary anatomy and behaviour, while Cartmill (1990), in a paper on 'Human Uniqueness and Theoretical Content in Paleoanthropology', has argued that palaeoanthropology should attempt to reduce and if possible eliminate the list of qualitatively unique human traits, since qualitatively unique phenomena cannot be explained by reference to any more general overarching laws or regularities. From the other side of the divide, Wolfe (1990:618) notes that "Any statement about human uniqueness, for sociologists an introduction to their science, constitutes for many students of animal behaviour a challenge to be met", and asserts the qualitative uniqueness of the human abilities to regulate behaviour (as 'interpreting selves') by reference to rules which are negotiated as social practices, and which are consequently subject to reorganization from one generation to the next. Philip Lieberman, in his recent book *Uniquely Human: the evolution of speech, thought, and selfless behaviour* (1991), argues that humans are distinguished by their possession of a higher moral sense (cognitive altruism), which is mediated by language and related cognitive abilities to extend the concept of 'relatedness' and to regulate conduct by concepts which are only explicable using language.

Clearly the debate revolves around the scope of comparative and evolutionary analyses to account for language and for rule-governed social behaviours in the human case. The approach to human social behaviour and its mediation by cultural traditions taken by the post-processualists has followed the route taken in text studies by structuralism, post-structuralism, and hermeneutics. The strategy taken in the programmes of textual analysis which underly this work is predicated on the assumption of the cognitive inaccessibility of the physical and material environment (including the network of forces and resistances which make up a social environment) to human agents, without the mediating of cultural structures which as systems of signs are essentially arbitrary in their relationship to that environment. *Narrative* has become an increasingly popular focus of attention for students of actual patterns of language use. In Hayden White and Louis Mink's post-structuralist philosophies of history, narrative imposes a formal coherence "on a virtual chaos of 'events', which in themselves (or as given to perception) cannot be said to possess any particular form at all, much less the kind that we associate with 'stories'" (White 1981:794). The concept of narrative encompasses more than just histories, myths, or poetic fictions (cf Prince 1987). Stories do, however, play a fundamental role both in socializing and in construing representations of the world. If *individual* goal-directed agency involves the move from pre-existent conditions to a projected future goal state under the control of representational memory, then *social* agency involves the move from a past to a destined future under the control of a persuasive construal of the causal forces of a given situation. Stories, with their temporal structure embodying such a move, are the formal medium for socially co-ordinating individual agency in this way.

However, the post-structuralist supposition that socialization through participation in story-telling events involves the acquisition of essentially arbitrary sets of 'meaning-relations' which then guide subsequent action seems to me to be fundamentally mistaken. Narrative *comprehension* involves the listener or reader constructing or updating a mental representation of the situation and actions being described, following the narrator's cues as to the appropriate focus of attention in regard to topics, characters, and locations. In simple stories, the intentions, goals, or plans of the central characters appear largely to determine perceptions of relevance, enabling inference of causal links between events and focussing attention on actors, places and objects potentially relevant to achieving or thwarting such goals (Bower & Morrow 1990). In *narratives*, the past is necessarily as much spatially as it is temporally localised (Nicolaiesen 1991). Narratives are defined as having a formal structure involving (minimally) at least two events (or one situation and one event), neither of which logically presupposes or entails the other, and a 'complicating action' (Prince 1987:58). By way of comparison, in Premack's (1990) formula, *intentional action* is *directly perceptible* due to its characteristic dynamic 'signature' to visual perception: if causality can be directly inferred from patterns of induced movement, and intentionality from patterns of self-propelled movement, then *social intentionality* - action with the goal of affecting a second agent - may be directly inferred from perception of 'self-propelled objects' in B-D-R sequences (base - deflection from base - return to base). *There is then a basic correspondence between the mapping of agency through narrative, and the actual patterns of intentional action in the cognitively accessible physical environment.* It may therefore be that the principles involved in narrative production and comprehension are the same as those used more generally in understanding people's actions in everyday life (Bower & Morrow 1990). Grammar, and higher-level discourse structures such as narratives, may therefore encode the properties of causality and social agency using processes which are conceptually linked with more general, non-linguistic cognition. In terms of concepts and the organization of long term memory, the relationship between language (at the *semantic* level) and visual cognition may involve fundamental common principles which are culturally universal. Thus the 'localist' hypothesis of language structure argues that there is a formal analogy between how grammars encode existence in physical location and change in location, and how grammars encode states and changes more generally (Ikegami 1984). Jackendoff (1987), answering the question 'How can we talk about what we see?', argues that visuospatial cognition at its most abstracted level - the three-dimensional mental imagery which is computationally derived from the local organization of boundary elements in the visual field - is linked to and underwrites the conceptual semantics of high-level language processing, so that "semantics will not have to back up into ever murkier levels of 'interpretation' to explain our ability to talk about the visually perceived world" (*ibid.*:93). This is also implied by other recent topological theories of semantics, including *metaphor* (Lakoff & Johnson 1987, Pinker & Bloom 1990, Gelepithedes 1990). Similarly, Talmy (1988) has argued that (in addition to structuring principles of language relating to visual perception) the semantic category of *causatives* - how entities interact with respect to force - are the product of general cognitive processes for abstracting physical dynamics in *kinesthetic* perception.

This point about the language-cognition relation is also relevant to any consideration of the relationship between individual action and social context or cultural environment. *Conversation* is the fundamental site of language use, and one dependent on continuous second-order representations of mutual comprehensibility among participants. In psychobiological terms, we can account for this in terms of the differentiation of function within the neocortexof the human brain between left and right hemispheres, and between front and back within each hemisphere (Kinsbourne 1989). At its most simple, we can relate the neurochemical basis of these distinctions to the basic animal behavioural decision to approach or to withdraw, and see language use as an approach behaviour motivated towards a goal. In the 'activity cycle' posited by Kinsbourne (*op. cit.*), activity motivated towards a goal involves a series of acts punctuated by monitoring of the physical situation to assess the concordance or mismatch between schema or plan, and monitored consequence, with plans being continually updated as part of this cycle. Different cortical regions would be involved in different phases of this cycle. If language is seen as one of a class of such 'approach behaviours' following (as an activity) this general pattern, then metapragmatic aspects of language use simply function in the monitoring of communicative intent and achieved comprehension in a speaking situation (we do not then need to go through the elaborate explanatory contortions of Davidson & Noble 1989).

The capacity to interpret behaviour in intentional terms is fundamental to social agency, and depends on capacities to infer unspoken intentions, to recognize discourse conventions, and to negotiate agreement on the grounds for and organization of specific social actions. In face-to-face interactions, in addition to directly perceptible cues or 'leakages' (gaze direction, facial expression of emotion, etc.), interpretation will depend on acquired background knowledge ('culture'), including not just 'habitus' but explicit procedural knowledge relating to roles and statuses, public display rules, and to speech genres and discourse conventions. In some form, interpretive instruments such as metalinguistic terms for commenting on language use (epistemics, metapragmatics, genre terms) occur cross-culturally in both literate and non-literate societies (e.g. Turner 1980, Stross 1974). Once again, as was the case with the relationships between physical or kinaesthetic perception and grammatical structures which I discussed earlier, the evidence for *reflexivity* as a human universal in symbolic interactions also points beyond the allegedly arbitrary 'meaning-relations' of the structuralist and post-structuralist frameworks, to the dynamics of actual language use in social interactions, and the visual monitoring of the effect of a linguistic interaction on the intentions and dispositions of participants.

Thus as a framework for characterizing the formation of cultural repertoires in human societies, the post-processual approach is flawed not merely by its neglect of the relationship between subjective intentions and cultural traditions, and the dynamics of the external environment, but also by a semiotics of language which precludes recognition either of the universality of cognitive access to the dynamics of the physical and social environment as this can be directly perceived, or of the universality of some level of reflexivity in linguistic interactions. Ultimately, this leads to a very deterministic view of human social agency. The recognition of reflexivity in human spoken interaction is more consistent with expectations of the character of social behaviour derived from animal behaviour studies, which stress the importance of perspective-taking and intentional manipulation in social information transfer: for example, Whiten and Byrne's studies of the frequency of field observation of tactical deception in primates demonstrates the correlation between frequency of observations, and cognitive capacity or neocortical progression across primate species (see Figure 5.1). This is the basic insight of Krebs and Dawkins' theory of nonhuman animal communication (1984), in which signallers are seen as manipulating receivers' behaviour, and receivers are seen as engaging in 'mind-reading' to elicit the intentions of the signallers.

Human linguistic interactions: the vocal grooming model.

One of the problems with arguments for a continuity between human language and nonhuman primate vocalizations has been that it seemed that there was no evident continuity in the neural circuits involved. Indeed, establishing the nature of the continuity between nonhuman animal communication and human language remains fraught with methodological and theoretical pitfalls (cf Snowdon 1993, Hauser 1992). It is, however, now quite clear that there are fundamental continuities between the cortical circuits implementing human speech, and the circuitry involved in processing some monkey vocalizations (cf Steklis 1985). *Close-range intragroup affiliative* *vocalizations* appear to be the most likely homologue of human language (cf Seyfarth 1987). The detailed functional importance of different classes of primate vocalization - particularly these 'within group vocalizations' (Harcourt *et al.* 1986) - has yet to be properly understood. However, in squirrel monkeys, 'chuck' calls (the most commonly heard close-range affiliative vocalizations) are structured by 'conversational' turn-taking and by simple syntactic rules, and occur within established groups principally during quiet, relaxed and unthreatened periods. Playback experiments elicited 'chuck' responses to 'chuck' playback most effectively when the original chuck came from an individual of the same group as the respondent, suggesting that familiarity is the key variable in eliciting response (or participation in 'conversational' vocal exchange), based on evident mechanisms for learning to discriminate individuals by their vocalization characteristics (Biben & Symmes 1991). Dunbar (1988:250) has suggested that the squirrel monkey data, and similar observations in gelada groups, justify the suggestion that "contact calling (and similar vocalisations) may be used as a form of vocal grooming in the maintenance and servicing of relationships".

Snowdon (1989), in a review on New World monkey vocalizations, notes that vocal interactions such as duetting can reinforce the pair-bond in monogamous species, and that dialect or individual differences in vocal behaviour can serve in close range affiliative vocalizing to communicate information about the relationships involved, rather than about internal motivational states. In looking for primate analogies with human vocal production, Andrew (1963) argued that the appropriate analogy was with baboon vocalizations, since *Papio* spp. and *Theropithecus* can produce speech-like sounds much closer to human production than can chimpanzees or rhesus macaques. Richman (1987), in a study of *Theropithecus* (gelada) vocalizations, noted that they are richly varied, and accompany a diverse range of social interactions, using an abundance of segmental, acoustic rhythmic, and melodic features. Their immediate social functions include the vocalizer's manipulation of the attention of addressee(s) to aspects of their shared perceptual environment (e.g. classes of objects, members of different social categories in the group, different social actions of third parties, or the emotional arousal state of the vocalizer). *Rhythm* and *melody* are used to introduce a sequential order into such gestures, and to delimit the boundaries of a communicative event. In the long term, the social functions of such vocalizations are to form bonds between individuals, for example through developing patterns of dyadic vocal exchanges.

In considering continuities between human language and primate vocal communication, it is useful to recall an exchange over the nature of verbal behaviour that took place between B.F. Skinner and Noam Chomsky in the late 1950s. In 1957, Skinner published a famous book, *Verbal Behavior*, which received an even more famous and negative review by Chomsky in *Language* in 1959, a review which is widely acknowledged to have 'nailed' behaviorism as a dominant paradigm for explaining human cognition. 'Nailed', that is, until the recent revival of neo-behaviorism in alliance with connectionist artificial intelligence modelling (parallel distributed processing models) (Andresen 1990, cf Edelman 1987).

Chomsky favoured a theory of verbal behaviour based on the concepts of generative grammar: the rationalistic study of the innate formal rules for generating linguistic utterances. Skinner by contrast, in defining verbal behavior as "behavior reinforced through the mediation of other persons" (1957:14), favoured an approach which focussed on human beings as 'localities' rather than as actors; which did not separate the written from the spoken, nor the vocal from the gestural; and which did not separate the speaker from the listener in any speech episode. Andresen (1990) finds similarities, consequently, between Skinner's approach and those of Foucault, Derrida, Austin, or Voloshinov - founding fathers of modern humanities research. It is evident that a model of human linguistic exchanges which took account of the 'vocal grooming' aspects would fit better with the focusses of the humanities (for example, on the importance of unreflective routines and on the reasons for engaging in activities such as 'permanent communication' which appear to violate the assumptions of economic rationality).

In studying the evolution of the human brain and of the capacity for language, we are all of course immensely privileged: we are engaged in a continuous experiment in language use ourselves, as living products of hominid evolution. Now, *conversational* talk - ordinary, mundane, everyday conversation - is the most frequent and generalized form of natural language use, and can therefore be taken as a model for the functions of proto-language in pre-modern *Homo*. And as Robert Louis Stevenson (1887) put it, "people talk, first of all, for the sake of talking". Such talk is intrinsically co-operative - Scheff (1986) even argues that turn-taking in language use is a human hard-wired genetic universal behaviour pattern - and is constitutive of social bonds, and ultimately of social institutions (cf Zimmerman and Boden 1991). This approach is also congruent with a model proposed by Jaffe and Anderson (1979) in which the rhythms of adult conversation derive from the conjoint rhythms of kinesic and vocal interactions in the mother-infant pair, such that "human communication is based on an evolved capacity for the acquisition, use, and elaboration of rhythmically structured gestural systems" (*ibid.*:21).

So in studying our own behaviour as language-using human agents, we must address the issue of the *social motivations* which underwrite active individual participation in a conversational exchange. There is an increasing interest in psychology in the 'hot' processes of *motivation* which interact with the 'cold' cognitive processes which were the focus of the 'cognitive revolution' (cf. Hoebel 1988, Appley 1990). Even in the life sciences, behavioural optimization theories rarely address the mechanisms whereby conflicting needs are ranked to generate a single behavioural output. Cabanac (1992) has proposed that sensory pleasure maximization, and displeasure minimization, are the final common currencies by which animals reach a choice between possible behaviours, as the proximate mechanisms for achieving physiological homeostasis: "the necessity for comparing the merits of different courses of action [implies] that there must be some trade-off mechanism built into the motivational control system. Since the trade-off process must take into account all relevant motivational variables, it is clear that the mechanism responsible must be located at a point of convergence in the motivational organization" (McFarland & Sibly 1975). Similar points are made by Csikzentmihalyi (1975, Csikzentmihalyi & Massimini 1985) when he shows that human individuals make choices to maximize 'flow' - "a condition of heightened awareness in which the reduction in tension about performance allows a positively evaluated enjoyment of personal experience. [...] Experiences of flow associate with the repetition of actions that preserve and restore personal well-being and facilitate relationships of high compatibility with others." (Crook 1989:26). A related argument has also been made by Nesse (1991), who suggests that the ultimate evolutionary function of high and low mood in social behaviour is to enable the individual to cope with situations of 'high and low propitiousness', where propitiousness denotes the availability of opportunities to accomplish a goal.

J.H. Turner (1987), in a 'sociological theory of motivation', has offered a composite model of the motivational variables in social interactions, including the need for a sense of group inclusion, the need for a sense of trust, the need for a sense of 'ontological security', the need to avoid diffuse anxiety, the need for a sense of facticity, the need for symbolic and material gratification, and the need to sustain a self-conception, with these needs met through mechanisms including self-presentations, negotiated exchanges, the use of 'ethnomethods', and mental deliberations or calculations. The discussion of mood as a motivational system, and of linguistic interactions as servicing social relationships, suggests that it would be useful to think about the nature of the emotion-cognition interactions which generate such 'social motivation'.

Social motivations and emotional regulation of physiological state.

The integration of an understanding of motivations with the modelling of natural cognition is self-evidently essential if we are to understand adaptive behaviour in animals in their natural setting. Panksepp has formulated a general model of *endogenous opioid mediated social behaviour*, in which social contact and affiliative behaviour provides a partly opioid mediated comforting effect, while social separation results in distress analogous to opiate withdrawal (e.g. Panksepp 1988). The implication of this hypothesis is that social affiliation and social motivations should not be assumed to be purely 'cognitive' in their organization, but that they could equally well be modelled as pleasure-seeking or displeasure-averting behaviours in which the reward or positive reinforcer is release of endorphins, with concomitant attenuation of experienced stress symptoms such as anxiety, pain, or heightened arousal. There are some reports of decreased behavioural responsiveness to social isolation after opiate administration, in many bird and mammal species including nonhuman primates (and cf Keverne *et al.* 1989) (however, the explanation or generalizability of these findings remains controversial [Winslow & Insel 1991]). *Perhaps, therefore, when we analyse 'social motivations' or the behavioural optimization of 'flow', it is at this level that we should look for their physiological correlates.*

This is very much at the centre of Eric Keverne's view of the determinants and consequences of primate social relationships (Keverne 1992), when he argues that "Although it is unrealistic to consider any one peptidergic system to be chemically coded for a specific category of behavior, there is good reason to assume that beta-endorphin is of importance in adult primate social interactions. [...] acute separation studies reveal a significant reciprocal interaction between CSF opiates and affiliative social behavior. They can be interpreted in terms of opiates acting as part of a neural reward for social interactions, whereas social interactions in turn maintain 'opiate tone'" (*ibid.*:29). Understanding the processes of emotional arousal regulation and of motivational control in primates is fundamental for understanding the behavioural mechanisms which underwrite complex primate social systems. Stressors and coping behaviours are central to primate social life. The concept of 'stress' in conscious animals denotes the physiological consequences of some threatening external event. Memory and context influence the response, which may depend on the individual experiencing such environmental stimuli in terms of 'novelty' or 'distress' (cf Herd 1991). Social stress, and the variable individual adaptations to it, produce neurochemical and neuroendocrine responses which can influence dominance ranking, immunological status, and reproductive success. It is evident (from a study of wild olive baboons) that adaptation to social stressors in coalitional behaviour is a function, not just of the external events themselves, but also of 'personality traits' (ability to predict and control the outcome of social interactions and find outlets for tension) via modulation of the hormonal processes involved in aggression and avoidance behaviours (Sapolsky 1990; cf Figure 5.2). Indeed, dominance has been found to have potential physiological costs for chimpanzees also in terms of decreased immune status (Masataka et al. 1990). If, therefore, we explain the evolution of language by its use for servicing hominids' intragroup social relationships, then we should also be thinking about the effects of ordinary language use in *these* terms.

In nonhuman primate social systems, the principal proximate medium of social communication in coalition formation appears to be *social grooming* (Dunbar 1988a, Goosens 1989). Ultimately, this conciliatory and affiliative behaviour also serves the hygienic function of removing ectoparasites and dirt from areas of the pelage inaccessible to the recipient animal (Barton 1985). In accordance with Panksepp's model, the affiliative social bonds which are serviced by primate social grooming appear in some monitored instances to be mediated by release of endogenous opiates, natural 'pain-killers' which modulate responsiveness to stress and which are mimicked by the action of artificially synthesized (and addictive) painkillers such as morphine. Endogenous opioid levels have been found to vary with grooming relationships in talapoins (*Cercopithecus talapoin*) (Keverne *et al.* 1989). Specific forms of allogrooming appear to produce autonomic nervous system changes in the recipient: Boccia *et al.* (1989) report observations of the effect of reception of stroking by a female pigtail macaque (*Macaca nemestrina*) in heart rate deceleration, an effect particularly striking in 'conciliatory' grooming events following aggression.

A number of studies suggest that the development of physiological self-regulation in humans involves entrainment to repetitive patterns in social interactions, with specific systems regulated by hidden rhythms in specific aspects of interactions and relationships (Hofer 1984). Observed empirical instances may include such diverse phenomena as the synchrony of menstrual cycling in young women living together for a period of time (McClintock 1971), or the covariation of individual crew members of a B-52 bomber in levels of adrenal cortical output (Mason 1959). These processes of 'mutual adaptation' may have longer term consequences for individual adaptability to stressors: thus for example, variability in human infant-caregiver attachment patterns, differentiated in the secure/insecure dimension, correlates with variability in autonomic reactivity (insecure infants show greater physiological reactivity to stress), and also with developmental personality variables (irritability) (Izard *et al.* 1991). Clearly social touch (the closest analogue of primate allogrooming) still plays a fundamental role in human social relationships - as Thayer comments, "above all communication channels, touch is the most carefully monitored and guarded, the most vigorously proscribed and infrequently used, and the most primitive, immediate and intense of all communicative behaviours" (1986:24). However, *conversational talk*, with its turn-talking and its repetitive, collaboratively scripted and reproduced routines, serves as precisely such a medium of 'mutual adaptation': in conversational speech, partners adapt elements of their conversation to one another, including basic 'paralinguistic' elements of the acoustic speech signal itself (fundamental frequency of phonation) (Gregory 1986). It has been found that cyclicity increases in the course of a conversational interaction, and can be taken as an index of the success of the interaction in servicing the relationship among participants (Warner 1992). There has been relatively little work on the physiological correlates of conversational interactions, but it is clearly an area in which the ethological approach could be of benefit.

Talking is, then, a central mechanism for negotiating the satisfaction of socially-motivated needs. Common forms of collaborative talk in ordinary conversation include insult, ridicule, and teasing (aimed at individuals present during the exchange), and gossip (aimed at individuals absent during the exchange): in these, and in the collaborative construal of narratives, the interactions serve to meet individuals' needs for self-respect, and to generate consensus on shared perspectives, thereby consolidating in-group cohesion (cf Eder 1988, Eder & Emke 1991). However, it is also clear that conversational exchanges involve more social negotiation than just the 'phatic communion' which Malinowski first classified - social uses of language to signal friendship, or at least the absence of enmity. There is also the use of linguistic interactions to assert or contest dominance relations among participants. For Burling (1986:8), for instance, "it is in defining ourselves in relation to others, in conducting interpersonal negotiations, in competing, in manipulating, in scheming to get our own way, that the most subtle aspects of language become important".

In an essay of Robert Louis Stevenson's which I have already quoted (1882), he wrote that "the spice of life is battle; the friendliest relations are still a kind of contest; and if we would not forego all that is valuable in our lot, we must continually face some other person, eye to eye, and wrestle a fall whether in love or enmity. It is still by force of body, or power of character or intellect, that we attain to worthy pleasures. Men and women contend for each other in the lists of love, like rival mesmerists; the active and adroit decide their challenges in the sports of the body; and the sedentary sit down to chess or conversation."

How do chess and conversation compare as arenas of status competition or affiliative bonding? Csikzhentmihalyi (1988, cf Simon 1988) has criticized cognitive scientists like Herbert Simon who attribute creativity in problem-solving (as in Simon's work on chess strategy) to the rational exercise of computational procedures and and other such constructs, without any influence from the motivational factors which inspired Stevenson's essay. In fact, it is evident that successful chess-players *are* strongly motivated, and that this can be monitored in terms of the elevated levels of circulating testosterone (a gonadal sex hormone related to aggression or dominance-seeking behaviours) in winners as oposed to losers in club chess tournaments (using a male sample, since males produce more testosterone, and are therefore easier to monitor using saliva sampling) (Mazur *et al.* 1992).

Mazur (1985) has proposed that conversational language use should be seen as another, very subtle form of status-competition or coalition-building behaviour, analogous to other more visibly competitive interactions such as sporting contests. He argues that conversational interactions (the primary mode of human face-to-face interaction) are continuous with other primate mechanisms for negotiating social rank in face-to-face encounters, and that the underlying physiological basis for this is short-term changes in hormonal levels relating to achievement or loss of dominance in an interaction - "individuals are assumed to compete often for status in fairly well-defined contests, each trying to 'outstress' the other through actions or words" (*ibid.*:377). Such competition enters most powerfully into a conversation when the 'rules' are broken - rules relating to turn-taking, to visual monitoring of the other, to patterns of inhibition of aggression, to patterns of responsiveness to the other's requests, and to the distribution of control over the structure and length of a conversation between a dominant and a subordinate. This theory has been tested not by physiological monitoring, but by analysis of rule-setting and rule-breaking in experimental conversational dyads: Mazur and Cataldo (1989) have found that dominant conversational partners control initiation and topic switching in an exchange, but that dominance may not be a reliable predictor of absolute durations of active talking for any conversational participant. The implication is that while conversations may serve as the vehicle for status competition, they also establish friendly (or at least non-hostile) relationships through the entrainment of partners to a conversational rhythm.

The paradox here, then, is that while the model of language which informs social scientific paradigms such as structuralism and post-structuralism eliminates individual consciousness, the evidence of a grammar-cognition interaction and of reflexivity in natural human language use is entirely consistent with expectations from the behavioural ecology of animal communication. Moreover, it can be argued that the 'vocal grooming' model of conversational interactions gives a better explanation of apparently non-rational activities such as habitual communication than do the theories of 'humanities-babble', with the added advantage that the vocal grooming model does not need to invoke any qualitatively unique human cognitive or motivational traits which place the analysis of human speech outside the domain of comparative analysis.

Cognition, language, and personality in human evolution.

Foley (1989:473) has argued that "[t]he most appropriate model for social evolution in hominids is one based on the development of kin-based male-male alliances and the increase of paternal care, both occurring in the context of increased group size. These characteristics were a response to the open environments in which they were living". His model of the selection pressures acting on a hominoid social structural 'inheritance' in hominid taxa undergoing habitat shift to a more open savannah environment takes account of the phylogenetic constraints of a hominoid pattern of sociality based on male-male affiliative bonds: whereas papionine (baboon) sociality in a similar habitat has been constrained by a pattern on male out-transfer and female matrilineal kin-based core affiliative bonds, this pattern would not be transferrable to a hominid analogue due to phylogenetic constraints. Thus according to Foley's cladistic analysis, hominid social behaviour is grounded ancestrally in male-male affiliative bonds, with subsequent accretion of stronger male-female bonds and female-female bonds.

Now, whereas Foley is concerned with the evolutionary phylogenetic relationships of species-invariant traits, I am concerned with such traits at the proximate level - *behavioural mechanisms of affiliation* and their neurobiological correlates. I have analysed in a previous Chapter some prominent models of primate social system evolution, and their relationship to models of primate neocortical evolution. I want in this Chapter to point to some alternative approaches to primate social systems which may be more useful in accounting for the evolution of human language and cultural transmission.

Moore (1992:366) has recently highlighted what he thinks "will be a major direction of primate socioecology in the next decade: the investigation of ecological bases for what have been called 'temperament' or 'style' differences among species". Differences in 'temperament' or 'style' between primate species are the subject of Frans De Waal's very accessible comparative study of *Peacemaking in Primates* (1989). The subject of that book is conciliatory behaviour - the mechanisms for maintaining and servicing close kin or coalitional relationships by containing social conflict within acceptable bounds. De Waal describes his work with two pairs of species of nonhuman primate in captivity, and extrapolates analogies with human behaviour. The paired species are rhesus and stumptail macaques (*Macaca mulatta* and *Macaca arctoides*), and common and pygmy chimpanzees (*Pan troglodytes* and *Pan paniscus*). De Waal contrasts rhesus macaques, with their "hotheaded, belligerent temperament" (*ibid.*:95), to stumptails with their "peculiar sex life, high social tolerance, and frequent reconciliations", their dedicated grooming and the high frequency of minor aggression with a very low probability of escalation (*ibid.*:166). He contrasts common chimpanzees with bonobos, noting that bonobos are considerably less belligerent and have a much greater repertoire of non-reproductive sexual behaviours used in deescalatory conflict management. De Waal has some suggestions as to the natural factors selecting for these different 'styles' - for instance, that stumptail reconciliation behaviour must reflect the paramount importance of group unity and cohesiveness, and a pattern of ranging in close-knit groups with little option to resolve disputes by male dispersal (as in a high predation risk foraging niche) (*ibid.*:167); or that common chimpanzee reconciliation behaviour reflects the extreme territoriality of male chimpanzees, and the low probability of survival of males dispersing beyond their home range (*ibid.*:64), whereas bonobos have a more female-dominated social system with weak male-male bonding. However, De Waal does not go into any depth on the ecological variables which may constitute the selective environment favouring differences in 'temperament' or 'style', nor does he analyse the physiological variables which may underly such distinctive species-specific patterns of behaviour.

A recent survey extends this treatment to a wider range of primate species, although individually in less depth. This is Kappeler and van Schaik's (1992) study of methodological and evolutionary aspects of reconciliation among primates. The paper consists of a review of primate studies documenting reconciliation behaviours, defined as affinitive contact between former opponents soon after a conflict, and an attempt to test four competing hypotheses of the evolutionary origins of reconciliation behaviours in the primate order. Kappeler and van Schaik reject the hypothesis that anthropoid-level cognitive complexity is required, since reconciliation behaviours also exist in prosimians (redfronted lemurs). They also reject the hypothesis that conciliatory behaviours are a necessary condition of group living, since some social primates do not exhibit such behaviours (e.g. ringtailed lemurs). The reconciled hierarchy hypothesis, which states that reconciliation is "functionally related to dominance relationships, because it is granted by dominant animals in exchange for the formal acknowledgement of their superior status" (*ibid.*:62), is also rejected because its predictions are not met: some reconciliation has been observed in primate social systems where there are no clear dominance relations or formalized submissive signals (e.g. redfronted lemurs, patas monkeys), while it has not been observed in some systems which do have these traits (ringtailed lemurs). Kappeler and van Schaik find the data to be most consistent with the fourth hypothesis, the 'good relationship' hypothesis, which states that reconciliation serves to maintain valued relationships with other group members, because they are relatives, alliance partners, potential mates, or members of a group-level alliance against other groups. A corollary of this is the expectation of a correlation between a species' 'conciliatory tendency' and the degree of tolerance within groups, and this appears crudely consistent with observations: "chimpanzees, bonobos and stumptail macaques can all be characterized as being near the tolerant end of the spectrum. These same species show a very high tendency to reconcile. ... Interestingly, they are also the ones that use specific acts disproportionately or exclusively in the context of reconciliation" (*ibid.*:66).

The possible relevance for cultural transmission studies can be seen in miniature in a recent study of coaction leading to mutual benefit in two macaque species, *Macaca mulatta* and *Macaca tonkeana* (Petit *et al.* 1992). It has been suggested that Tonkean macaques (*Macaca tonkeana*) are members of the group of macaque species characterized by their conciliatory behaviour and relaxed dominance style (Thierry 1986). In this study, rhesus macaques and Tonkean macaques in separate enclosures were provided with food hidden under flat stones of varying weights (the concealment of the food was carried out in their full view), and were monitored for the rate at which they succeeded in removing the food and for the frequency of coaction involving two or more individuals moving the stones to reach the food. The Tonkean macaques showed a much higher incidence of such 'coproduction' of the joint benefit - recovered food - than the rhesus macaques. Petit *et al.* interpret this not as evidence of intentional collaboration towards a common goal (indeed, macaques appear to lack the ability to attribute intentional states to other individuals), but rather as the opportunistic result of stochastic variation in the approaches of different individuals to the same stones leading on occasion to unintended exertions of joint forces of more than one animal to move these objects. The point here is that the social systems of the Tonkean macaques permit much more relaxed interaction patterns, physical contacts, and tolerance of co-feeding than is the case in the formal, agonistic hierarchy of rhesus society, and that such social characteristics can have as an unintended consequence patterns of coproduction of joint benefits. Although the cognitive abilities of the two species may not differ, their social 'temperament' or patterns of dominance style differ, and have an effect on the probability of social interactions which may involve joint benefits. There is no reason why the same should not be expected to apply to patterns of *social information transfer*.

The idea that social information transfer may depend as much on the pattern of social interactions as on the cognitive capacities of individual animals is fairly transparent, but it remains an idea which many biological anthropologists may have trouble with. Nonetheless, it is the evolution of brain size as an adaptation to resource unpredictability and extended social learning that characterizes the track through Eisenberg's (1981:442, cf Figure 5.3) model of the evolution of complex interdependent social groupings in mammals. Social learning and social interdependence are correlated traits.

Moreover, the possible range of processes whereby an animal may come to share some of the behavioural repertoire of another animal is extensive, as reviewed recently by Whiten and Ham (1992, taxonomy reproduced in Figure 5.4), and involves many processes which depend on the social interaction of the two animals rather than on cognitive capacity as a trait of the species. Active social information transfer involving teaching appears to be very infrequent indeed in higher vertebrates (Figures 5.5, 5.6): as the data in Figure 5.5 shows, by a stringent definition even chimpanzees may be held to show only ambiguous evidence of imitation or instructed learning (after Tomasello 1990). Thus the extensive data on behavioural diversity among common chimpanzee populations (summarized in Tables 5.1, 5.2) need not necessarily represent cultural traditions in the sense of collectively valued knowledge bases transmitted through active teaching: this behavioural diversity has a zonation which corresponds both with the zonation of the three common chimpanzee subspecies, and with ecological variation in habitat type (Table 5.2). The variation may represent emergent distinctions in the adaptations of chimpanzee populations to different habitats, which are passed on largely through passive processes of mimicry, social influence, or social learning, without any conscious active transmission of a 'cultural tradition'.

As a consequence, and in conclusion to this section, the archaeological record of hominid cultural transmission processes may be interpreted not just as evidence of an evolving cognitive capacity for the series of extinct species, but also (or even alternatively) as an index of the characteristics of the social organization of hominid groups which facilitated reproduction of existing cultural behaviour patterns across generations. The temperament or dominance style of a species in the interactions within groups may both reflect the socioecology of the species in evolution, and also facilitate or inhibit passive processes of cultural transmission independent of the ultimate constraints of cognitive capability which we track in studying the evolution of the hominid neocortex. If language evolution can be explained in terms of the function of spoken interactions in 'vocal grooming', then this may not only harmonize with the emphasis of interpretive sociology on apparently non-rational behaviours like 'permanent communication', but also have implications for the frequency of adaptive social information transfer across such interpersonal channels - as a dependent function and consequence of their primary role in servicing or maintaining relationships.

Socioecology of species-specific 'temperament'.

These new studies of 'temperament', 'dominance style', or conciliatory tendency among primate species represent a promising new direction for palaeoanthropology, since they are consistent with the sort of analysis of the evolutionary functions of human language which I have discussed earlier in this Chapter - namely, rank order negotiation and mutual adaptation through entrainment of physiological rhythms, as in 'vocal grooming'. However, they lack the essential ecological dimensions which would enable us to generalize about the factors which select for this or that social behavioural 'profile'. In order to go some way to making good this deficit, I have compiled some data for several such species which bear on the socioecology of species-specific 'temperament' or interactional 'style' (Table 5.3).

Table 5.3 summarises some relevant data on three pairs of closely related species, each pair involving a contrast in temperament or 'conciliatory tendency'. The first pair is that of two free-living squirrel monkey populations (*Saimiri* spp.), one in Costa Rica and the other in Peru. The populations differ in group size, levels of aggression, dominance relations between the sexes, and patterns of natal dispersal (Mitchell *et al.* 1991, cited Ketterson & Nolan 1992:S39). Boinski (unpub. research cited *idem.*) has detected a correspondence between these population differences in the wild and differences in adrenocortical function among laboratory-held *Saimiri* which may underly the observed differences in disposition or emotional reactivity: the more aggressive population (Peru) may have a higher setting to their adrenocortical axis, resulting in higher levels of cortisol and slower recovery from stress, perhaps the result of a few changes in receptor density, availability of neurotransmitter, or adrenocorticotropic hormone levels. Boinski speculates that this may reflect differences in ecology: "where the preferred food is abundant but concentrated (Peru), group size and social interaction increase; when food is dispersed (Costa Rica), social stress may be less a factor in driving social organization. This system is currently under study" (Ketterson & Nolan 1992:S40).

The second pair summarised in Table 5.3 are the two macaque species, rhesus (*Macaca mulatta*) and stumptail (*Macaca arctoides*). The data on pro and contra rates, from de Waal and Luttrell's studies of reciprocity in captive primates (1988), denote the partial correlation between individual A's rate of pro-interventions with B with B's pro rate with A, after controlling for effects of symmetrical traits such as proximity, same-sex combination, and kinship. They therefore constitute an index of social cognitive reciprocity. As the table shows, while neither species shows a consistent pattern of cognitive reciprocity in interventions, nonetheless the rhesus macaques are more accurate in this respect than the stumptails. By contrast, the conciliatory tendency of these species (quantified as the percentage of agonistic interactions which are followed by some attempt at reconciliation between the opponents) is almost three times as strong for the stumptails as for the rhesus macaques (data from Kappeler and van Schaik 1992). In Table 5.3 I have also given data on body size, brain size, and sexual dimorphism, which show that these species are also markedly differentiated by their sexual body-size dimorphism and by their adult body weights: the stumptails are among the biggest of the macaque species, and have a very low degree of sexual size dimorphism. The ecological determinants of these differences remain to be determined, not least because of the lack of data on free-living stumptail macaques. However, Moore (1992) has argued that the low levels of escalated aggression which characterize the dominance styles of stumptail, bonnet, and also Barbary macaques may reflect richer natural habitats in which decreased feeding competition permits males to co-exist in troops without intense sexual competition for access to females, resulting in the high male:female ratios characteristic of these species (where observed, typically nearly 1:1). The nepotistic basis of such male-male tolerance, the evolution of elaborated formal conciliatory behaviours or 'rituals', and the low level of male dispersal could therefore derive from distinctive features of these species' foraging niches which differentiate them from species such as the rhesus macaques, which have low quality diet, low male:female ratios (females will favour male dispersal since it means less mouths to feed), and high levels of escalated aggression. To this analysis we may now add the data on sexual size dimorphism, which also suggests a low incidence of male-male sexual competition in the stumptails' natural habitat.

The final pair of species on which data is given in Table 5.3 are the chimpanzee species, *Pan troglodytes* and *Pan paniscus*. The data on conciliatory tendency again indicate the percentage frequency of reconciliation behaviours following on from agonistic interactions, and show that the bonobos have a stronger conciliatory tendency than common chimpanzees. The data on intrasexual and intersexual grooming combinations are frequency data averaged over four free-living populations of each species (data in Wrangham 1986:359, Table 16.2), and show that among the bonobos male-male combinations are consistently less frequent than in common chimpanzees. The evidence for body size dimorphism is inconclusive, but the bonobos are characterised by larger and more stable group sizes, and by the richness of their habitat (larger fruiting trees, more terrestrial herbaceous vegetation). This has led Blount (1990) to propose that bonobo 'style' in conciliatory behaviour - notably, the broad repertoire of non-reproductive sexual interactions - may reflect the need to dissipate tension relating to feeding interference at rich but patchy and ephemeral food concentrations such as fruiting trees.

These socioecological studies of dominance 'style' are a new direction in primate research, and it is premature to derive any general models which might be used in palaeoanthropological inference. However, they add a further dimension to the comparative and evolutionary study of primate social systems which may prove central to the evolutionary interpretation of pheneomena such as human language and cultural transmission. They represent a new generation of work which addresses the issues raised in Chance's dichotomy of 'agonic' and 'hedonic' modes of primate sociality, which also inform Strum's outline of the two pathways to primate social complexity (Chance e.g. 1988; Strum 1987; points compiled in Figure 5.7).

In conclusion, I would like to discuss a further strand of this discussion of dominance style in primates, and outline a speculative model of the socioecology of language evolution (construed in these ethological terms) in later hominids (early modern *Homo sapiens*).

Dispersal, language and global colonization by Homo sapiens sapiens.

Thierry (1990) has given a formal model of the conditions which differentiate different macaque species by 'dominance style', in which he follows Vehrencamp's (1983) distinction between 'despotic' and 'egalitarian' animal societies, and argues that despotic macaque social systems arise when social bonds are mostly based on kinship, while egalitarian macaque social systems evolve when social bonds are less kin-based, animals keep affiliative ties with all members of the group, and "the individual retains a certain degree of freedom in relation to the power of kin networks" (*ibid.*:511). In other words, differences in dominance style between macaque species reflect the differing balance between individual and social power, where social power is a product of kin-biassed coalitions and alliances. The model has been criticised for underplaying the socioecological variation which underlies such contrasts in the emphasis placed on kin-bonds by members of different macaque species (Das and van Hooff 1993). Nonetheless, it is interesting not least because it introduces the concepts of despotic and egalitarian societies into primate socioecology, in such a way that the concepts might be taken up and used by palaeoanthropologists to reexamine the Marxist notion of 'primitive communism'.

Vehrencamp's paper (1983) introduced these concepts in the wider context of the study of animal social systems generally, and she applied them to avian social systems in her own test of her model. However, Vehrencamp's paper has the corresponding virtue of addressing the problems of species differences in dominance hierarchy in generic terms, and it is to this paper that I now turn.

Vehrencamp argues that dominance in animal societies represents the ability of individual group members to appropriate resources from other group members. She argues that the costs for subordinate individuals of remaining in a group are a function of a number of factors, including relatedness to the dominant individuals (due to inclusive fitness pay-offs) and the costs of dispersal, where the costs of dispersal include probability of successfully relocating to another habitat patch, and successfully integrating with another mate or breeding group with a resultant reproductive fitness exceeding that experienced in the original group.

In a society with low dispersal costs and low coefficient of relatedness among group members (for instance in large groups), one would expect low levels of bias towards dominant individuals in resource allocation, because the subordinates can disperse with low cost when the costs of such bias exceeds the benefits accruing to the subordinates from remaining with the group.

Boehm (1993) has recently argued that the original social condition of modern humans in groups was characterized by an egalitarian ethos and a 'reverse dominance hierarchy', in which leaders are dominated by their followers through the use of egalitarian sanctioning on individual dominance-seeking behaviours. Boehm's cross-cultural survey identified this ethos in mobile foragers, horticulturalists, and pastoralists, throughout the world. the levelling mechanisms used include public opinion, criticism and ridicule, disobedience, and extreme sanctions which include assassination, deposition, and deswertion (when a whole group or some of its members physically desert the leader and disperse elsewhere). Boehm also sees a functional relationship between this egalitarian ethos and the persistence in history of small scale social groups: "egalitarian behaviour ensures that leadership will be weak and, as a side effect, that fission will take place readily and communities will remain small" (*ibid.*: 236).

In the body of this Chapter I have argued for a model of language as a hominid adaptation which stresses the affiliative nature of conversational interactions, and the way in which conversational language serves as a subtle means of status competition with low probability of escalation to higher levels of aggression. I have also argued that language, seen in these terms, is analogous to other 'special behaviours' seen in other primate species where there is relaxed dominance style and a high value placed on social relationships (as in the case of bonobo nonreproductive sexual behaviour).

Finally, in this section I have discussed models of despotism and egalitarianism in animal social systems which relate the egalitarian, relaxed dominance styles to contexts where there is a low level of kin bias in social relationships within groups, and a low cost of dispersal for subordinates. Boehm's model based on extensive qualitative survey of ethnographic data is certainly consistent with my ethological model of language origins.

As I noted at the beginning of this Chapter, the appearance of modern *Homo sapiens sapiens* morphology is associated by many palaeoanthropologists and Palaeolithic archaeologists both with increasing capability for language use and with accelerated dispersal throughout the globe from an original African hearth ('Out of Africa 2'). The proposal which I shall now make is therefore that language evolution (as a vocal grooming behaviour) and dispersal are both consequences of a socioecological shift in hominid strategies, quite late in the course of human evolution, which resulted in decreased kin-bias in social relationships within a group, and decreased costs of dispersal to other groups or new unoccupied habitat patches. The signature of this is fossil evidence of an enhanced vocal apparatus, and archaeological evidence of increased rates of group fission and dispersal to new or unoccupied habitat patches. These signatures are, of course, the principal elements of the arguments used by proponents of 'Out of Africa 2'.

Invoking a latent variable to explain the correlated apearance of more complex language capability and global dispersal does not, of course, solve the problem of modern humans' evolution in southern Africa. To do this, we would need to explain how humans solved the problem of dispersal costs, for example by effective predator defense, or by dietary shift into the 'carnivore guild', and thus competitive exclusion of some competing carnivore species. Nevertheless, the model which I have proposed in this Chapter has the virtue of integrating human language adaptations with the study of other species-specific behaviours for servicing and maintaining valued social relationships, and as I have shown, that comparison also leads on to interesting speculations concerning the nature of social relationships and dominance interactions in the earliest modern human social groups.

This model provides a coherent alternative 'primate model' to that of Aiello and Dunbar (1993), which relates language evolution to absolute group size increases - and as we have seen in Chapter 3, their model is is based on fairly weak analytical grounding in the comparative primate database. It may be hoped that socioecological studies of dominance style in primates will continue during the 1990s, to allow more highly specified quantitative modelling of the parameters relevant to the alternative model which I have here proposed.

CHAPTER SIX: THE STRUCTURE OF EVOLVED PROPENSITIES FOR SOCIAL EXCHANGE

Introduction.

One of the features of human society which have most often been cited as evolutionarily novel is cooperation between non-kin, for example through a division of labour. Games theorists have found it hard to specify the conditions under which cooperation can evolve as a stable strategy.

A number of recent theoretical works on the preconditions of social co-operation in human societies have implicated the evolution of norms and of conformity to group behaviour patterns: for example, Scharpf (1990) has argued that norms are a precondition of realistic co-operative games, since they enable actors to be mutually predictable in respect of those rules which everyone can be expected unconditionally to respect (cited by Offe 1991). Lukes (1991) argues that it is mistaken to oppose rational to norm-guided action, but that we should look for the rationality of norm-guided behaviour, and for evidence that people exercise selectivity in deciding which norms to adhere to. He argues also that norms should not be contrasted with outcome-oriented motivation, since (for example) to be seen to be engaged in normative behaviour per se may be socially desirable as a goal in itself. Finally, he notes that self-interest should not be opposed to norms since self-interest is often defined by normative rules or guides: some people are willing to let norms play a part in defining for them what their self-interest is.

Similar points have been made by Hollis and Sugden (1992) in a critical discussion of the inability of the rationalistic and instrumental model of human decision-making in standard games theory to generate either replications or realistic explanations of human deontic rules, promissory obligations, or coordinated collective agency. Hollis and Sugden suggest that this points to a need for a greater sense of the social construction of human agency, and for a theory of games more closely modelled on Wittgensteinian games, in which the institutional context of rule-governed behaviour analytically preceeds and informs the actions and motives of individuals. Collins (1993), in a commentary on a recent paper attempting to present Schutz's theory of social action as consistent with rational choice theory, notes the importance of the concept of a second order of rationality beyond that of everyday cost-benefit calculations, an order of rationality dedicated to deciding whether to calculate in this way or to stick with an accepted routine or typification. He notes that decisions about switching 'bundles of habits' depend on subjective probabilities of finding a superior 'bundle of habits', and that this probability estimation may take place at the level of affective rather than cognitive assessment ("perhaps by way of calculations made unconsciously in the neural/endocrinological substrate", *ibid.*:66).

Another, distinctive attack on this problem has come from Jonathan Turner (1992), who has extended his own earlier work on a synthetic model of 'social motivation' to a model of the rationality of social solidarity or group norms. In the earlier paper (Turner 1987), Turner proposed a synthesis of the models of human motivation in interpersonal relationships which are explicit or implicit in several sociological traditions (Homans' exchange theory, symbolic interactionism, ethnomethodology, Giddens' adaptation of psychoanalytic theory, and Collins' theory of interaction ritual). The model (Figure 6.1) is structured such that as one scans from left to right, so one moves towards aspects of social motivation which are increasingly accessible to conscious thought. In a separate attempt to synthesise various models of the implicit 'rationality' of solidaristic social actions, Turner (1992) combines elements of the theoretical work of Hechter and of Coleman on rational choice and social norms, to propose a model of the rationality of extensive, prescriptive norms in social networks where there is a high level of private (within-group) consumption of jointly produced goods (Figure 6.2). This synthesis draws on work in rational choice theory concerned with 'outsider' and 'free-rider' problems, i.e., how to enforce contributions from those who may receive benefits in a cooperative group. The aim of Turner's work is evidently to demonstrate the rationality of social behaviour which has no immediate instrumental benefits to its participants beyond the consolidation of the relationship itself.

These approaches all address the question of the rationality of norm-governed behaviour, and have the potential to advance this branch of the theory of rational choice beyond the position according to which norms and traditions are explained only by recourse to some postulated bias in social reasoning. Deontic reasoning is reasoning about norms, defined by Allison (1992:282) as socially learned rules of behaviour, typically of the form 'if conditions are A, then do B', which have been almost or universally adopted within a group. If norm-governed action can be seen to have an evolutionary rationale in ancestral human groups, then we might expect theorists to look for a mechanism enabling humans to conform to, and enforce compliance with, beneficent norms (perhaps to the extent to which they are either shared, or enforced, or beneficent). One rationale for this may be derivable from the excessive information processing loads demanded by repeated ad hoc calculation of response probabilities from potential cooperators in groups where there is no compliance with norms and thus no enhanced predictability of others' behaviour in cooperative interactions.

These discussions also tie in with recent work on the evolution of cooperation in mobile organisms in general, which emphasizes the instability of cooperation as a strategy in systems with high levels of individual mobility, such that 'free riders' can search for and exploit cooperative 'victims'. Enquist & Leimar (1993) have summarized this work and pointed out that models of the evolution of cooperation which build in assessment mechanisms, such as suspicion of strangers or exchange of social information through gossip, drastically improve the chances of cooperation stabilizing in model populations. Norms, and the ability to assess conformity to norms in others, would constitute a basis for assessment mechanisms of precisely this kind.

Reasoning about social rules.

Work in cognitive psychology during the past twenty-five years has yielded a set of results on certain reasoning tasks which have been offered in support of the 'social intelligence' hypothesis of human evolution, and which also bear directly on the question of the nature of human evolved predispositions selectively to follow (and to enforce) norms of behaviour relating to the costs and benefits of social action. This chapter reports a pilot trial of an experiment designed to replicate these results and to generate sufficient variability in response patterns between individual subjects for correlation analysis with personality trait data. The personality data is collected on the occasion of the reasoning task experiment, and relates to attitudinal variation and variation in social competencies in areas which specifically bear on the 'social intelligence' issue. This is the first experiment known to me which attempts to look for such determinants of patterning in the differences between individual subjects' performances in this set of tasks. The test booklet used was therefore of my own design.

Content-biased reasoning: the Wason selection task.

Research in human reasoning processes in the past thirty years has falsified the assumption that human rationality can be described by some content-independent formal logic. This conclusion has derived from two separate research fields, those of deductive reasoning (the Wason selection task) and of probabilistic reasoning (Bayesian statistical inference tests) (cf Gigerenzer and Hug 1992). Both these fields draw on an analogy between the hypothesised models of human reasoning which they set out with, and models of scientific reasoning (respectively, Popperian falsification theory, and Bayesian theories of prior and posterior probability). In both areas of psychological research, the experimental evidence shows that human reasoning procedures are not consistent with these models.

In the case of probabilistic reasoning, a series of studies by Kahneman and Tversky has shown that human inference about probabilities will 'short-cut' considerations of 'base rate' probability by using 'heuristics' - general problem-solving procedures that most often work in solving everyday problems. Thus inference about probability may be biased by the availability of material in memory (when things come readily to mind, we tend to assume that they are more common than things which are harder to access from our memory store). Inference may also be biased by the level of similarity between the case being examined in a task, and some prototypical case: if there is sufficient similarity, people tend to assume that the features and behaviour of the prototype apply also to the experimental case or situation, even where this violates actual probabilities.

For example, consider this pretend situation:
a stranger tells you about someone who is short, slim, and likes to read poetry, and then asks you to guess whether this person is more likely to be a professor of classics at an Ivy League university or a truck driver. Which would be your best guess (Meyers 1986, in Best 1986:387)?

Most often, a naive subject will opt for the classics professor: the description fits the prototype of a classics professor better than that of a truck driver. However, consider the real probabilities. There are about 40 to 50 classics professors in the USA Ivy League universities, of whom perhaps half fit the description. By contrast there are about 500,000 truck drivers in that country. Even if only one in one thousand fits the description, that leaves a population of 500 truck drivers as opposed to 25 Ivy League professors from whom the person described may be randomly drawn. The 'representativeness heuristic' has led us to distort the true probabilities in this reasoning task.

A similar set of results has characterized research into human conditional reasoning, reasoning about rules framed in the form of an 'if-then' statement. The general framework for a conditional reasoning task is usually of this sort:

'If P [antecedent condition], then Q [consequent condition].'

An observation is then given:

'P', or 'not-P', or 'Q', or 'not-Q'.

An inference may also be given, based on the observation:

'therefore Q [or not-Q, or P, or not-P]'.

The subject has to evaluate whether the inference is logically consistent with the rule. In the terms of propositional logic, there are two valid forms of inference in such cases:

'P [observation]'

'therefore Q [inference]'

(this is the inference rule called modus ponens).

'not-Q [observation]'

'therefore not-P [inference]'

(this is the inference rule called modus tollens).

There are also two common reasoning errors:

'not-P [observation]'

'therefore not-Q [inference]'

(this is the error of denying the antecedent).

'Q [observation]'

'therefore P [inference]'

(this is the error of affirming the consequent).

Both the latter two errors derive from the misconstrual of the rule as being of this form:

'If and only if P, then Q'.

Whereas in fact, the rule 'If P, then Q' does not preclude the occurrence of Q independent of the antecedent condition P.

The question posed by cognitive psychologists in this context is, therefore, whether or not humans reason using this sort of propositional logic.

Human conditional reasoning strategies in different situations have been extensively examined experimentally through use of the Wason selection task. The task is of the following form:

(1) Statement of a rule ['If P, then Q']

(2) Presentation of partial information about four cases where both the presence or absence of the antecedent condition, and the presence or absence of the consequent condition, have been observed. The representation is in the form of four cards, one each of which has the information 'P', 'not-P', 'Q', or 'not-Q', written on the side which is visible to the subject. In each case, the obverse side carries the other half of the observation. (3) The subject has to indicate which cards definitely must be turned over to see whether or not the rule applies to the four cases.

This is best demonstrated by means of an example. Figure 6.3 shows a typical version of the Wason task. The task is presented in the 'shell' of a story giving the background or context. The rule is stated in the form, "If a person has a 'D' rating, then his documents must be marked code '3'". The cards display the four possible observations relevant to the assessment of the reliability of the rule: 'D' (= 'P' in formal terms); 'F' (= 'not-P'); '3' (= 'Q'); and '7' (= 'not-Q'). The correct solution within the tenets of propositional logic is therefore to turn up the 'P' and 'not-Q' cards: here, those marked 'D' and '7'.

Results of the task in many experiments have shown that 'naive' humans perform very differently in different experiments in terms of the frequency of accurate responding, and that what differentiates this or that set of results seems to be the content of the version of the problem which is being presented. Thus the problem in its abstract version (the alphanumeric version, Figure 000) will generally elicit only c.10% correct 'P and not-Q' responses from 'naive' subjects. However, when the problem is framed in a context which is familiar, or which relates to situations where reasoning has a pragmatic importance for humans in normal life, then levels of respondent accuracy increase dramatically: it is common for a 50-75% level of 'P and not-Q' responses to be found for such versions of the selection task.

This finding has led Cheng and Holyoak (1985) to propose a model of human deductive reasoning which has parallels with Kahneman and Tversky's model of 'cognitive heuristics' in probabilistic reasoning tasks. However, in contrast with models of content effect based on the level of familiarity of the subject with the material given in a particular version's context story (paralleling Kahneman and Tversky's 'availability heuristic'), they argue that what facilitates accuracy in some versions of the Wason task is the way in which the rule may cue a 'pragmatic reasoning schema', a context-sensitive set of rules for reasoning about problems in particular pragmatically important task domains. For example, a 'permission (or obligation) schema' may be activated in reasoning about deontic rules, where the problem relates to issues of social ethics or duties and relates actions to their preconditions in an ethically prescriptive way. Cheng and Holyoak's model of the content effect on human deductive reasoning tasks therefore conflicts with models of human reasoning based on formal propositional logic, but nonetheless accounts for content effects in particular domains (such as reasoning about 'social contracts') as exemplifying a generic tendency to form pragmatic reasoning schemas.

Pragmatic schemas and cognitive development.

In a previous Chapter I have noted the model of human cognitive and brain evolution derived from Piagetian cognitive psychology as developed by Kathleen Gibson and Sue Parker. This model has generated a recent set of edited papers on "'language' and intelligence in monkeys and apes" (Parker and Gibson 1990) which are presented under the banner of Comparative Developmental Evolutionary Psychology (CDEP).

The basic premises of this model are that human cognition and language capabilities differ from those of other primates as a result of quantitative increments in neocortical processing capacity in humans, not of qualitative differences in brain organization, and that comparison of humans and other primates can therefore proceed based on a cross-species extension of Piaget's framework for understanding human cognitive development. The model is recapitulationist: primates are tested for their capacity to attain a threshold level of cognitive ability within Piaget's framework, the ability is assumed to be domain-general (thus dependent on some content-independent computational calculus), and differences in observed levels of attainment across species are predicted to correlate with differences in the size of the neocortical computer (or in some statistically processed index of neocortical 'progression').

We have seen in previous chapters that it can be claimed that there is a strong association between social system complexity and neocortical volume measures in nonhuman primates, independent of other dimensions of ecological variation, and have examined the 'social intelligence' hypothesis of primate brain evolution using such correlational methods. We have also seen that these patterns of correlation are not sufficient in themselves to refute a 'weak' version of the social intelligence model, which posits differences in domain-general cognitive ability as the behavioural correlate of such neocortical variation across taxa. Although there are studies which focus on the social competence of monkeys and apes, and which speculate that these competences are more developed than non-social or instrumental cognitive abilities (e.g. Cheney and Seyfarth 1990), experimental evidence remains ambiguous due in part to the difficulty of designing suitable tasks or orchestrating suitable environmental challenges.

Experimental studies with human subjects are by contrast well advanced, and the use of the Wason selection task to explore content effects is a good example of an application which tests precisely this aspect of domain-specific competence in reasoning. Hypothetico-deductive reasoning is explicitly a component of the 'formal operational' mode in Piaget's scheme, and is assumed to develop as a content and context-independent 'propositional calculus': "reasoning is nothing more than the propositional calculus itself" (Inhelder and Piaget 1958:305). Thus according to Piaget's doctrine of formal mental logic, faced with a complex situation "the subject will ask himself two kinds of questions: (a) whether fact x implies fact y ... To verify it, he will look in this case to see whether or not there is a counter-example x and non-y. (b) He will also ask whether it is really x which implies y or whether, on the contrary, it is y which implies x ..." (Piaget, in Beth and piaget 1966:181) [Quotations taken respectively from Gigerenzer and Hug 1992, and Johnson-Laird 1983]. However, the Wason task literature shows that adult reasoning is affected by content, while studies such as those of Girotto and Light (1992) show that children at the putatively pre-formal operational mode can nonetheless solve 'meta-inferential' problems in suitable circumstances. Girotto and Light favour the account of facilitating content which Cheng and Holyoak have proposed with the concept of 'pragmatic reasoning schemas', but note that the existence of other pragmatic domains capable of generating a similarly large facilitatory effect on response accuracy in the selection task to that of deontic rules remains to be demonstrated. Girotto and Light also note that the observation of violations of such deontic rules presupposes a capacity for 'perspective-taking' in the detection of cheating, and suggest therefore that the ability to evaluate deontic rules may depend on the capacity to hold a 'theory of mind', as evinced in perspective-taking, deception, and attribution of mental states to others.

Cosmides' model of 'Darwinian algorithms'.

There is, however, a 'strong' interpretation of the effect of content on accuracy in the Wason task. This has been proposed by Leda Cosmides (1989). Cosmides argues that all versions of the Wason task which have, to date, produced a very strong 'content effect' on accuracy share a common structure and relate to a specific domain of pragmatic reasoning: that is, they all have the structure of 'social contract' rules involving costs, consequent benefits, and the entailed possibility of cheating. Cosmides therefore proposes that the evidence adduced in Wason task experiments for a content effect attests to the presence in human minds of an evolved 'Darwinian algorithm' for detecting cheating in co-operative social transactions. This proposal has an adaptive rationale based on the inferred importance during human evolution of enforcement of compliance in social networks where there is a high incidence of 'reciprocity', as in hominid and modern human hunter-gatherer bands.

Although this proposal is highly domain-specific, Cosmides is reluctant to specify the neurophysiological evidence for such a 'Darwinian algorithm' which might support or falsify her hypothesis (which is framed at the level of cognitive science - i.e., moving from observed performance biases to models of the information processing software which could generate such biases, without moving from there to predictions about derived neurophysiological traits). This limits the usefulness of the hypothesis for palaeoanthropology. However, we should be warned by the mixed reception in neurophysiological circles of an earlier sociobiological proposal that prosopagnosia - the pathological condition in which people exhibit a deficit in facial recognition tasks without other apparent impairment - is another form of evidence of the selective evolution of a mechanism for enforcing reciprocity - in that case, by storing information about the differentiating facial characteristics of individual co-actors. The idea that evolution of adaptive cognitive abilities proceeds on the model of expansion of a computer system through the addition of individuated, modular ROM chips with some domain-specific algorithm on each one may fit the adaptationist framework of human sociobiology, but it appears counterintuitive to anyone familiar with the basic organization of the human brain.

Responses to Cosmides' proposal have concentrated on two areas: the validity or otherwise of her claims about the specificity of the 'content effect', and the plausibility of her model of 'Darwinian algorithms' as an explanation of such content effects.

A recent study by Gigerenzer and Hug (1992) gives evidence that indicates the need to revise both Cosmides' and Cheng and Holyoak's accounts of the specificity of the content effect. Gigerenzer and Hug found that the content effect could be cued by the following elements in a version of the Wason task: "If a selection task (rule and context information) (i) cues a person into the perspective of one party engaged in a social contract, and (ii) the other party has a cheating option, then a 'look for cheaters' algorithm is activated that selects the conjunction of cards that define being cheated, e.g., 'benefit taken and costs not paid by the other party'" (1992:). They extend the definition of cheating to include three possible conjunctions of events:
"(1) Someone takes the benefit and does not pay the cost.
(2) Someone takes the benefit and does not meet the precondition.
(3) Someone meets the precondition and does not pay the cost." (1992:).

This study is neutral as to the mechanism involved in the facilitation on perspective-taking versions: the cheater-detection algorithm may either by explained in evolutionary terms, or in developmental terms as an aspect of perspective-taking in the subject's 'theory of mind'. However, Gigerenzer and Hug's study suggests that the capacity to adopt the perspective of one or other party in a social transaction governed by normative ethical rules is the prerequisite for experiencing the facilitating effect of social contract contexts on solution of the Wason task.

Individual variability in response accuracy on cheater-detection tasks: Darwinian algorithms or developmental personality traits?

To summarize the discussion so far, studies of human deductive reasoning using the Wason selection task have therefore falsified the model of an innate content-independent mental propositional calculus. It is evident that content facilitates or inhibits accuracy, and that the sorts of content which most facilitate accuracy (on present evidence) are those which relate to social transactions involving the possibility of cheating. From the perspective of palaeoanthropology, this supports models of human evolution which emphasize the cognitive demands of social relationship servicing and manipulation in hominid groups, since the ultimate function of such an evolved bias in human reasoning would be to maintain reciprocity among co-operators in a social network. However, palaeoanthropologists will also need a satisfactory account of the evolution of a phenotypic mechanism producing such a bias, since much of the evidence for human brain evolution is usually seen as consistent with 'general intelligence' or encephalization models of evolved cognitive abilities.

If facilitation in cheater-detection versions of the task depends on an innate 'Darwinian algorithm', then we should expect no systematic variation between individual subjects in their ability to solve such versions of the task. However, if facilitation depends on developmental personality traits affecting efficiency in processing information about social transactions, then we should expect systematic variation between individual subjects in their ability to solve such versions, as a function of their ratings on various tests for personality and social skills. Such variability, if found, might be explicable within the framework of Johnson-Laird's (1983:117f) account of individual variability on syllogistic reasoning tasks, which correlates differences in reasoning ability with differences in the processing capacity of working memory, compounded by personality traits such as impulsivity. Thus it is possible that any effect of personality traits on social contract reasoning in the Wason task might relate to some variation in social cognitive strategy, which in turn affects load on working memory.

The experiments reported here were designed to test between these two theories of the mechanism underlying the content effect, on the one hand the 'evolved predisposition' theory of Cosmides' Darwinian algorithms, on the other hand the 'developmental personality trait' theory of perspective taking as a function of the acquisition of an efficient 'theory of mind'. The experiments involve subjects solving six versions of the Wason selection task taken from the existing literature (three non-social contract, three social contract), and completing a suite of tests for various academic abilities and personality traits. The use of personality data in this way is predicated on their interpretation not as denoting immutable individual 'essences', but as denoting typical individual response-tendencies, in this case relating to social or interpersonal skills (cf Riggio et al. 1990, Lorr et al. 1991).

The test used for academic ability is the Shipley-Hartford test, a short twenty minute timed test of abstract reasoning and of vocabulary size. This is used quite often as a quick guide to 'academic intelligence' in studies looking for intercorrelations with scores on other tests, such as tests of social competence (e.g. Riggio et al. 1992).

The personality tests were selected for their usefulness as indicators of the capacity to take another person's perspective, since this has been implicated in the content effect on the Wason task by Cosmides' and by Gigerenzer and Hug's studies. I used the Mach V test (Christie and Geis 1970) in Experiment 1, and the Questionnaire Measure of Emotional Empathy (Mehrabian and Epstien 1972) for Experiment 2. It is worth going into the background of these tests in some depth, since they have not been used in this way before, and since they test for qualities - 'Machiavellianism' and empathy - which have been cited as aspects of social perspective-taking by two major recent proponents of the 'social intelligence' hypotheses, Byrne and Whiten (e.g. 1988).

The Mach V personality test.

When Byrne and Whiten chose the term 'Machiavellian intelligence' to denote the domain-specific cognitive adaptations which are posited by 'social intelligence' hypotheses of primate brain evolution, they justified their choice in the following terms:

> "Why did we call the book 'Machiavellian intelligence'? We expect to be criticized for appearing to emphasize the nastier side of primate social behaviour by the use of Machiavelli's name, which conjures up the use of superior knowledge and skill to deliberately manipulate, exploit, and deceive social companions. We started off, in fact, with a much more neutral title, but the fact is that the strong thrust in the data available at present is Machiavellian: in most cases where uses of social expertise are apparent they are precisely what Machiavelli would have advised! Co-operation is a notable feature of primate society, but its usual function is to out-compete other rivals for personal gain. Having said that, we do not want anyone to take us as arguing that primate uses of intelligence, let alone human ones, are limited to purely exploitative ones. In particular, it seems likely that the later course of human evolution has been characterized by a much greater emphasis on altruistic uses of intelligence. However, the force of the core idea of the book is that the high intelligence on which we rely originally evolved in response to a need for social manipulation, which we have highlighted by talking of 'the Machiavellian intelligence hypotheses'. Remember, it was not a baboon giving advice to another who said:
> '[The prince] must be a great simulator and dissimulator. So simple-minded are men and so controlled by immediate necessities that a prince who deceives always finds men who let themselves be deceived. For a prince, then, it is not necessary to have all the [virtuous] qualities, but it is very necessary to appear to have them ... [It[is useful, for example, to appear merciful, trustworthy, humane, blameless, religious - and to be so - yet to be in such measure prepared in mind that if you need to be not so, you can and do change to the contrary' [Machiavelli, The Prince]" (Byrne and Whiten 1988:vi).

One implication of this core idea is that more highly Machiavellian people might be expected to reason more accurately in social exchange tasks which activate a putative 'cheater-detection algorithm'.

The Mach V test was designed to rate subjects by the level of their agreement with the view of human nature and of ethical conduct found in the writings of the Renaissance political philosopher Niccolo Machiavelli (its existence is apparently unknown to the Byrne and Whiten group). It consists of twenty sets of three statements of social attitude or belief, one of which is either a direct or an inverted version of some aphorism or tenet of Machiavelli's philosophy. Of the other two statements, one is matched with the Machiavelli tenet for general 'social desirability' (based on extensive sampling of social attitude evaluations by subjects in the USA, where the test was developed), and the other is a buffer (either markedly more or markedly less 'socially desirable' than the other two). Subjects are then scored according to the extent to which they liken their own attitudes to those contained in the Machiavelli tenets in the test, vis-a-vis the other statements of non-Machiavellian attitude. In these experiments, a revised scoring formula given by Rogers and Semin (1973) was used to reduce the effect of possible cultural differences in perception of the relative social desirability of items in the test for a British sample.

The history of uses of this test over the past twenty five years shows that no significant correlation appears to exist between Mach score and I.Q., or Mach score and political or ideological position (Christie and Geis 1970). Mach score does, however, appear to correlate positively with a high level of self-monitoring (Madonna et al. 1988), with an ability to withstand the distraction of emotional arousal, and with 'anomic disenchantment', disbelief in people, hostility, and duplicity or lack of honesty (Christie and Geis 1970). High Mach individuals tend to endorse ethical positions which are more relativistic and less idealistic than low Mach individuals (Leary et al. 1986). It has been suggested that their 'interpersonal constructs' may be less cognitively complex, but this finding has not been replicated (Sypher et al. 1981). There are also indications that Machiavellianism may decline with age (Mudrock 1989).

Experiments monitoring the effect of Machiavellianism on social behaviour in structured settings have focussed on deception abilities and on behaviour in bargaining situations. Despite a quite extensive literature, evidence of a link between Mach score and deception ability remains slight and ambivalent: some studies find an advantage for high Mach scorers (e.g. Geis and Moon 1981), others do not. One survey of eleven studies of deception found evidence for only a slight advantage in deception ability for high Mach individuals (Zuckerman et al. 1981, cited by Riggio et al. 1988).

Studies of the behaviour of high Mach individuals in bargaining and cooperative games have found no increase in the incidence of cheating, but a greater tendency to cheat to avoid punishment (as opposed to to attain a reward) (Flynn et al. 1988); a tendency to achieve low joint bargaining outcomes in face-to-face negotiations with low Mach individuals, due to the personality dynamics of such dyads (Fry 1985); and a tendency to exploit others in order to maximize short-term personal gains in 'commons dilemma' type game situations (Smith and Bell 1992).

This historical survey suggests that it may be mistaken to expect the most highly Machiavellian members of a human sample to be most effective in perspective-taking tasks, and that they may not in fact experience the greatest facilitation in social contract versions of the Wason selection problem. That is, however, the prediction derived from Byrne and Whiten's 'core idea'.

The Questionnaire Measure of Emotional Empathy.

'Empathy' is a multidimensional construct involving both cognitive perspective-taking dimensions, and affective (vicarious emotional experience) dimensions. Recent work by Levenson (1992) suggests that empathy may have a basis in 'shared physiology'. The Questionnaire Measure of Emotional Empathy (Mehrabian and Epstein 1972) was developed as a pencil-and-paper measure of emotional empathy (the tendency for vicarious experience of the emotions of others). Although its accuracy in predicting subjects' ability to infer the emotional state of others, though significant, is limited (Levenson 1992), its validity as a personality measure is well established, and studies have found positive correlations between QMEE rating and general 'arousability', inhibition of aggression, helping behaviours, and expressive facial reactivity to emotional stress (review in Chlopan et al. 1985). There has been little work on correlations between QMEE rating and Machiavellianism, but one study in the USA using adapted versions of these tests for fourth- and fifth-grade schoolchildren found a negative correlation (low empathy children had significantly higher Mach scores than high empathy children), and found that this effect was further compounded by taking into account cognitive perspective-taking ability (low empathy/high cognitive perspective-taking children had the highest mean Mach score), suggesting that "the child who is particularly insightful about the feelings of others may be inclined to act in a manipulative and unhelpful manner unless that insightfulness is tempered with emotional sensitivity and compassion" (Barnett and Thompson 1985:303).

Males and females tend to have significantly different mean QMEE ratings (with female groups' mean scores considerably higher than males [Mehrabian and Epstein 1972, Lorr et al. 1991]). One recent study of cognitive/verbal perspective-taking found that while both sexes performed equally well in the experimental situation, accuracy in inferring emotions and social orientations correlated with social/cognitive perspective-taking in males, but with emotional empathy in females. This suggested to the authors of the study that "it may be the case that men and women possess different skill strengths - with women having an advantage in much of the emotional realm of communication, and men possessing some greater skills in certain other areas of social skill" (Riggio, Tucker and Coffaro 1989:98). Given this sex-based difference, and the heightened 'arousability' of high emotional empathy scorers, and the expectation derived from earlier work with the Mach tests that heightened arousability may inhibit accuracy and information capacity in social cognition (Christie and Geis 1970), it seemed reasonable to use the QMEE test as a measure of a different dimension of social cognitive skills which might also affect people's performance on SC versions of the Wason task. Additionally, emotional empathy measures contrast with Machiavellianism measures in their perceived 'valence' - the former being perceived as a more 'socially desirable' trait than the latter - giving their use in this experiment an intuitive rationale. If Machiavellianism is the 'nastier side of primate social behaviour' (Byrne and Whiten 1988), then empathy has the positive valence implied in the title of a recent book, 'The Brighter Side of Human Nature - Empathy and Altruism in Everyday Life' (Kohn 1990).

Experiment 1.

Methods.

Six versions of the Wason Selection task were chosen, to include three abstract/descriptive and three social contract story-lines, and the cards ordered randomly for each version. The versions were chosen from the existing literature (see Table). These were then themselves ordered in random sequence. Subjects (33 first year archaeology students, 18 male, 15 female, all volunteers) were instructed to work through the test in the order given, without referring back to or revising their answers in earlier versions in light of their completion of later versions in the series. On completion of this task, subjects completed the Shipley-Hartford general intelligence Test (in timed conditions) and the Mach V personality test. The test booklet is reproduced in Appendix 6.1.

Results.

Mean score on the Selection task battery was 2.15 (36%) (SD 1.3). Mean score for males was 2.17 (36%), and for females 2.13 (35%) (t=0.07, p=0.94, n.s.). For the abstract-descriptive problems, mean score was 0.33 (11%), males only = 0.34 (11%), females only = 0.33 (11%) (t=0, p=1, n.s.). For the social contract problems, mean score was 1.82 (61%), males only = 1.83 (61%), females only = 1.8 (60%) (t=0.08, p=0.93, n.s.). Of 4 not-P and Q responses in the whole sample, 2 were to the switched perspective version of the Pension story-line (bilateral cheating option).

Mean scores on the Shipley-Hartford test were 70.45 (SD 4.04), males only = 70.94 (SD 3.62), females only = 69.87 (SD 4.55) (t=-0758, p=0.454, n.s.).

Mean scores on the Mach V Test (scored following the revised method of Rogers and Semin 1973) were: overall mean = 101.65 (SD 12.9), mean for males only = 103.5 (SD 12.9), mean for females only = 99.43 (SD 12.9) (t=-0.8999, p=>0.35, n.s.).

Analysis.

Analysis was designed to test the hypothesis of an effect of Mach V score on performance on the social contract versions of the Wason task, after controlling for 'academic intelligence'. For each sex, individuals were assigned to one of three categories on the basis of their Mach V score: Low Mach (lower quartile, n=4), Average Mach (middle two quartiles, n=10 males, n=7 females), and High Mach (upper quartile, n=4). Mean scores on the three social contract versions (SC) and on the Shipley-Hartford general intelligence Test (S-H) were then calculated for each of these six groups.

Results were as follows:

Bivariate scatterplots of Mach V against Shipley score, and of Social Contract score against Shipley score, suggest no relationships within either of these pairs of variables (Figs 6.4 and 6.5).

Bivariate scatterplots of Mach V score and SC scores for males and females suggested patterning for the males only, in the form of a nonlinear effect of Mach V on SC response accuracy independent of Shipley score (Figures 6.6 and 6.7).

	MALES		FEMALES	
	SC	S-H	SC	S-H
Low Mach	50%	70	67%	71.75
Average Mach	89%	71	57%	71.29
High Mach	0%	71.75	58%	65.5

	lowMACH	averageMACH	highMACH
M	50	89	0
F	67	57	58

Chi-square test of male and female distributions of SC scores against Mach grouping: chi-sq.=24.8047, 5 df, p=<0.001.

Discussion.

(1) The experiment replicated findings from studies with much larger samples in Harvard, USA (n=000, Cosmides 1989) and Konstanz, Austria (n=93, Gigerenzer and Hug 1991), in which the effect of social-contract versions of the Wason task over no-

social contract versions was to produce a 50% increment in the incidence of P & not-Q responses. In the Southampton experiment reported here, the mean score on the no-social contract versions was 11% P and not-Q responses, compared with 61% for the social contract versions. The increment - exactly 50% - compares with that of 54% in Cosmides' Harvard study (21% no-SC, 75% SC) and with that of 50% in Gigerenzer and Hug's Konstanz study (44% no-SC, 94% SC).

Gigerenzer and Hug tentatively attributed the higher 'baseline' level of response accuracy in the Konstanz sample to the training in formal logic received by students in the pre-university German gymnasium. By extension, this suggests that English secondary education is relatively poor in instilling such academic discipline in pre-university pupils. However, it is also at least technically possible that the different baseline response levels relate to differences in the construction or administration of the test battery, since contextual aspects of the story which give a plausible 'rationale' for the rule have been found markedly to facilitate response accuracy, and these aspects could have been more and less salient in the three test batteries. This possible explanation could be confirmed or eliminated by inspection of the content of the Gigerenzer and Hug task versions in their original (German) form, but these are not available in the published report of their study.

(2) No significant differences between males and females were found in the levels of response accuracy for the Wason task battery or for its two components (no-SC and SC versions). No significant differences between males and females were found in the scores for the Shipley and the Mach V tests.

(3) The overall mean score for the Mach V scale was 101.65 (SD=12.9), close to the theoretical mean of 100 and to previously observed population means for British and American student samples (98.79 SD=12.39, n=228 UK students, Rogers and Semin

1973; 97.5, US college students, Christie and Geis 1970). This suggests that the sample was representative of the normal range of variation for this trait.

(4) The relationship between Mach V score and performance on the social contract versions of the Wason task was significantly different for the males and for the females. Although the two groups did not differ in their characteristics in terms either of mean and SD Mach V score or of mean score on the SC versions, the scatterplots suggest that while there is no relationship between Machiavellianism and Social Contract reasoning for the female subjects, there is a marked nonlinear relationship for the males. Thus for the males, low scorers on the Mach V test had a moderate success rate, males whose scores were clustered around the sample (and reference population) mean had a high probability of getting all three versions right, while the four with the highest Mach V scores all scored zero on the SC versions; indeed, they were the only four male subjects to do so. If this result proves replicable and indicative of a general relationship between Machiavellianism and deontic reasoning or perspective taking in males, then it implies that those who are markedly more Machiavellian than the average member of their social network are effectively disabled in co-operative social transactions. This is in marked contrast to what one might expect from Byrne and Whiten's model, namely a positive linear relation between Machiavellianism and cognitive efficiency in social transaction analysis. The finding of no relationship between Machiavellianism and social reasoning for the female group also supports Gibson's critical comments on the Byrne and Whiten book (Gibson 1989:517) - "with its tendency to equate deception and political manoeuvering with intelligence, the book may ... possess an ethnocentric (even sexist?) bias. As Crook concludes, behaviors such as cooperation and altered attentional states, so important to many human societies, deserve more recognition and research" - although our replication for both male and female groups of the content effect in this task suggests that her own position, derived from Piagetian general intelligence models of human reasoning skills, may also need qualification.

Experiment Two

A second experiment was set up using the same series of six versions of the Wason task, followed by the QMEE empathy questionnaire. Unfortunately, the small sample of volunteers successfully recruited for this experiment (n = 7) rendered its results effectively uninterpretable. In Figure 6.8 I have graphed the results on Social Contract versions of the task against QMEE emotional empathy rating, with point codes for gender. It is intended that this experiment will be repeated with a larger sample later in the year (1993). This problem partly reflects the difficulty of finding samples of students who are compliant and who have not previously encountered the Wason task.

Conclusions.

The experiments showed that it is possible to correlate individual variation on the social contract versions of the task with personality variables relating to social skills and perspective taking. This implies that the model of an innate 'Darwinian cheater detection algorithm' is misleading. If co-operative reasoning depends on proximate mechanisms of perspective-taking and cheater detection, then these are acquired with the development of social competencies.

The experiments also showed that the unidimensional model of social cognitive adaptation in Byrne and Whiten's core idea of 'Machiavellian intelligence' may misrepresent the nature of adaptive social skills in humans, and by extension, misconstrue the nature of the selected-for phenotypic response to selection pressures for social relationship skills in hominid evolution.

Future research directions.

There are two directions which may be taken in pursuing these issues. One concerns the identification of other suites of personality trait variables affecting performance on deontic reasoning versions of the Wason task, and the other concerns the theory of how social cooperation evolves in human societies in relation to social motivations and social norms.

Firstly, it has been argued that social competence is a global, multidimensional construct which cannot be reduced to a single dimension (such as Machiavellianism or emotional empathy) (Riggio 1986, Lorr et al. 1991), and that such global measures of social skills may be better predictors of perspective-taking tasks such as those involved in deception (Riggio et al. 1988a,b). One useful pencil-and-paper measure may be Riggio's Social Skills Inventory, a 90-item self-report measure which assesses six basic social/communication skills and on which total score appears to correlate positively with self-report measures of empathy, assertiveness, and self-esteem, and with various measures of social effectiveness: there is also evidence of partial overlap with academic intelligence test scores (Riggio et al. 1991). Future tests for the personality correlates of facilitation on deontic reasoning tasks should therefore look for these more global indices of social competence.

Secondly, the recasting of the content effect of deontic rules on success in the Wason task in the cost-benefit language of Cosmides and Tooby's social exchange theory (1989) may divert attention towards computational skills in individual bargaining negotiations, when attention should perhaps be focused on the predisposition to conform ones behaviour selectively to beneficent social norms, and enforce compliance in others. The rationality of normative behaviour is central to Cosmides' interpretation of results on the Wason selection task, which indicate a bias to greater accuracy in deductive reasoning about deontic rules (ethical obligation, duty, contractarian reasoning). Cosmides' work is focussed on norms which have a fairly transparent cost-benefit rationale. Cheng and Holyoak (1989) point out, however, that many of Cosmides' 'social exchange' problems are in fact pseudo-exchange problems which do not have both cost and benefit components. It is stretching the definition of social exchange to say that in a rule specifying that 'If you are under eighteen years old, then you may not purchase alcohol', to be eighteen or over is a 'cost'. These 'pseudo-exchange' versions (which secure the same 'content effect' as 'true' cost-benefit exchange versions) must be understood as relating to permissions or obligations - the issue is one of prescriptive norms rather than exchange transactions.

It follows from this that future experimental work in the paradigm used for this Chapter should examine covariance not just in social contract reasoning skill and in social competence, but also in general attitudes to the conditions for compliance with prescriptive social norms.

So we may revise Cosmides' interpretation of the content effect in the Wason selection task as follows: a subject experiences facilitation in deductive reasoning for versions of the Wason task containing deontic rules (permissions and obligations), but only to the extent that the subject has also acquired global social competences (or some aspect of them); and this effect may reflect an evolutionary context selecting for (selective) adherence to, and enforcement of compliance with, (beneficent) social norms. The ultimate function is to increase inclusive fitness among co-operators, and the proximate mechanism is the developmental acquisition of interpersonal skills. Future work should aim to test this hypothesis with larger samples from the same population, and also cross-culturally.

CHAPTER SEVEN: SUMMARY AND CONCLUSIONS

In this brief Chapter I shall draw some conclusions concerning the work reported in the foregoing Chapters. I should emphasize at the outset that I do not see the object of this Chapter as the construction of a composite representation of the original human society (or, by extension, of the foundations of 'human nature'). The purpose of the preceding Chapters has been to promote the worth of interdisciplinary approaches to human behavioural evolution, with particular attention to comparisons with other living primates. Consequently, the main focus of this Chapter will be to draw together a coherent case for the eclectic use of methods which has characterized these studies.

Despite this, the studies reported also made substantive contributions to debates on human evolved propensities and on hominid socioecology which deserve to be summarized. In Chapter 2, I analysed evidence which supported a correlation of language ability with gross neocortical size and its organizational correlates. I also noted the difficulty of eliminating Deacon's argument that human brain evolution has involved a divergent pattern of 'cortex ratios' from that of the other anthropoid primates.

Leslie Aiello and Robin Dunbar's work on hominid socioecology, reviewed in Chapter 3, is based on the presumption of a constant linear relationship between cortex ratio and total brain size in anthropoids and in humans, and Deacon's model would be incompatible with the predictions which they make on the basis of that assumption. However, while I have supported the simpler model of human brain evolution in my analyses in Chapter 2, I have nonetheless refuted the arguments made by Dunbar for a bivariate causal relationship between cortex ratio and group size in primates. Thus we have seen that while the cognitive systems which underwrite human language ability evolve as a function of absolute anthropoid brain size, the socioecological evidence does not allow us to associate this to a single causal mechanism such as the cognitive demands of large group interactions.

In Chapter 5, I have proposed an alternative primate model of language evolution which also starts with the analogy to social grooming, but which interprets the role of language in hominid evolution more as a special behaviour serving to maintain affiliative social bonds in a socioecological niche which permits the evolution of a relaxed 'dominance style' in the interactions among members of a social group. Thus the socioecological variable which is crucial for this model of language evolution in hominids is not absolute group size (as with Aiello and Dunbar), but decreased dispersal costs coupled with real benefits from cooperative social interactions. Because I have taken the view that brain evolution in *Homo erectus* effectively just tracked body size evolution, I have located the period of increased selection pressure for this trait late in hominid evolution, from archaic *Homo sapiens* through to the appearance of anatomically modern humans.

In Chapter 5 I oppose a primate model of conversation as serving the affiliation and, secondarily, the low-escalation status seeking motivations, to the conventional 'conduit model' of language as transmission of information through a channel between two speakers who share a common grammar, lexicon, and set of mental representations (what Andresen [1992] calls the 'FAX theory of communication').

This is more than a flippant intellectual move in a pluralist discursive field. The FAX metaphor has gone hand-in-hand with a rejection of continuity with the mental life of other animal species (which become simply 'good to eat' or 'good to think with'), and a group-selectionist functional account of information propagation which assumes that individuals do not cheat or exploit each others' communicative intentions. The alternative 'vocal grooming' model places affiliation and mutual adaptation at the foundation of conversational talk, and thus accounts for the incidental success of language as an information propagation medium - since the information propagation depends on the prior or simultaneous establishment of an affiliative bond through conversational rhythms and rapports. Thus even Palaeolithic archaeologists who think of language only as an evolved propensity for information transmission must recognize that this very capacity for information transfer presupposes an evolved social system characterized by mutual dependence and a very relaxed dominance 'style' among group members. This adds a new dimension to researching modern human origins.

The model proposed in Chapter 5 places great weight on dispersal patterns as indicators of the kind of socioecological shift which would also predict this kind of 'special behaviour'. Dispersal is also the theme of Chapter 4, when I argue that normal patterns of dispersal would be a sufficient explanation of the 'equilibrium basin' mechanism needed to explain Acheulian assemblage continuity in space and time. I have already argued in Chapter 2 that there were cognitive limits to the individual ability of members of the *Homo erectus* taxon which derived from the organization of the brain at that level of total volume, and the proposal here would be that the conservatism of biface morphology represents a local optimum-seeking process in which the analogue of a 'search routine' is effectively the unintended consequences of dispersal behaviour. It may also be the case that social interactions were constrained by the pattern of land-use to the extent of affecting transmission probabilities for certain sorts of variation, but this would require separate study.

Finally, in Chapter 6 I have attempted to clarify the nature of the reasoning bias that produces the striking results reported by Cosmides in human deductive reasoning tasks. This was perhaps the Chapter that came closest to defining a modular 'evolved propensity' or bias in human cognition, but my conclusion was that the bias in reasoning appeared differentially in individuals, apparently as a function of more global personality variation in social perspective-taking skills. Thus the issue of the anatomical or socioecological correlates of this 'evolved predisposition' remains to be resolved in future work.

My own conclusion then would be that the studies clarified the process of human behavioural evolution, highlighted the role of brain size in cognitive evolution, refuted one model of the socioecological correlates of language evolution and replaced it with another, and demonstrated the importance of dispersal as a mechanism of cultural diffusion and as a litmus test of various socioecological variables such as predation risk and ease of intergroup transfer.

With respect to the claims made for the uses of interdisciplinary research using such an eclectic portfolio of methods, it will be the individual studies which best serve as a basis for their evaluation. However, certain points must be made about the difficulty of making informed judgements concerning such claims.

In the introductory Chapter I noted the difficulties of achieving an academically respectable synthesis of data and theory from several disciplines or research fields, and argued that this threatens the integrity of scholarly research on fundamental anthropological problems in human evolution, such as the nature and causes of brain and language evolution. In fact, I would go further and suggest that this problem is more noticeable in the anthropological subdisciplines in the United kingdom than in the United states of America.

While this may relate in part to the sheer dearth of researchers on interdisciplinary topics in a smaller country like the U.K., and consequently the difficulty of achieving a critical mass in establishing a paradigm or hybrid research field, I suggest that there are other structural variables which differentiate research activity in the two countries and which may underly this difference in competence. I have in mind the fact that in the U.S.A. higher education is a mass access operation, with modularised course structures and a high level of nonvocational uptake of courses by students. By contrast, the British system is still shaking off its recent history as an 'elite system' (in terms of participation rates), with an emphasis on professional training and accreditation and on disciplinary autonomy in curriculum design.

In the epilogue to this thesis, I have dissected some contemporary processes of change in British higher education primarily with a view to making the focus of this research project - human skills and abilities, their evolution and the extent of their domain-specificity - relevant to contemporary policy decisions. It is striking how thoroughly academics in a discipline whose focus is cultural transmission and social reproduction have remained oblivious of the reflexive implications of this fact for their analysis of the functions and social relations of the workplace, in particular the role of the students who are the targets of the disciplinary transmission process.

One aspect of this changing structure of British higher education which I did not examine, but which I might also have highlighted, is the implication of expansion of access and dissolution of the binary divide for modularisation of the higher education curriculum. If modularisation leads to greater awareness of the irrational boundaries which can divide the discourses of disciplines, then one benefit may be an increased incidence of high quality interdisciplinary work on the sorts of fundamental problems which I have attempted to address in this thesis. It would be a shame if that were the only way in which such work were able to receive the academic recognition which it deserves.

CHAPTER EIGHT: EPILOGUE

Part One.

In this epilogue to the thesis, I want to look beyond the immediate field where the foregoing analyses are relevant - palaeoanthropology - to the philosophical implications of the 'model of human nature' which is contained in the version of the social intelligence hypothesis I have been discussing, for pedagogy in the universities. Higher education is a training in competences and skills which are expected to increase the life-chances of the graduand, howsoever these life-chances may be construed or ranked for their intrinsic worth. How well are we fulfilling our evolutionary mandate to enhance students' social competences, or their capacities to selectively adopt and enforce compliance with beneficent social norms?

An old-fashioned view of the place of archaeology in the hierarchy of the sciences might hold that archaeology, like other arts and social science disciplines, is a field of research into the highly localised and anomalous 'negentropic' structures of living organisms, specifically those organisms which are held in relationship with one another by the coordinating directions of chains of symbolic instructions continuously flowing across a network of communication channels (cf Figure 8.1). In conformity with this view, the academic disciplines could be ranked by the specificity and negentropic tendency of the phenomena which they study (Figures 8.2, 8.3). In many ways this seems to me to remain the most coherent framework for understanding the relationships between the sciences in terms of their focal research fields.

One consequence of this view is a reflexive understanding of the role of the teacher in conveying the skills and training needed to maintain these stable patterns of interaction in human groups. Thus in the model in Figure 8.4, we can see that while the theory-observation circuit may be construed as a closed circuit for researchers within an established paradigm or research tradition, nonetheless where the focus of the theory-building is the role of social institutions, the development of theory is bound to have implications for one's understanding of and adaptation to or modification of the institutional matrix within which the research process itself takes place. If in our research analyses we assume institutions to play a social role, then we should try to conform our behaviour and the structure of our own institutions to the functions postulated by that theoretical analysis.

It follows from this that a taxonomy of academic disciplines could be constructed which takes into account not just the 'internal' traits which make a discipline's culture distinctive - the trait axes postulated by Becher (1989) and reproduced in Figure 8.5 are a case in point - but also the traits which characterize the 'external' impact of the discipline. In Figure 8.6 I have specified two traits which could be used to characterize this 'external' impact from the viewpoint of the life-chances of the graduand. The employability index is an index of the marketability of the degree discipline to employers, while the entropy index is an index of the extent to which the knowledge and skills transferred to the student in a degree course are specific to a wide or narrow range of possible workplace applications.

Figure 8.7 gives some data points for various disciplines derived from U.K. databases. For the data on the entropy index I have taken figures calculated by Dolton (1992) which indicate the extent to which first destinations of graduates in the employment market after graduation (classified as occupational sectors) are predictable for each of a sample of the major disciplines (with increasing predictability in destinations corresponding to a reduction in 'entropy'). The data on the vertical axis are for 'employability', and correspond to the percentage of graduates in each of the sampled disciplines who remain unemployed or in short-term work six months after graduation. As the graph shows, there is a strong negative correlation between a degree discipline's 'entropy' in the external marketplace, and the immediate employment chances of its graduates. Indeed, if the outlier point for law is removed (law graduates go into a wide and unpredictable range of first destinations, but do not have their job chances correspondingly diminished), then the correlation coefficient (r-squared) increases from 0.45 to about 0.70.

Using such 'external' impact-related traits to characterize a discipline's culture supports the old-fashioned view of the disciplines as contributing to the formation of graduates by increasing their competence in a narrowed range of contexts (i.e., adding to their capacity to act as negentropic structuring elements in society): the more focused or vocational the course, the faster the adoption of the graduate in a structural role in society.

The wider context of the development of the role of the universities in this sort of professional formation is that of the changing structure of post-industrial society, notably the expansion of the service sectors. Table 8.1 shows some of the trends in the major occupational classes in Britain during this century, notably the decline in the proportion of the workforce made up by manual workers, and the expansion of the role of clerical workers, managers, and professionals. Figure 8.8 summarizes data on graduate first destinations into the major employment sectors between 1962 and 1990 (from Dolton 1992:Fig. 1). This graph shows very clearly the increasing importance during the seventies through the eighties of this century of the service sectors (commerce and public sector services) for graduate employment. This expansion of the professional sectors is reflected in the changing balance of intakes to the different degree disciplines in British universities: in Tables 8.2 and 8.3 I have compiled tables from the D.E.S. annual statistical records to track changes in the numbers of students in the major subject groups between 1966 and 1989, and in Figure 8.9 I have summarized the results in terms of the changing rank order of different subject groups in rate of expansion relative to the expansion of the university intake as a whole. Particularly striking are the increase in subdivisions of the subject groups between the old (1966-1981) and new (1979-) classification systems, and the decline in the proportion of students in the arts or humanities (excluding languages). It would be a useful further step to correlate these trends in the rank-ordering of disciplines as to their rates of expansion of intake, with an index of their evolving 'entropy' or of the changing levels of employability of their graduates in the job market.

Figures 8.10-8.18 summarize demographic and economic aspects of the expansion of the British higher education system in the 1980s. As these figures show, expansion of enrolment of the 19-23 years age group in Britain has only kept pace with that of other developed countries, and the U.K. remains in the low end of the range for access from this target age group. Because of the continuation until 1992 of the 'binary divide', university enrolment as a proportion of total higher education in the U.K. in 1988 was lowest of all the developed countries (Figure 8.13); however, British higher education remains very clearly stratified in terms of certain aspects of student provision such as contact time or modal teaching group size (Figure 8.14), supporting the classification of U.K. higher education in the eighties as a remanent 'elite' system. In financial terms, public expenditure per student in higher education has dropped in the U.K. to only about the average level for these countries, although the reduction has been considerable and painful to those administering or researching and teaching within the system (Figures 8.15 and 8.16). Nonetheless, in absolute terms U.K. funding relative to student intake remains comparatively high (1988 figures, Figure 8.17). In addition, the U.K. system overall is exceptionally efficient in achieving very low drop-out rates (Figure 8.18). It is relevant to note that these efficiency measures and achievement levels for the U.K. higher education system as a whole have been sustained in a country in which economic growth has been relatively slow over the past forty years, and in which short to medium-term budgetary constraints on public educational spending are being affected by a short-term decline in the size of the 15-24 years age cohort, and by increasing spending requirements in other public sector services to meet the needs of an aging population (Table 8.4 and Figure 8.19 illustrate these points, with comparisons from the Netherlands).

The most recent British government White Paper, 'Higher Education, a New Framework' (CMI 1541, 1991), projects an increase from current rates (c.20%) to 50% age cohort participation in full time-equivalent higher education by the year 2000. This is a target access level which may be exaggerating the potential of the system to expand: according to the Institute of Manpower Studies (Pearson et al. 1989:101, quoted Smethurst 1992), "if student numbers are to be doubled over the next 25 years then dramatic step changes in all these rates will be needed such that:

A-level attainments for the age groups rise from 13.8% to 20.7%.

and Attainment rates (of 2 A-levels) in social classes III to V rise by a further 50%.

and Female participation rates match those of men.

and Participation by the vocationally qualified matches that of A-level students.

and The participation rates of mature students rise by 50%."

Because of these points, it would be unwise to expect recent trends to increase access levels to degree courses to continue unchecked. The point is, rather, that the system has already expanded and is now entering a phase of intensive consolidation of these changes.

It may seem surprising that I should have seen fit to undertake such exercises in data compilation myself, in the course of work on an archaeology thesis. However, it is striking how few publications on these general topics are both aimed at the general academic readership, and informed by careful statistical analysis of such comparative datasets. Thus for example, a recent publication edited by the Publications Committee Chair of the U.K. Society for Research into Higher Education, 'Arts Graduates, Their Skills and Their Employment (Eggins 1992), is prefaced with the assertion that "we are unique in Europe in producing such a high percentage of arts graduates" (ibid.:vii). Certainly, comparison of Britain and Germany shows that in the 1970s the British system produced a far higher proportion of graduates in the 'pure academic disciplines' - sciences and humanities - than the German system (Table 8.5). However, the British.

figures for intake to higher education by degree discipline appear in fact to be representative of the average for the developed countries: it is Germany which has in the past been anomalous in this regard. When one compiles the returns of the developed countries to UNESCO one finds that degree-level graduates in the humanities (languages, literature, linguistics, history, archaeology, philosophy, religious studies, etc.) are no more numerous in the U.K. as a percentage of the total than in the average such country (Table 8.6 - the compilation is compromised by difficulties in comparability across systems, and it should be noted that the U.K. returns are for the university sector alone). Certainly there are problems in the employability of arts graduates in the U.K., as illustrated by Dolton's (1992) compilations of early career destinations data for graduates from each of the major faculties over the past thirty years (reproduced in Figures 8.20, 8.21). But they must relate to course content, not to course intake levels.

The decline of the traditional 'arts' disciplines, and their evident weaknesses as preparations for graduate entry into the employment market, must be assumed to be correlated. Structural aspects of arts courses which differentiate them generically from those of other faculties include the tendency for teaching to be in small groups, with low frequencies of contact in such formal settings (Figures 8.22, 8.23). In terms of the bias in arts courses towards developing certain sorts of skills over others, arts degrees seem to be superior in 'academic' skill training but deficient in 'social' skill training and in developing numeracy. If, as I shall now argue, archaeology has expanded to the point where it must be considered a high entropy discipline in this sense, then it becomes relevant to the future of the discipline to ask how well archaeology graduates can be expected to fare in the same market over the coming decade.

Part Two.

In Figure 8.24 I have drawn a model of the production of graduate competences in a vocational degree discipline: the assumption is that output is regulated by demand in a tightly targeted sector of the employment market, such that expansion of access to the higher education system as a whole will not force corresponding expansion in output in the vocational discipline. This is demonstrated in the worked examples in that Figure. Concrete instances include medicine and education, which are highly targeted degree disciplines and which are regulated by quotas in this way.

The prescriptive core curriculum proposed for archaeology degree courses by the SCUPHA report to the UGC in the later 1980s (Figure 8.25) appears to convey the expectation that an archaeology degree is a vocational training in the sense just described. However, this expectation is belied by the actual pattern of expansion of this degree discipline over the past twenty years. Figure 8.26 shows the overall pattern of expansion of U.K. higher education in the post-Robbins period,and Figure 8.27 shows that this expansion has been accompanied by an even steeper trend to equality in the representation of the sexes on courses. If we compare the absolute numbers of students on courses in archaeology and in history, for example (Figure 8.28), we could gain the impression that archaeology has the small output levels of a vocational, highly-targeted discipline. However, inspection of the pattern of expansion of archaeology shows (Figure 8.29) that its expansion has in fact been very fast and appears to be continuing. It is interesting to note the contrast with the situation in Germany (former F.D.R.), where graduate output in 1988 was evidently running at less than ten percent of the level in the U.K. (Sommer 1991; Figure 8.30), since as I have noted the West German higher education system has often been held up as an example of a system geared to maintenance of a high technical skils level in its professional strata. These data suggest that U.K. archaeology is in fact a non-vocational, or 'high-entropy' degree discipline.

In Figure 8.31, I have adduced a reference distribution by age of I.F.A. members (the shape of the distribution is my own guess, based only on experience of this profession and on the corresponding age distribution of archaeological staff in the universities). I have then calculated the replacement rate for this pool of professionals, assuming a stable population and uniform patterns of retirement at age sixty. I have done the same for the academic sector of British professional archaeology, this time using the reference population age structure given by Keep and Sisson (1992) for U.K. academic staff as a whole (Figure 8.32). I have then aggregated the replacement projections for these two sectors of British archaeology and graphed them as components of the total graduate output in archaeology from British universities, assuming a stable output of 500 graduates per annum (a conservative estimate). As the graph shows (Figure 8.33), even at the point in the future where replacement rates reach a maximum (in ca. 2005-2015), less than twenty percent of annual graduate output will be absorbed into the existing profession - and that ignores competition from the accumulating pool of graduates from the intervening fifteen to twenty-five years who may have remained on the periphery of the profession seeking access to a secure position. The average figure overall for graduate employment within the archaeological profession over the next forty years is closer to ten percent of expected minimum output.

Of course, many graduates will choose to take their chances in the vocational skills market for their degree discipline even if these chances are sub-optimal. To illustrate this point, in Figure 8.34 I have reproduced a graph from Keep and Sisson (1992) showing the expansion of short-contract staff in the British academic sector as a whole, and have given a formal 'preference function' which states that the probability of a graduate entering into the vocational job market for his or her degree discipline is affected by a number of separate factors, including regulatory actions by professional or governmental organizations (e.g. quotas), the structure of opportunity for the graduate in other sectors of the employment market, and the social and material benefits of pursuing the professional activity. Even where the objective chances of a secure position in archaeology are slight relative to graduate output levels, a substantial minority may choose to take their chances in this field because the perceived benefits outweigh the costs of this strategy in a situation of imperfect information about lifechances in other occupational sectors, or in a situation where those alternative lifechances are genuinely poor.

Despite this, I assert that the evidence considered in the foregoing pages of this Chapter point to an obligation to categorize archaeology first degree courses in the United Kingdom as predominantly non-vocational and 'high entropy'. The difference between a highly vocational discipline in which intake is governed by projected professional demand for the skills, and a nonvocational course in which intake expands with applicant demand as constrained by budgetary limits on the whole higher educational system, can be seen by comparing the model and worked example in Figure 8.24 with those in Figure 8.35, in which I have represented expansion of intake to a nonvocational degree course as a function of expansion of intake to the system as a whole. It will be seen from the worked example that as intake to such a discipline expands in line with applicant demand and with the whole system, so the proportion declines of graduates who can be expected to go into a vocational niche if that is not also expanding. This is a particularly relevant consideration for contemporary academic archaeology courses in Britain, where (as I have demonstrated) intake levels have increased dramatically in the past five years.

In the next part of this Chapter, I will explore the issue of what skills should be developed in a first degree curriculum oriented primarily to non-vocational graduate output. The relevance of the issues discussed in my thesis will be evident, since those studies call into question the underlying assumptions of many academics that general academic skills are sufficient for these undergraduates' training, are transferrable across domains (for instance into the interpersonal or groupwork domains), and are equally easily learned by students whatever the content of the academic tasks they undertake for their degree coursework. The need for some such reappraisal is reinforced by considering the changing climate of public opinion with respect to the U.K. public education system in general.

Part Three.

In the course of the 1980s public opinion in Britain, as sampled annually by the *British Social Attitudes* survey series, increasingly favoured a substantial increase in opportunities for young people to go on to higher education, particularly to university (Brooks et al. 1992: I-19,I-26). There is also evidence of a majority opinion favouring loans (as opposed to grants) selectively applied to the financing of higher education for average-ability students with middle income parents, as opposed to either high ability or low parental income students (who should receive grants) (ibid.: I-26). The climate of public opinion in Britain favours increased public spending targeted on the health and education sectors, but analysis of more specific aspects of this dominant set of public attitudes shows that in education this spending is seen as most desirable (in order of preferences) on special needs education, secondary education, primary education, higher education, and finally as a lowest priority pre-school education (ibid.:F-11-12, I-14). Furthermore, the first two priorities for improving education at the secondary level are more training and preparation for jobs, and stricter discipline (ibid.: I-16).

It is worth noting the changing climate of educational opinion in the compulsory levels of the system, since these will inevitably have an effect on tertiary education itself. Ormell (1992) has argued that educationists need to rethink the progressive dogmas of theories of school-age education derived from the 1970s (permissive, unfocussed, implicitly 'depressive' about the *content* of the cultural cupboard) through a new dialogue with the 'behavioural objectives' literature of the 1950s. 'Behavioural objectives' (as opposed to rote learning of specific content) were defined systematically by Bloom's (1956) *Taxonomy of Educational Objectives*, but were subjected to strong criticism in the mid-1970s for regimenting the child's development. Ormell suggests that the climate of public opinion in the 1990s mandates a return to 'objectives', defined not in terms of quantifiable behavioural achievements (which could be attained through unreflective mimicry) but in terms of the attainment of understanding, or the demonstrable ability to transfer insight across problem types and problem domains, based on a synoptic, over-arching knowledge base (Figure 8.36). Richard Pring, Director of the Department of Educational Studies at Oxford University, points out (1992) in this context that recent government reforms to the British secondary education system move it further away from the narrow pathway of three restricted subject-range A-levels (seen primarily as serving the interests of the universities, not of the schoolchildren, and currently operated with a 30% average exam failure rate). The reforms move secondary education towards a broader, more practical curriculum including 'core skills' packages, National Vocational Qualifications and Diplomas, BTEC Foundation courses, coursework assessment, and Records of Achievement, and also towards a broader range of choice in A-level subject combinations. This will have a knock-on effect on higher education by forcing a redefinition of recruitment procedures and of application assessment. The context here is a historical deficit in training of the British workforce at higher intermediate levels (Tables 8.7 and 8.8).

The general historical point is made by Richard Aldrich, of the London Institute of Education (1992:68), that "although it is natural for commentators in the U.K. to see the educational legislation of the 1980s as a manifestation of the ideological victory of the far right - of the Institute of Economic Affairs, of the Centre for Policy Studies, of the *Black Papers* - there are grounds, from both the national and international perspectives,for arguing that such changes depended more on fundamental causes, and commanded wide political and popular support. [...] In the 1980s, perhaps essentially in response to the oil crises of the 1970s, but more immediately at the behest of political regimes whether of right or left that were searching for greater national efficiency and competitiveness, many of these education systems [in Europe, the U.S.A., Canada, Australia, and New Zealand] became characterized by more public scrutiny, and by a greater concern with testing and outcome." The implication of these comments and surveys is that while there are good reasons to favour expanded access to higher education, this does not just mean 'more of the same'. There are also implied demands for a reorientation of the structure of academic priorities. Inevitably, this must entail a dethroning of research activities from their unquestioned position as the pinnacle of academic aspiration for every teacher at degree level, in every course, in every institution.

Don Aitkin, Chairman of the Australian Research Council, in an address on the subject of 'How research came to dominate higher education and what ought to be done about it' (1991), outlines a three stage model of the development of the modern university in developed Western states:

Period 1. From the beginnings of university foundations to some time after World War Two. Features: Universities small in number and size. Universities not deeply involved in research.

Period 2. From the post-war period to the 1980s. Features: Government-funded expansion of higher education during a period of strong economic growth. Increase in number and size of universities, increasing involvement of academics in research. Strengthening of basic scientific research to generate solutions to major social, economic and political problems.

Period 3. From now to ?. Features: Further expansion of the system, but not of the numbers of institutions. Research function selectively allocated to a proportion of academic staff. Increasing institutional differentiation. Increasing institutional role in the community.

This model is drawn from his experiences in Australia, Britain and the U.S.A., although he notes parallels in other developed Western educational systems over the same time span. He is, in passing, critical of the construction and deployment of a dominant ethic of research productivity, noting the low average use-rates of published articles - "We have let a million flowers bloom, but we have forgotten to develop a cut-flower market" (*ibid.*:243). The analysis leads him to suggest a new paradigm for the academic career and its 'prestige system', 'The Five-Fold Path to Honour', with five essential tasks for any academic to contribute to:

- teaching and learning;
- research;
- scholarship;
- collegial administration;
- community service.

Sir Peter Swinnerton-Dyer (1991), former Chairman of the British University Grants Committee (1983-89) and then Chief Executive of its successor, the University Funding Council (1989-91), has also argued that research funding will necessarily become increasingly selective for the forseeable future, with selectivity exercised by funding agencies leading to an inevitable stratification of H.E. institutions by their research and teaching functions. He notes that maintenance of quality standards during expansion to a mass access system will place new demands on teaching methods, which may best be met by standardising the core curriculum of disciplines across campuses and by use of computer-aided interactive learning technology.

Peter Wright, in a paper on 'Rethinking the Aims of Higher Education' (1988:185-187), has predicted that:

> "an increasing proportion of teaching in higher education will be structured according to externally-given ends, such as the needs of employment or the career demands of individual students, rather than in terms of how the academic community has traditionally interpreted internal principles such as

> intellectual progression, disciplinary coherence, and so on [...] the changes in British higher education toward something closer to the American model, which I have argued are now taking place (more general programmes of study structured to an increasing extent around needs external to the academic world) [...] would, for instance, tend to erode the power of the discipline to act as the central principle of organization and major source of identity for both students and staff [...] in higher education the very concepts of quality and standards are hard to disentangle from disciplinary assumptions; disciplines thus tend to form the grid through which all such questions are viewed. Thus, for example, the [...] U.G.C. research evaluation was organized in terms of discipline.
>
> These issues which, in the future, seem likely to become increasingly important in higher education - responding to the needs of students, developing new strategies for learning, fostering personal transferrable skills, preparing for employment - are not simply overlooked in the present discipline-based structure, although that does often happen; more important than that, they tend to become, by being fragmented into a set of secondary issues, ancillary to the main focus of attention - the transmission of the discipline. Their marginality means that thay are the main business of almost no one, other, perhaps, than a few careers advisers and specialists in educational development. Teaching staff who take such questions seriously tend to be regarded by their peers as neglecting the 'main business' of academic life - their discipline."

From the perspective of those who were socialised into the values of the research ethic, these developments must seem threatening to the central rationale of academic culture. However, it is also quite possible to view these developments more constructively as challenging academics to rethink their value-system in an evolving if indirect dialogue with their students, these students' future employers, and these students' parents or guardians. This dialogue will inevitably focus on the structure and content of the undergraduate degree curriculum. My proposal is that curriculum development at first degree level can be seen not as a diversion from the primary research function, but as a form of active research which explicitly implements theories about human skills and abilities: in other words, curriculum design in nonvocational first degree courses is not just a reaction to changing external forces, but also an active experiment in social engineering.

For this purpose I shall represent the first degree curriculum as a zone of overlap between the partially competing interests of a number of different interest groups. These groups I propose to be academics, students, higher education administrators, and contractors or employers who buy the product of academic work, whether in the form of research or in the form of graduate skills. In Figures 8.37-8.40 I have diagrammed some of the possible relationships of influence between these different interest groups, and have represented the curriculum either as being pulled in opposite directions by these different interests, or as being a site for positive negotiation of each interest group's priorities (Figures 8.41, .842). These priorities I construe to be the reproduction and expansion of the discipline (academic interests); the acquisition of transferrable insights, skills, and competencies (student interests); the acquisition of specific occupationally-relevant skills and abilities (employers' interests); and the constraints of budgets and of corporate goals (higher education administrators' interests).

Consistent with the focus of this thesis, I shall argue for a greater role for social and communication skill development in the undergraduate arts curriculum (here, in the case of archaeology). However, in order to justify this focus here I can cite relatively few relevant research findings relating either to the existing values of the academics who build curricula, or to the values and skills of the graduating students going into nonvocational employment. One alternative to systematic survey data is to sample the ideology or worldviews of academics and graduates through their published expressions of perspective, as for example in editorial and features reporting in the *Times Higher Education Supplement* in the U.K. Qualitative evidence, however, is generally accorded little weight due to the assumed ephemerality of journalistic expressions of viewpoint, and to the editorial positions adopted by particular publishing houses or professional associations.

A recent survey of student perceptions of higher education (Boys *et al.* 1988), sampled across the range of British H.E. institutions, found significant differences between arts students, and those in the natural and social sciences. The arts students (history and English) were the least likely to have chosen their course for its effect on their career prospects, and were the most likely to have chosen their course for reasons of personal interest and in order to have a 'breathing space' before they made a career choice. They scored highest on self-rated academic skill acquisition, but lowest for acquisition of numeracy and leadership skills: they were also the least oriented to careers involving team work or technological development. They demonstrated relatively little interest in a career with a high salary, promotion prospects, and social prestige, but were relatively likely to aspire to careers which are people oriented (helping others, improving society, working with people rather than things). They also tended to value the opportunity for creativity and originality more highly than the opportunity to use content-knowledge and specialist skills from their degree course.

With regard to the values of academics, one study on competency-based higher education carried out recently in the U.S.A. (White 1991) which polled the educational values of faculty academics on a single campus did find a marked convergence between the values most prized by the faculty members, with a premium placed on 'personal development' and on general academic *and* social skills; however, it would be unwise to generalize from this study to the values of the academic population in the U.K., particularly on campuses where the competency-based approach is not dominant.

In order to make a start on gathering data in this area, I conducted a pilot study in the second semester of the 1992-1993 academic year among third year archaeology undergraduates at Southampton University, asking them to complete a copy of the skills and career aspirations questionnaires used by Boys et al (1988) in their surveys of a sample of the major academic disciplines as preparers of graduates for the world of work. The form is reproduced in Appendix 8.1, with the respondents' mean scores for each question also reproduced for the sake of record.

Unfortunately the questionnaire was issued under somewhat restricting conditions, in that returns contained no directly identifying information as to the respondent's name, and I had agreed not to follow up the initial mailing in order not to add to the pressures of final year studies. Consequently, a disappointing sample of 10 (out of 32) third year students returned completed forms. Nonetheless, while the results may have no statistical validity, there were patterns in the answers which suggested that the exercise might usefully be repeated with a larger and more complete sample of undergraduate opinion.

Much the most striking single result was the consistency with which respondents agreed that they had experienced no improvement in numeracy as a result of their attendance at university. Given the quantitative nature of field recording and analysis, and the strength of the Southampton Department in computer applications research and teaching, I must confess to having been taken aback by that result - which recalls more general observations that arts graduates are handicapped in the jobs market not by their degree subject but by their lack of number skills.

Equally, however, there was a tendency to acknowledge improvements in academic skills (critical thinking, objective thinking, working independently), but less overall improvement in creativity and social skills (reliability, leadership. original thinking). This was noteworthy, since respondents also expressed in general a higher priority for career considerations such as responsibility, the chance to exercise leadership, and the opportunity to be creative and original, than they gave to the opportunities either to use skills and knowledge acquired on their degree course, or to work in an academic environment. If this were to prove to be a general pattern among respondents in future, larger samples, then it would suggest the existence of a discrepancy between the skills graduates most aspire to use in their careers, and the skills which they currently most improve or acquire during their stay in higher education.

It would be premature to voice any recommendations on the basis of this sort of evidence. However, the area of curriculum reform is clearly one area in which the research topic of this thesis could find an application. I have discussed the 'social intelligence' hypothesis of primate and human brain evolution, have noted ways in which the transactional nature of many human abilities (linguistic, tool-using) mandates that linguistic and cultural transmission take place in a context of stable long-term social relationships, and have examined anatomical and behavioural evidence bearing on the extent to which social competences are (or are not) discriminable from general academic skills and competences (such as content-independent formal logic). Social skills and 'social intelligence' are increasingly the focus of work on psychometric testing, and there are some relevant discussions of the issues in recent papers by Riggio *et al.* (1991) and by Lorr *et al.* (1991). Lorr *et al.* (1991), responding to a growing need in the applied domain of counseling and psychotherapy for a formal definition of the structure of social abilities (since deficits in these are seen to underly many of the problems with which clients present themselves for such services), identified a hierarchy of interpersonal skills which included social assertiveness, directiveness, defense of rights, confidence, and empathy, with two higher-order organizing constructs also being identified: social skill and empathy. Thorndike (1920), a pioneer of psychometric testing, defined social intelligence as "the ability to understand and manage people and to act wisely in human relations" (Riggio *et al.* 1991:695). Riggio *et al.* note that social intelligence has yet to find a satisfactory definition in the psychometric literature, but that it may be made up of a number of facets or 'building blocks': expressivity (sending skill), sensitivity (receiving skill), and skill in controlling or regulating communication processes. These three basic processes they locate in each of two separate domains: the non-verbal and the verbal. Thus in non-verbal communication, which they take to be dominated by emotional communication, these.

skills are manifested as emotional expressivity, sensitivity, and control. In verbal communication, the skills appear as generic social expressivity, sensitivity, and control. They also note that tacit knowledge, as contained in 'social etiquette' ("knowing how to behave appropriately in various common, 'formal' social situations" [*ibid.*:696]), is another facet of practical social skills. Such a multi-faceted model of social intelligence should be contrasted with single-factor models which account for social intelligence in terms of a single ability, such as cognitive perspective-taking skill.

Riggio *et al.* (1991) report a preliminary test of various measures of social and academic intelligence, some based on performance and some based on self-reported ratings, which suggest that "the domains of academic and social intelligence do indeed overlap considerably, and this is not merely due to shared method variance in measurement instruments" (*ibid.*:700). However, they also note that "with greater refinement and sophistication of social intelligence measures, and renewed research interest in the topic, we should soon be able to more clearly define and measure the construct and differentiate it from academic intelligence" (*ibid.*:701). If social competences are distinguishable from academic intelligence, and if social competences are the foundation of human culture and social organization, then the development of a more explicit focus on transferrable social and communications skills in graduates of nonvocational first degree courses such as archaeology would seem a reasonable move. This would be an example of the kind of reflexive modification of the institutional setting for social research which I described at the beginning of this Chapter.

It is evident that social skills are not the sole or perhaps even the primary deficit identifiable in the 'typical arts curriculum'. One of the weaknesses of curriculum design guided by the particular research expertises of a small number of academics is that the underlying philosophy may be insufficiently broad-based. What is at issue, however, is the relationship between research practice, especially where that research bears directly on the definition of generic human skills, and curriculum design. It is common for social scientists whose work is in the interpretive paradigms of hermeneutics or poststructuralism to imply that academic practice reproduces the same structural aspects of society as do any other routinized social practices. In this thesis, which has been predicated on the assumption that research can proceed motivated by scientific concerns and regulated by more-or-less objective standards of validation, the reflexive loop goes in the opposite direction, namely from research findings to conscious social strategies for the workplace. This is also a fitting point on which to conclude this thesis.

LIST OF REFERENCES

Aiello, L. and Dean, C. (1990) *An Introduction to Human Evolutionary Anatomy.* London: Academic Press.

Aiello, L.C. and Dunbar, R.I.M. (1993) Neocortex size, group-size, and the evolution of language. *Curr. Anthropol.* 34: 184-193.

Aitkin, D. (1991) 'How research came to dominate higher education and what ought to be done about it' *Oxford Rev. Educ.* 17: 235-247

Aldrich, R. (1992) Educational legislation of the 1980s in England: an historical analysis. *Hist. Educ.* 21: 57-69

Aldrich-Blake, F.P.G. *et al.* (1971) Observations on baboons, Papio anubis, in an arid region in Ethiopia. *Folia Primatol.* 15: 1-35

Allen, G.E. (1987) Materialism and reductionism in the study of animal consciousness. In Greenberg, G. and Tobach, E. (Eds) *Cognition, Language, and Consciousness: Integrative Levels,* 137-160. Hillsdale, N.J.: L. Erlbaum

Allison, P.D. (1992) The cultural evolution of beneficent norms. *Social Forces* 71: 279-301

Amann, A. (1985) *The changing age structure of the population and future policy.* Strasbourg: Council of Europe

Anderson, C.M. (1987) Female transfer in baboons. *Am. J. Phys. Anthr.* 73: 241-250

Anderson, C.M. (1986) Predation and primate evolution. *Primates* 27: 15-39

Andresen, J.T. (1990) Skinner and Chomsky thirty years later. *Historiographia Linguistica* 17: 145-165.

Andresen, J.T. (1992) The behaviorist turn in recent theories of language. *Behavior and Philosophy* 20: 1-19

Andrew, R.J. (1963) Evolution of facial expression. *Science* 141:1034-41

Apel, K.-O. (1981) Intentions, conventions, and reference to things [...]. In Parret, H. and Bouveresse, J. (Eds) *Meaning and Understanding*, 79-111. Berlin: De Gruyter

Apel, K.-O. (1984) *Understanding and Explanation* Cambridge, Mass.: MT. Pres

Appley, M.H. (1991) Motivation, equilibration, and stress. In Dienstbier, R. (Ed.) *Perspectives on Motivation*, 1-68. Nebraska: U. of Nebraska Press

Armstrong, E. (1990) Brains, bodies and metabolism. *Brain, Beh. and Evol.* 36: 166-176

Armstrong, E. (1983) Metabolism and relative brain size. *Science* 20:1302-1304.

Asher, H.B. (1976) *Causal Modeling* London: Sage.

Baba, H. (1993) Pelvic structure and evolution of the human bipedalism [abstract]. *Anatom. Record Suppl.* 1:34.

Bard, K.A., Hopkins, W.D. & Fort, C.L. (1990) Lateral bias in infant chimpanzees (Pan troglodytes). *J. Comp. Psychol.* 104:309-21

Barnett, M.A. and Thompson, S. (1985) The role of perspective taking and empathy in childrens Machiavellianism, pro-social behavior, and motive for helping. *J. Genetic Psychol.* 146: 295-305

Barton, R.A. (1985) Grooming site preferences in primates and their functional implications. *Int. J. Primatol.* 6:519-532

Bearder, S.K. (1987) Lorises, bushbabies, and tarsiers: diverse societies in solitary foragers. In B.B. Smuts *et al.* (eds), 11-24

Beauchamp, G. & Cabana, G. (1990) Group size variability in primates. *Primates* 31:171-182

Becher, T. (1989) *Academic Tribes and Territories: Intellectual Enquiry and the Cultures of Disciplines* Milton Keynes: SRHE & Open U. Press

Berger, J. (1990) Market and state in advanced capitalist countries. In A. Martinelli and N.J. Smelser (eds) *Economy and Society*, 103-132. London: Sage

Best, J.B. (1986) *Cognitive Psychology* St Paul: West Pub. Co.

Beth, E.W. and Piaget, J. (1966) *Mathematical epistemology and psychology.* Dordrecht: Reidel

Biben, M. & Symmes, D. (1991) Playback studies of affiliative vocalizing in captive squirrel monkeys: familiarity as a cue to response. *Behaviour* 117:1-19

Bisiach, E. (1988) Language without thought. In (Weiskrantz, L., Ed.) *Thought without Language*, pp. 464-484. Oxford: Clarendon Press.

Blinkov, S.M. and Glezer, I.I. (1968) *The Human Brain in Figures and Tables*. USA: Basic Books

Bloom, B.S. (1956) *Taxonomy of Educational Objectives*. London: Longman

Blount, B.G. (1990b) Spatial expression of social relationships among captive *Pan paniscus*: ontogenetic and phylogenetic implications. In S.T. Parker and K.R. Gibson (eds) *'Language' and Intelligence in Monkeys and Apes*, 420-432. Cambridge: C.U.P.

Blount, B.G. (1990a) Issues in bonobo (*Pan paniscus*) sexual behavior. *Am. Anthr.* 92:702-714.

Boccia, M.L., Reite, M. & Laudenslager, M. (1989) On the physiology of grooming in a pigtail macaque. *Physiology and Behavior* 45:667-70

Boehm, C. (1993) Egalitarian behavior and reverse dominance hierarchy [with commentary and reply]. *Curr. Anthropol.* 34: 227-254

Boesch, C. and Boesch, H. (1990) Tool use and tool making in wild chimpanzees. *Folia Primatol.* 54: 86-99

Borgatti, Everett, and Freeman (1992) *UCINET IV Version 1.0*. Columbia: Analytic Technologies.

Bott, E. (1957/1971) *Family and Social Network.* New York: Free Press.

Bower, G.H. & Morrow, D.G. (1990) Mental models in narrative comprehension. *Science* 247: 44-48

Boys, C.J. *et al.* (1988) *Higher Education and the Preparation for Work.* London: Jessica Kingsley

Brain, C. K. (1981) *The Hunters or the Hunted?* Chicago: University of Chicago Press.

rewer (1985) The story schema: universal and culture-specific properties. In Olson, D.R., Torrance, N. & Hildyard, A. (Eds) *Literacy, Language and Learning*,Cambridge: C.U.P.

Brodmann, K. (1912) Ergebnisse uber die vergleichende histologische Lokalisation der Grosshirnrinde mit besonderer Berucksichtigung des Stirnhirns. *Anatomischer Anzeiger (Supplement)* 41: 157-216

Brook, L. *et al.* (1992) *British Social Attitudes: Cumulative Sourcebook: the First Six Surveys*. Aldershot: Gower.

Brothers, L. and Raleigh, M.J. (1991) Simians, space and syntax: parallels between human language and primate social cognition. *Beh. Brain Sci.* 14: 613-614

Brown, B.B. (1992) The ecology of privacy and mood in a shared living group. *J. Environm. Psychol.* 12: 5-20

Brown, C.H. & Hauser, M.D. (1990) Primate vocal gestures [Abstract] *Am. J. Primatol.* 20:177-8

Brown, D.E. (1991) *Human Universals*. Philadelphia: Temple U. Press

Burling, R. (1986) The selective advantage of complex language. *Ethology and Sociobiology* 7:1-16.

Byrne, R.W. and Whiten, A. (1992) Cognitive evolution in primates: evidence from tactical deception. *Man (n.s.)* 27: 609-627

Byrne, R.W. and Whiten, A. (1988) (Eds) *Machiavellian Intelligence*. Oxford: Clarendon

Cabanac, M. (1992)Calvin, W.H. (1993) The unitary hypothesis: a common neural circuitry for novel manipulations, language, plan-ahead, and throwing? In K.R. Gibson and T. Ingold (eds) *Tools, Language and Cognition in Human Evolution*, 230-250. Cambrige: C.U.P.

Carlson, M. (1985) Significance of single or multiple cortical areas for tactile discrimination in primates. In A.W. Goodwin and I. Darian-Smith (eds) *Hand Function and the Neocortex*, 1-16. Berlin: Springer

Caro, T.M. and Hauser, M.D. (1992) Is there teaching in nonhuman animals? *Q. Rev. Biol.* 67: 151-174

Cartmill, M. (1990) Human uniqueness and theoretical content in paleoanthropology. *Int. J. Primatol.* 11: 173-192

Chance, M.R.A. (1988) (ed) *Social Fabrics of the Mind.* Hillsdale, NJ: Lawrence Erlbaum

Cheney, D. and Wrangham, R. (1986) Predation. In Smuts *et al.* (1986), 227-239.

Cheney, D. and Seyfarth, R. (1990) *How Monkeys See the World* Chicago: U. of Chicago Press

Cheney, D., Seyfarth, R. & Smuts, B. (1986) Social relationships and social cognition in nonhuman primates. *Science* 234:1361-1 366.

Cheng, P.W. and Holyoak, K.J. (1985) Pragmatic reasoning schemas. *Cog. Psychol.* 17: 391-416

Cheng, P.W. and Holyoak, K.J. (1989) On the natural selection of reasoning theories. *Cognition* 33: 285-313.

Chism, J. and Rowell, T.E. (1988) The natural history of patas monkeys. In A. Gautier-Hion *et al.* (1988) (eds), 412-438.

Chlopan, B.E. *et al.* (1985) Empathy - review of available measures. *J. Pers. and Soc. Psychol.* 48: 635-653.

Chomsky, N. (1959) Review of Skinner (1957). *Language* 35: 26-58

Christie, R. and Geis, F.L. (1970) (eds) *Studies in Machiavellianism.* New York: Academic Press

Clutton-Brock, T.H. and Harvey, P.H. (1977a) Primate ecology and social organization. *J. Zool. (Lond.)* 183: 1-39

Clutton-Brock, T.H. and Harvey, P.H. (1977b) Species differences in feeding and ranging behaviour in primates. In T.H. Clutton-Brock (ed) *Primate Ecology.* London: Academic Press

Clutton-Brock, T.H. and Harvey, P.H. (1980) Primates, brains and ecology. *J. Zool. Lond.* 190:309-323.

C.M.I. (1991) White Paper 1541 *Higher Education, A New Framework.* H.M.S.O.

Coles, J.M. and Higgs, E.S. (1969) *The Archaeology of Early Man.* London: Faber

Collins, R. (1993) The rationality of avoiding choice. *Rationality and Society* 5: 58-67

Cosmides. L. (1989) The logic of social exchange: has natural selection shaped how humans reason? Studies with the Wason selection task. *Cognition* 31: 187-276

Cosmides, L. and Tooby, J. (1989) Evolutionary psychology and the generation of culture, Parts 1 and 2. *Ethology and Sociobiology* 10: 29-49, 51-97.

Crook, J.H. (1989) Introduction: socioecological paradigms, evolution and history: perspectives for the 1990s. In Standen, V. & Foley, R.A. (Eds) *Comparative Socioecology*, 1-36. Oxford: Blackwells Scientific

Csikzentmihalyi, M. (1975) *Beyond Boredom and Anxiety*. San Francisco: Jossey-Bass

Csikzentmihalyi, M. & Massimini, F. (1985) On the psychological selection of biocultural information. *New Ideas in Psychology* 3: 115-138

Csikzhentmihalyi, M. (1988) Motivation and creativity: toward a synthesis of structural and energistic approaches to cognition. *New Ideas in Psychology* 6: 159-176

C.V.C.P. (1990) *University Entrance: The Official Guide*. London

D.E.S. (1961-79) *Statistics of education Part 3*.

D.E.S. (1981-) *Statistics of Education: Further Education.*

Daigneault, S., Braun, C.M.J. and Whitaker, H.A. (1992) An empirical test of two opposing theoretical models of prefrontal function. *Brain and Cognition* 19: 48-71

Das, M. and van Hooff, J.A.R.A.M. (1993) A nonadaptive feedback loop to account for the differences between the macaques' social systems - is it convincing? *J. Theor. Biol.* 160: 399-402

Davidson, I. & Noble, W. (1989) The archaeology of perception: traces of depiction and language. *Current Anthropol.* 30:125-155

Davidson, I. and Noble, W. (1993) Tools and language in human evolution. In K.R. Gibson and T. Ingold (eds) *Tools, Language and Cognition in Human Evolution*, 363-388. Cambridge: C.U.P.

Davidson, R.J. (1992) Anterior cerebral asymmetry and the nature of emotion. *Brain and Cognition* 125-151.

Dawkins, R. and Krebs, J.R. (1978) Animal signalling: information or manipulation? In J.R. Krebs and N.B. Davies (eds) *Behavioural Ecology*, 282-309. Oxford: Blackwell Scientific.

Day, M.H. (1986) *Guide to Fossil Man, 4th Ed.* London: Cassell

De Bruin, J.P.C. (1990) Social behaviour and the prefrontal cortex. *Progr. Brain Res.* 85: 485-497

De Waal, F.B.M. (1989a) Food sharing and reciprocal obligations among chimpanzees. *J. Hum. Evol.* 18: 433-460

De Waal, F.B.M. (1989b) *Peacemaking Among Primates* USA: Harvard U.P.

De Waal, F.B.M. and Luttrell, L.M. (1988) Mechanisms of social reciprocity in three primate species: symmetrical relationship characteristics or cognition? *Ethology and Sociobiology* 9:101-118.

Deacon, T.W. (1988a) Human brain evolution: I. Evolution of language circuits. In (Jerison, H.J. & Jerison, I., Eds) *Intelligence and Evolutionary Biology,* 363-82. Berlin: Springer

Deacon, T.W. (1988b) Human brain evolution: II. Embryology and brain allometry. In (Jerison, H.J. & Jerison, I., Eds) *Intelligence and Evolutionary Biology*, 383-416. Berlin: Springer

Deacon, T.W. (1990a) Fallacies of progression in theories of brain-size evolution. *Int.J. Primatol.*11:193-236

Deacon, T.W. (1990b) Problems of ontogeny and phylogeny in brain-size evolution. *Int. J. Primatol.* 11:237-282

Deacon, T.W. (1990c) Rethinking mammalian brain evolution. *Amer. Zool.* 30: 629-705

DeVore, I. and Hall, K.R.L. (1965) Baboon ecology. In I. DeVore (ed) *Primate Behavior: Field Studies of Monkeys and Apes*. New York: Holt, Rhinehart and Winston.

Diamond, A. (1988) Differences between adult and infant cognition: is the crucial variable presence or absence of language? In (Weiskrantz, L., Ed.) *Thought without Language*, pp. 337-370. Oxford: Clarendon Press.

Dolton, P. (1992) The market for qualified manpower in the U.K. *Oxf. Rev. Econ. Policy* 8: 103-129

Douglas, M. (1991) The idea of a home - a kind of space. *Soc. Res.* 58: 287-307.

Duchin, L.E. (1990) The evolution of articulate speech - the comparative anatomy of the oral cavity in Pan and Homo. *J. Hum. Evol.* 19:687-98

Dunbar, R.I.M. (1988) *Primate Social Systems* London: Croom Helm

Dunbar, R.I.M. (1992) Neocortex size as a constraint on group size in primates. *J. Hum. Evol.* 20: 469-493

Edelman, G. (1987) *Neural Darwinism.* Oxford.

Eder, D. and Emke, J.L. (1991) The structure of gossip: opportunities and constraints on collective expression among adolescents. *Amer. Sociol. Rev.* 56: 494-508

Eder, D. (1988) Building cohesion through collaborative narration. *Soc. Psychol. Q.* 51:225-235

Eggins, H. (1992) (ed) *Arts Graduates, Their Skills and Their Employment.* Brighton: Falmer

Eisenberg, J.F. (1981) *The Mammalian Radiations.* Chicago: University of Chicago Press

Enquist, M. and Leimar, O. (1993) The evolution of cooperation in mobile organisms. *Anim. Beh.* 45: 747-757

Falk, D. (1983) Cerebral cortices of East African early hominids. *Science* 221:1072-74

Falk, D. (1987) Brain lateralization in primates and its evolution in hominids. *Yearb. phys. Anthrop.* 30:107-125.

Ferrari, S.F. and Lopes-Ferrari, M.A. (1989) A re-evaluation of the social organization of the Callitrichidae, with reference to the ecological differences between genera. *Folia Primatol.* 52: 132-147

Fiske, A.P. (1992) The four elementary forms of sociality: framework for a unified theory of social relations. *Psych. Rev.* 99: 689-723

Flynn, S. *et al.* (1988) Cheating as a function of task outcome and Machiavellianism. *J. Psychol.* 121: 423-427

Focardi, S. and Paveri-Fontana, S.L. (1992) A theoretical study of the socioecology of ungulates. *Theor. Pop. Biol.* 41: 121-134

Foley, R.A. (1987) *Another Unique Species.* London: Longmans.

Foley, R.A. (1989) The evolution of hominid social behaviour. In Standen, V. and Foley, R.A. (Eds) *Comparative Socioecology*, 473-494. Oxford: Blackwells Scientific

Foley, R.A. & Lee, P.C. (1989) Finite social space, evolutionary pathways, and reconstructing hominid behaviour. *Science* 243:901-906

Freeman, L.C. (1979) Centrality in social networks: conceptual clarification. *oSocial Networks* 1: 215-239

Freeman, L.C. *et al.* (1988) On human social intelligence. *J. Soc. Biol. Struc.* 11: 415-425

Fry, W.R. (1985) The effect of dyad Machiavellianism and visual access on integrative bargaining outcomes. *Pers. and Soc. Psychol. Bull.* 11: 51-62

Fuster, J.M. (1991) The prefrontal cortex and its relation to behavior. *Progr. Brain Res.* 87: 201-211

Gamble, C.S. (1986) *The Palaeolithic Settlement of Europe.* Cambridge: C.U.P.

Garland, T. Jr *et al.* (1992) Procedures for the analysis of comparative data using phylogenetically independent contrasts. *Syst. Biol.* 41: 18-32

Gautier-Hion, A. (1988) The diet and dietary habits of forest guenons. In A. Gautier-Hion *et al.* (1988) (eds), 257-283.

Gautier-Hion, A., Bourliere, F., Gautier, J.-P., and Kingdon, J. (1988) (eds) *A Primate Radiation: Evolutionary Biology of the African Guenons*. Cambridge: C.U.P.

Geis, F.L. and Moon, T.H. (1981) Machiavellianism and deception. *J. Pers. and Soc. Psychol.* 41: 766-775

Gelepithedes, P.A.M. (1988) Survey of theories of meaning. *Cognitive Systems* 2[2]:141-162

Gibbons, A. (1992a) Chimps: more diverse than a barrel of monkeys. *Science* 255: 287-288

Gibbons, A. (1992b) Extinct hominid did not veg out. *Science* 256: 1281.

Gibson, K.R. (1988) Brain size and the evolution of language. In Landsberg, M.E. (Ed.) *The Genesis of Language*, 149-172. Berlin: Mouton de Gruyter

Gibson, K.R. (1990) New perspectives on instinct and intelligence. In Parker, S.T. and Gibson, K.R. (Eds) *'Language' and Intelligence in Monkeys and Apes* Cambridge: C.U.P.

Gigerenzer, G. and Hug, K. (1992) Domain-specific reasoning - social contracts, cheating, and perspective change. *Cognition* 43: 127-171.

Girotto and Light, P. (1992) In P. Light and G. Butterworth (eds) *Context and Cognition*, London: Harvester Wheatsheaf

Goldman-Rakic, P. S. (1987a) Circuitry of the prefrontal cortex and the regulation of behavior by representational memory. In (Plum, F., Ed.) *Handbook of Physiology Section 1, Volume 5*, pp. 373-417. USA: Oxford University Press.

Goldman-Rakic, P. S. (1988) Topography of cognition: parallel distributed networks in primate association cortex. *Ann. Rev. Neurosci.* 11:137-156.

Goldman-Rakic, P.S. (1987b) Motor control function of the prefrontal cortex. In (Ciba Foundation Symposium 132) *Motor Areas of the Cerebral Cortex*, 187-200. Chichester: Wiley

Goosens, C. (1989) Social grooming in primates. In (Mitchell, G. & Erwin, J., Eds) *Comparative Primate Biology Volume 2 Part B: Behavior, Cognition and Motivation*, 107-31. New York: Wiley

Gowlett, J.A.J. (1990) Technology, skill and the psychosocial sector in the long term of human evolution. *Arch. Rev. Cambridge* 9[1]: 82-103

Graves, P. (1991) New models and metaphors for the Neanderthal debate. *Current Anthropology* 32:513-541

Greenfield, P.M. (1991) Language, tools and brain: the ontogeny and phylogeny of hierarchically organized behavior. *Beh. Brain Sci.* 14: 531-595

Gregory, S.W. Jr (1986) Social psychological implications of voice frequency correlations: analyzing conversation partner adaptation by computer. *Soc. Psychol. Q.* 49: 237-246

Griffin, D.R. (1990) Foreword. In Bekoff, M. and Jamieson, D. (Eds) *Interpretation and Explanation in the Study of Animal Behavior Vol. 2*, xiii-xviii. Boulder: Westview

Hall, K.R.L. (1965) Behaviour and ecology of the wild patas monkey, *Erythrocebus patas*, in Uganda. *J. Zool. (Lond.)* 148: 15-87.

Hamilton, M. and Hirszowicz, M. (1987) *Class and Inequality in Pre-industrial, Capitalist and Communist Societies.* Brighton: Wheatsheaf

Hamilton, W.J. *et al.* (1976) Defense of space and resources by chacma (*Papio ursinus*) baboon troops in an African desert and swamp. *Ecology* 57: 1264-1272

Harcourt, A.H. *et al.* (1981) Demography of *Gorilla gorilla. J. Zool. (Lond.)* 195: 215-233.

Harcourt, A.H., Stewart, K.J. & Harcourt, D.E. (1986) Vocalizations and social relationships of wild gorillas: a preliminary analysis. In (Taub, D.M. & King, F.A., Eds) *Current Perspectives in Primate Social Dynamics*, 346-56. New York: Van Nostrand Reinholt

Harding, R.S.O. (1976) Ranging patterns of a troop of baboons (*Papio anubis*) in Kenya. *Folia Primatol.* 25: 143-185

Hareven, T.K. (1991) The home and the family in historical perspective. *Soc.Res.* 253-295.

Harvey, P. H. (1988) Allometric analysis and brain size. In (Jerison, H. J. & Jerison, I., Eds) *Intelligence and Evolutionary Biology*, pp. 199-210. Berlin: Springer Verlag.

Harvey, P. H. & Bennett, P. M. (1983) Brain size, energetics, ecology and life history patterns. *Nature* 306:314-315.

Harvey, P.H. and Krebs, J. (1990) Comparing brains. *Science* 249: 140-146

Harvey, P.H., Martin, R.D., & Clutton-Brock, T.H. (1987) Life histories in comparative perspective. In Smuts, B.B., *et al.* (Eds) *Primate Societies*, 181 - Chicago: University of Chicago Press

Hauser, M.D. (1992) Exploring the primordial linguistic soup [review]. *Am. J. Primatol.* 28:307-312.

Hawkes, K. (1991) Showing off. *Ethol. and Sociobiol.* 12: 29-54

Heffner, H.E. & Heffner, R.S. (1989) Cortical deafness cannot account for the inability of Japanese macaques to discriminate species-specific vocalizations. *Brain and Language* 36:275-285

Heilbroner, P.L. & Holloway, R.L. (1988) Anatomical brain asymmetries in New World and Old World monkeys: stages of temporal lobe development in primate evolution. *Am. J. Phys. Anthr.* 76:39-48

Heilbroner, P.L. & Holloway, R.L. (1989) Anatomical brain asymmetry in monkeys: frontal, tempoparietal, and limbic cortex in Macaca. *Am. J. Phys. Anthr.* 80:203-211

Herd, J.A. (1991) Cardiovascular response to stress. *Physiol. Reviews* 71: 305-330

Herr, A.M. *et al.* (1990) Fiber type of primate upper respiratory muscles, and implications for understanding the uniqueness of the human vocal tract [abstract]. *Am. J. Phys. Anthro.* 81: 240

Hill, A. (1987) Causes of perceived faunal change in the later Neogene of East Africa. *J. Hum. Evol.* 16: 583-596

Hinde, R.A. (1987) *Interactions, Relationships, and Culture.* Cambridge: C.U.P.

Hinde, R.A. (1976) Interactions, relationships, and social structure. *Man (n.s.)* 11: 1-17

Hiraiwa-Hasegawa, M. *et al.* (1984) Demographic study of a large-sized unit-group of chimpanzees in the Mahale Mountains, Tanzania: a preliminary report. *Primates* 25: 401-413

Hoebel, B.G. (1988) Neuroscience and motivation: pathways and peptides that define motivational systems. In Atkinson, R.C., *et al.* (Eds) *Stevens' Handbook of Experimental Psychology*, New York: Wiley

Hofer, M.A. (1984) Relationships as regulators: a psychobiologic perspective on bereavement. *Psychosomatic Medicine* 46:183-197

Hollander, J. (1991) It all depends. *Social Research* 58: 31-49

Hollis, M. and Sugden, R. (1992) Rationality in action. *Mind* 102: 1-35

Holloway, R.L. (1983) Human brain evolution: a search for units, models, and synthesis. *Canad. J. Anthropol.* 3:215-232

Humphrey, N. K. (1976) The social function of intellect. In (Bateson, P. P. G. & Hinde, R. A., Eds) *Growing Points in Ethology*, pp. 303-317. Cambridge: Cambridge University Press.

Hurford, J.R. (1989) Biological evolution of the Saussurean sign as a component of the language acquisition device. *Lingua* 77: 187-222

Ibanez, A.E. (1986) Interanimal distance: spacing and social structure. *Comparative Primate Biology Volume 2A: Behavior, Conservation, and Ecology*, 169-194. Alan R. Liss, Inc.

Ikegami, Y. (1984) How universal is a localist hypothesis? In R.P. Fawcett et al. (Eds) *The Semiotics of Culture and Language, Vol. 1: Language as Social Semiotic.* London: Frances Pinter.

Inhelder, B. and Piaget, J. (1958) *The Growth of Logical Thinking from Childhood to Adolescence.* London: R.K.P.

Isaac, G.L. (1972) Early phases of human behaviour: models in Lower Palaeolithic archaeology. In D.L. Clarke (ed) *Models in Archaeology*, 167-199. London: Duckworths.

Isaac, G.L. (1976) Stages of cultural elaboration in the Pleistocene: possible archaeological indicators of the development of language capabilities. *Ann. N.Y. Acad. Sci.* 280: 275-288.

Isaac, G.L. (1978) The food-sharing behavior of protohuman hominids. *Sci. American* 238:90-108.

Izard, C.E. *et al.* (1991) Infant cardiac activity: developmental changes and relations with attachment. *Devel. Psychol.* 27: 432-439

Izawa, K. (1976) Group sizes and compositions of monkeys in the upper amazon basin. *Primates* 17: 367-399

Jackendoff, R. (1987) On beyond zebra - the relation of linguistic and visual information. *Cognition* 26: 89-114

Jaffe, J. and Anderson, S.W. (1979) Communication rhythms and the evolution of language. In A.W. Siegman and S. Feldstein (eds) *Of Speech and Time*, 17-22. Hillsdale, NJ: Lawrence Erlbaum.

Jarman, P.J. (1974) The social organization of antelope in relation to their ecology. *Behaviour* 48: 215-267

Johnson, I. (1984) Cell frequency recording and analysis of artifact distributions. In H. Hietala (ed) *Intrasite Spatial Analysis in Archaeology*, 75-96. Cambridge: CUP.

Johnson-Laird, P.N. (1983) *Mental Models*. Cambridge: C.U.P.

Jungers, W. L. (1988) Relative joint size and hominid locomotor adaptations with implications for the evolution of hominid bipedalism. *J. hum. Evol.* 17:247-265.

Kahneman, D., Slovic, P. and Tversky, A. (1982) (eds) *Judgement Under Uncertainty.* Cambridge: C.U.P.

Kappeler, P.M. and van Schaik, C.P. (1992) Methodological and evolutionary aspects of reconciliation among primates. *Ethology* 92: 51-69.

Keep, E. and Sisson, K. (1992) Owning the problem - personnel issue in higher education policy making in the 1990s. *Oxf. Rev. Econ. Policy* 8: 103-129

Kennedy, G. E. (1985) Bone thickness in Homo erectus. *J. hum. Evol.* 14:699-708.

Ketterson, E.D. and Nolan, V.Jr (1992) Hormones and life histories: an integrative approach. *American Naturalist 140 (Suppl.)*: S33-S62.

Keverne, E., Martensz, N. & Tuite, B. (1989) Beta-endorphin concentrations in CSF of monkeys are influenced by grooming relationships. *Psychoneuroendocrinology* 14:155-61

Keverne, E.B. (1992) Primate social relationships: their determinants and consequences. *Adv. Stud. Behavior* 21: 1-37

Kimura, D. & Watson, N. (1989) The relation between oral movement control and speech. *Brain and Lang.* 37:565-590

King, B.J. (1991) Social information transfer in monkeys, apes, and hominids. *Ybk Phys. Anthropol.* 34: 97-115

Kinsbourne, M. (1989) A model of adaptive behavior related to cerebral participation in emotional control. In G. Gainotti and C. Caltagirone (eds) *Emotions and the Dual Brain*, 248-260. berlin: Springer

Klein, L.L. and Klein, D.J. (1975) Social and ecological contrasts between four taxa of Neotropical primates.In R. Tuttle (ed) *Socioecology and psychology of primates*. The Hague: Mouton.

Kohn (1990) *The Brighter Side of Human Nature - Altruism and Empathy in Everyday Life.*

Kononova, E.P. (1962) *The Frontal Regions of the Brain.* Leningrad

Krebs, JR. and Dawkins, R. (1984) Animal signals: mindreading or manipulation? In (Krebs, JR + Davies NB eds) *Behavioural Ecology: an evolutionary approach*, 380-401. Blackwell.

Kroll, E.M. and Isaac, G.L. (1984) Configurations of artifacts and bones at early Pleistocene sites in East Africa. In Hietala, H. (ed) *Intrasite Spatial Analysis in Archaeology*, 4-31. Cambridge: CUP.

Kummer, H. (1968) Social organization of hamadryas baboons. A field study. *Biblioteca Primatol.* 6: 1-18

Kummer, H. (1967) Tripartite relations in hamadryas baboons. In (Altmann, S. A., Ed.) *Social Communication among Primates*. Chicago: University of Chicago Press.

Lakoff, G.A. and Johnson, M. (1983) *Metaphors We Live By*. Chicago: U. of Chicago Press

Leary, M.R. *et al.* (1986) Ethical ideologies of the Machiavellian. *Pers. and Soc. Psychol. Bull.* 12: 75-80

Levenson, R.W. and Ruef, A.M. (1992) Empathy: a physiological substrate. *J. Pers. and Soc. Psychol.* 63: 234-246

Li, C.C. (1991) Method of path coefficients: a trademark of Sewall Wright. *Human Biol.* 63: 1-17

Lieberman, L., Reynolds, L.T. and Friedrich, D. (1992) The fitness of human sociobiology: the future utility of four concepts in four subdisciplines. *Social Biology* 39:158-167.

Lieberman, P. (1991) *Uniquely Human: the Evolution of Speech, Thought, and Selfless Behavior* Cambridge, Mass.: Harvard U. Press

Lorr, M. *et al.* (1991) An inventory of social skills. *J. Pers. Assessment* 57: 506-520

Lovejoy, C.O. (1981) The origin of man. *Science* 211: 341-350

Lukes, S. (1991) The rationality of norms. *Arch. Eur. Sociologie* 32: 142-149

Mackinnon, J. (1974) The behaviour and ecology of wild orang-utans (*Pongo pygmaeus*). *Anim. Behav.* 22: 3-74

Maddison, A. (1987) Growth and slowdown in advanced capitalist economies: techniques of quantitative assessment. *J. Econ. Lit.* 25: 649-698.

Madonna, S. Jr *et al.* (1988) Situational and dispositional social cues that define the Machiavellian orientation. *J. Soc. Psychol.* 129: 79-83

Mandryk, C.A.S. (1993) Hunter-gatherer social costs and the nonviability of submarginal environments. *J. Anthr. Res.* 49: 39-71.

Markowitsch, H.J. (1988) Anatomical and functional organization of the primate prefrontal cortical system. In H.D. Steklis and J. Erwin (eds) *Comparative Primate Biology Vol 4. Neurosciences*, 99-153. New York: Alan R. Liss

Marks, A.E. and Volman, P. (1987) Technological variability and change seen through core reconstruction. In G. de G. Sieveking & M.H. Newcomer (eds) *The Human Uses of Flint and Chert*, 11-20. Cambridge: CUP.

Marler, P.(1969) *Colobus guereza*: territoriality and group composition. *Science* 163: 93-95

Martin, R.D. (1984) Body size, brain size and feeding strategies.In (Chivers,D.J., Wood,B.A. & Bilsborough, A., Eds) *Food Acquisition and Processing in Primates*, pp. 73-104. New York: Plenum Press.

Martin, R.D. and Barbour, A.D. (1989) Aspects of line-fitting in bivariate allometric analysis. *Folia Primatol.* 53: 65-81

Martin, R.D., Chivers, D.J., MacLarnon, A. M. & Hladik, C. M. (1985) Gastrointestinal allometry in primates and other mammals. In (Jungers, W. L., Ed.) *Size and Scaling in Primate Biology*, pp. 61-90. New York: Plenum Press
.

Maruhashi, T. (1982) An ecological study of troop fissions of Japanese monkeys (*Macaca fuscata yakui*) on Yakushima Island, Japan. *Primates* 23: 317-337

Maryanski, A. and Ishii-Kuntz, M. (1991) A cross-species application of Bott's hypothesis on role segregation and social networks. *Sociol. Persp.* 34: 403-425.

Masataka, N., *et al.* (1990) Dominance and immunity in chimpanzees (*Pan troglodytes*). *Ethology* 85: 147-155.

Mason, J. (1959) Psychological influences on the pituitary adrenal-cortical system. *Recent Progr. Hormone Res.* 15:345-389

Maurus, M., Barclay, D. & Streit, K.-M. (1988) Acoustic patterns common to human communication and communication between monkeys. *Language and Communication* 8:87-94.

Mazur, A.C. *et al.* (1992) Testosterone and chess competition. *Soc. Psychol. Q.* 55: 70-77

Mazur, A.C. (1985) A biosocial model of status in face-to-face primate groups. *Social Forces* 64: 377-402

Mazur, A.C. and Cataldo, M. (1989) Dominance and deference in conversation. *J. Soc. Biol. Struc.* 12:87-99.

McClintock, M.K. (1971) Menstrual synchrony and suppression. *Nature* 229:244-245

McFarland, D.J. & Sibly, R.M. (1975) The behavioural final common path. *Phil. Trans. R. Soc. London B* 270: 265-293

McHenry, H. M. (1986) The first bipeds: a comparison of the A. afarensis and A. africanus postcranium and implications for the evolution of bipedalism. *J. hum. Evol.* 15:17 7-191.

McHenry, H.M. (1988) New estimates of body weight in early hominids and their significance to encephalization and megadontia in 'robust' australopithecines. In Grine, F.E. (Ed) *Evolutionary History of the 'Robust' Australopithecines*, 133-148. New York: Aldine de Gruyter.

Mehrabian, A. and Epstein, N. (1972) A measure of emotional empathy. *J. Personality* 40: 525-545

Mitchell, R.J. (1992) Testing evolutionary and ecological hypotheses using path analysis and structural equation modelling. *Functional Ecology* 6: 123-129

Mitchell *et al.* (1991) *Beh. Ecol. and Sociobiol.* 28: 55-60.

Moore, J. (1984) Female transfer in primates. *Int. J. Primatol.* 5: 537-589.

Moore, J. (1992) Dispersal, nepotism, and primate social behavior. *Int. J. Primatol.* 13: 361-378.

Moss, C.J. and Poole, J.H. (1983) Relationships and social structure of the African elephant. In R.A. Hinde (ed) *Primate Social Relationships*, 314-324. Oxford: Blackwell.

Mudrack, P.E. (1989) Age-related differences in Machiavellianism in an adult sample. *Psychol. Reports* 64: 1047-1050

Mueller-Wille, C.S. and Dickson, D.B. (1991) An examination of some models of Late Pleistocene society in Southwestern Europe. In G.A. Clark (ed) *Perspectives on the Past: Theoretical Biases in Mediterranean Hunter-Gatherer Research*, 25-55. Philadelphia: U. of Pennsylvania Press

Mukherjee, R.P. and Saha, S.S. (1974) The golden langurs (*Presbytis geei* KHAJURIA, 1956) of Assam. *Primates* 15: 327-340

Nesse, R. (1991) What is mood for? *Psycoloquy* 2.9.2

Nicolaiesen, W.F.H. (1991) The past as place: names, stories, and the remembered self. *Folklore* 102: 3-15

Noe, R. (1990) A Veto game played by baboons: a challenge to the use of the Prisoner's Dilemma as a paradigm for reciprocity and cooperation. *Anim. Beh.* 39:78-90

O'Brien, J.H. *et al.* (1971) Evoked cortical responses to vagal, laryngeal and facial afferents in monkeys under chloralose anesthesia. *Electroencephalography and Clinical Neurophysiology* 31: 7-20

OECD (1992) *Education at a Glance: OECD Indicators.*

Offe, C. (1991) Introduction: the puzzling scope of rationality. *Arch. europ. Sociol.* 32:81-83

Ormell, C. (1992) Behavioural objectives revisited. *Educ. Research* 34: 23-33.

Owen, R.C. (1965) The patrilocal band: a linguistically and culturally hybrid social unit. *Amer. Anthropol.* 67: 675-690

Packer, C. (1985) The ecology of sociality in felids. In D. Rubinstein and R. Wrangham (eds) *Ecology and Social evolution: Birds and Mammals.* Princeton: Princeton University Press.

Pagel, M. D. & Harvey, P. H. (1988) How mammals produce large-brained offspring. *Evolution* 42:948-957.

Pagel, M.D. & Harvey, P.H. (1989) Taxonomic differences in the scaling of brain on body weight among mammals. *Science* 244:1589-93

Panksepp, J. (1989) The psychobiology of emotions: the animal side of human feelings. In Gainotti, G. and Caltagirone, C. (Eds) *Emotions and the Dual Brain*, 31-55. Berlin: Springer

Parker, S.T. and Gibson, K.R. (1990) (eds) *'Language' and Intelligence in Monkeys and Apes*. Cambridge: C.U.P.

Passingham, R.E. (1975) Changes in the size and organization of the brain in man and his ancestors. *Brain Behav. Evol.* 11:73-90

Passingham, R.E. (1982) *The Human Primate*. Freeman

Passingham, R.E. (1985a) Cortical mechanisms and cues for action. *Phil. Trans. R. Soc. London. B* 308:101-111.

Passingham, R.E. (1985b) Rates of brain evolution in mammals including man. *Brain Behav. Evol.* 26: 167-175

Passingham, R.E., Heywood, C.A. & Nixon, P.D. (1986) Reorganization in th human brain as illustrated by the thalamus. *Brain Behav. Evol.* 29:68-76

Pearson, R. *et al.* (1989) *How Many Graduates in the 21st Century?* Brighton: Inst. of Manpower Studies

Pelegrin, J. (1990)Prehistoric lithic technology: some aspects of research. *Arch. Rev. Cambridge* 9[1]: 116-125

Petit, O., Desportes, C. and Thierry, B. (1992) Differential probability of "co-production" in two species of macaque (*Macaca tonkeana, M. mulatta*). *Ethology* 90: 107-120.

Pickford, M. (1988) The evolution of intelligence: a palaeontological perspective. In H. Jerison and I. Jerison (eds) *Intelligence and Evolutionary Biology*, 175-198. Berlin: Springer

Pilbeam, D. (1988) Human evolution. In G.A. Harrison *et al.* (eds) *Human Biology*, 3-143. Oxford: Oxford Science.

Pinker, S.T. & Bloom, P. (1990) Natural language and natural selection. *Beh. Brain Sci.* 13: 707-784

Pinker, S. and Prince, A. (1988) On language and connectionism. *Cognition* 26: 89-114

Poizner, H., Bellugi, U. & Klima, E.S. (1990) Biological foundations of language: clues from sign language. *Ann. Rev. Neurosci.* 13:283-307

Poole, T. (1985) *Social Behaviour in Mammals.* Oxford: Blackwell

Potts, R. (1987) Reconstructions of early hominid socioecology: a critique of primate models. In W.G. Kinzey (ed) *The Evolution of Human Behavior: Primate Models*, 28-47. New York: SUNY Press

Prais, S.J. and Wagner, K. (1983) *Schooling Standards in Britain and Germany.* London: N.I.E.S.R.

Premack, D. (1984) Comparing mental representation in human and nonhuman animals. *Soc. Res.* 51, 985-999.

Premack, D. (1988) Minds with and without language. In (Weiskrantz, L., Ed.) *Thought without Language*, pp. 25-45. Oxford: Clarendon Press.

Premack, D. (1990) The infant's theory of self-propelled objects. *Cognition* 36: 1-16

Prince, G. (1987) *A Dictionary of Narratology*. Lincoln: Uni. of Nebraska Press

Pring, R. (1992) Access to higher education. *Oxf. Rev. Educ.* 18: 125-136.

Pusey, A.E. and Packer, C. (1986) Dispersal and philopatry. In Smuts *et al.* (1986) (eds), 250-266.

Quiatt, D. (1986) Juvenile/adolescent role functions in a rhesus monkey troop: an application of household analysis to non-human primate social organization. In J.G. Else and P.C. Lee (eds) *Primate Ontogeny, Cognition and Social Behavior*, 281-289. Cambridge: C.U.P.

Reidenberg, J.S. & Laitman, J.T. (1990) Surgically induced basicranial kyphosis and cranial vaulting in rats [Abstract]. *Am. J. Phys. Anthr.* 81:285

Richard, A. (1985) *Primates in Nature*. New York: Freeman.

Richard, A. (1986) Malagasay prosimians: female dominance. In Smuts *et al.* (eds) (1986), 25-33.

Richman, B. (1987) Rhythm and melody in gelada vocal exchanges. *Primates* 28: 199-223

Riggio, R.E. (1986) Assessment of basic social skills. *J. Pers. and Soc. Psychol.* 51: 649-660

Riggio, R.E. *et al.* (1988a) Social skills and deception ability. *Pers. Soc. Psychol. Bull.* 13: 568-577

Riggio, R.E. *et al.* (1988b) Personality and deception ability. *Pers. individ. diff.* 9: 189-191

Riggio, R.E. *et al.* (1990) Social skills and self-esteem. *Pers. individ. diff.* 11: 799-804

Riggio, R.E. *et al.* (1991) Social and academic intelligence: conceptually distinct but overlapping constructs. *Pers. individ. diff.* 12: 695-702

Riggio, R.E., Tucker, J. and Coffaro, D. (1989) Social skills and empathy. *Pers. individ. diff.* 10: 93-99

Ringo, J.L. (1991) Neuronal interconnection as a function of brain size. *Brain Behav. Evol.* 38:1-6

Robinson, J.G. and Janson, C.H. (1986) Capuchins, squirrel monkeys, and atelines: socioecological convergence with Old World primates. In Smuts *et al.* (eds) (1986), 69-82.

Rodman, P.S. (1988) Resources and group sizes of primates. In (Slobodchikoff, C.N., Ed.) *The Ecology of Social Behavior*, 83-108. London:Academic

Roebroeks, W., Kolen, J. & Rensink, E. (1988) Planning depth, anticipation and the organization of Middle Palaeolithic technology: the "archaic natives" meet Eve's descendants. *Helinium* 28, 17-34.

Rogers, R.S. and Semin, G.R. (1973) Mach V: an improved scoring system based on a triadic choice model. *J. Pers. and Soc. Psychol.* 27: 34-40

Rose, M. D. (1984) Food acquisition and the evolution of positional behaviour: the case of bipedalism. In (Chivers, D.J., Wood, B. A. & Bilsborough, A., Eds) *Food Acquisition and Processing in Primates*, pp. 509-524. New York: Plenum Press.

Routh, G. (1980) *Occupation and Pay in Great Britain, 1906-79.* 2nd Ed. London: Macmillan

Rowell, T.E. (1966) Forest living baboons in Uganda. *J. Zool. (Lond.)* 149: 344-364

Rowell, T.E. (1991) What can we say about social structure? In P. Bateson (ed) *The Development and Integration of Behaviour.* Cambridge: C.U.P.

Rykwert, J. (1991) House and home. *Soc. Res.* 58: 51-62.

Sailer, L.D. *et al.* (1985) Measuring the relationship between dietary quality and body size in primates. *Primates* 26: 14-27

Sapolsky, R.M. (1990a) Adrenocortical function, social rank, and personality among wild baboons. *Biol. Psychiatry* 28:862-878

Sapolsky, R.M. (1990b) Stress in the wild. *Sci. Am.* 262:106-13

Scharpf, F.W. (1990) Games real actors play: the problem of mutual predictability. *Rationality & Society* 2:471-494

Scheff, T.J. (1986) Micro-linguistics and social structure: a theory of social action. *Sociological Theory* 4:71-83

Schlanger, N. (1990) Technique as human action: 2 perspectives. *Arch. Rev. Cambridge* 9: 18-26

Seyfarth, R. (1986) Vocal communication and its relation to language. In (Smuts, B. B. *et al.*, Eds) *Primate Societies*, pp. 440-451. Chicago: University of Chicago Press.

Shea, B.T. (1989) Heterochrony in human evolution - the case for neoteny reconsidered. *Ybk Phys. Anthro.* 32: 69-101

Simon, H.A. (1988) Creativity and motivation - a response. *New Ideas in Psychol.* 6: 177-181.

Skinner, B.F. (1957) *Verbal Behavior* New York: Appleton-Century-Croft.

Smethurst, R.G. (1992) The university challenge - strategies for change. *Oxf. Rev. Educ.* 18: 137-145

Smith, J.M. and Bell, P.A. (1992) Environmental concern and cooperative-competitive behavior in a simulated commons dilemma. *J. Soc. Psychol.* 132: 461-468

Smuts, B.B. *et al.* (1986) *Primate Societies.* Chicago: University of Chicago Press.

Snowdon, C.T. (1989) Vocal communication in New World monkeys. *J. Hum. Evol.* 18: 611-633

Snowdon, C.T. (1993) A comparative approach to language parallels. In K.R. Gibson and T. Ingold (eds) *Tools, Language and Cognition in Human Evolution*, 109-128. Cambridge: C.U.P.

Soffer, O. (1985) *The Upper Palaeolithic of the Central Russian Plain.* Orlando, Fl.: Academic Press

Soini, P. (1982) Ecology and population dynamics of the pygmy marmoset, *Cebuella pygmaea. Folia Primatol.* 39: 1-21.

Sommer, U. (1991) Frontiers of discourse: the nature of theoretical discussion in German archaeology. *Arch. Rev. Cambridge* 10: 202-216

Squire, L.S. (1986) Mechanisms of memory. *Science* 232: 1612-1619

Steele, J. (1989) Hominid evolution and primate social cognition. *J. Hum. Evol.* 18:421-32

Steele, J. (1993) Talking to each other: why hominids bothered. In I. Hodder and M. Shanks (eds) *Interpretive Archaeologies*. Routledge, in press.

Steklis, H.D. (1985) Primate communication, comparative neurology, and the origin of language re-examined. *J. Hum. Evol.* 14:157-73

Stephan, H., Frahm, H. & Baron, G. (1981) New and revised data on volumes of brain structures in insectivores and primates. *Folia Prima.* 35:1-29

Stevenson, R.L. (1887) Talk and the talkers. In *Memories and Portraits.* First appeared in *Cornhill Magazine* (1882) 45: 534-541

Stross, B. (1974) Speaking of speaking: Tenejapa Tzeltal metalinguistics. In Bauman, R. and Sherzer, J. (Eds) *Explorations in the Ethnography of Speaking*, 213-239. Cambridge: C.U.P.

Struhsaker, T.T. (1988) Male tenure, multi-male influxes, and reproductive success in redtail monkeys (*Cercopithecus ascanius*). In Gautier-Hion *et al.* (1988) (eds), 340-363.

Struhsaker, T.T. and Gartlan, J.S. (1970) Observations on the behaviour and ecology of the patas monkey (*Erythrocebus patas*) in the Waza Reserve, Cameroon. *J. Zool. (Lond.)* 161: 49-63.

Strum, S.C. and Mitchell, W. (1987) Baboon models and muddles. In W.G. Kinzey (ed) *The Evolution of Human Behavior: Primate Models*, 87-104. New York: SUNY Press

Sutton, D. & Jurgens, U. (1988) Neural control of vocalization. In Steklis, H.D. and Erwin, J. (Eds) *Comparative Primate Biology Vol. 4: Neurosciences*, 625-648. New York: Alan R. Liss, Inc.

Swinnerton-Dyer, P. (1991) Policy on higher education and research. *Higher Education Q*. 45: 204-218

Sypher, H.E. *et al.* (1981) The interpersonal constructs of Machiavellians: a reconsideration. *J. Soc. Psychol.* 20: 219-220

Talmy, L. (1988) Force dynamics in language and cognition. *Cog. Sci.* 12: 49-100

Terborgh, J. (1983) *Five New World Primates*. Princeton: Princeton U.P.

Terborgh, J. & Janson, C.H. (1986) The socioecology of primate groups. *Ann. Rev. Ecol. & Syst.* 17:111-135.

Thayer, S. (1986) History and strategies of research on social touch. *J. Nonverbal Behavior* 10: 12-28.

Thierry, B. (1986) A comparative study of aggression and response to aggression in three species of macaque. In J.G. Else and P.C. Lee (eds) *Primate Ontogeny, Cognition and Social Behaviour*, 307-313. Cambridge: C.U.P.

Thierry, B. (1990) Feedback loop between kinship and dominance: the macaque model. *J. Theor. Biol.* 145: 511-521

Thorndike, E.L. (1920) Intelligence and its uses. *Harper's Magazine* 140: 227-235

Tobias, P. V. (1987) The brain of Homo habilis: a new level of organization in cerebral evolution. *J. hum. Evol.* 16

Tomasello, M. (1990) Cultural transmission in the tool use and communicatory signaling of chimpanzees? In S.T. Parker and K.R. Gibson (eds) *'Language' and Intelligence in Monkeys and Apes*, 274-311. Cambridge: C.U.P.

Tooby, J. & DeVore, I. (1987) The reconstruction of hominid behavioral evolution through strategic modeling. In (Kinzey, W. G., Ed.) *The Evolution of Human Behavior: Primate Models*, pp. 183-237. New York: SUNY Press.

Toth, N. (1985a) Archaeological evidence for preferential right handedness in the Lower and Middle Pleistocene, and its possible implications. *J. hum. Evol.* 14: 607-614

Toth, N. (1985b) The Oldowan reassessed: a close look at early stone artefacts. *J. Arch. Sci.* 12: 101-121

Toth, N. (1987a) Behavioral inferences from Early Stone Age artifact assemblages: an experimental model. *J. hum. Evol.* 16:763-787.

Toth, N. (1987b) The first technology. *Sci. Amer.* 256: 104-113

Tucker, D. & Williamson, P.A. (1984) Asymmetric neural control systems in human self-regulation. *Psychol. Rev.* 91:185-215

Turner, J.H. (1987) Toward a sociological theory of motivation. *Amer. Sociol. Rev.* 52:15-27

Turner, J.H. (1992a) Overcoming humanities babble: searching for universal types of human social relations. *Contemp. Sociol.* 21: 126-128

Turner, J.H. (1992b) The production and reproduction of social solidarity - a synthesis of 2 rational choice theories. *J. Theor. Soc. Beh.* 22: 311-328

Turner, V. (1980) Social dramas and stories about them. *Critical Inquiry* 7: 141-168

Turner, V. (1983) Body, brain, and culture. *Zygon* 18: 221-245

Tutin, C.E.G. *et al.* (1983) Social organization of savanna-dwelling chimpanzees, *Pan troglodytes verus*, at Mt. Assirik, Senegal. *Primates* 34: 154-173.

U.G.C. (1989) *Report of the Working Party on Archaeology* London: U.G.C.

UNESCO (1991) *World Education Report.* UNESCO

UNESCO (1975-1990) *Statistical Yearbooks*, 1975-1990. UNESCO

U.G.C. (1961-1990) *University Statistics* Cheltenham: Universities Statistical Record

Uylings, H.B.M. and van Eden, C.G. (1990) Qualitative and quantitative comparison of the prefrontal cortex in rat and in primates, including humans. *Progress in Brain Research* 85:31-62.

van Schaik, C.P. (1983) Why are diurnal primates living in groups? *Behaviour* 87: 120-144

van Schaik, C.P. and Dunbar, R.I.M. (1990) The evolution of monogamy in large primates - a new hypothesis and some crucial tests. *Behaviour* 115: 30-62

Vea, J.J. and Clemente, I.C. (1988) Conducta Instrumental del chimpance (*Pan troglodytes*) en su habitat natural. *Anuario de Psicologia* 39: 31-66

Vehrencamp, S.L. (1983) A model for the evolution of despotic versus egalitarian societies. *Anim. Beh.* 31: 667-682

Vrba, E.S. (1992) Mammals as a key to evolutionary theory. *J. Mammalogy* 73: 1-28

Wagner, K. (1986) *Relation between education, unemployment and productivity and their impact on education and labour market policies: a British-German comparison*. Luxembourg: Office for Official Publications of the Euroipean Communities

Warner, R.M. (1992) Cyclicity of vocal activity increases during conversation: support for a nonlinear systems model of dyadic social interaction. *Behavioral Science* 37:128-138.

Watanabe, K. (1981) Variations in group composition and population density of two sympatric Mentawaian leaf-monkeys. *Primates* 22: 145-160.

Wenban-Smith, F. (1990) Researching the Upper Palaeolithic: an organizational manifesto. *Lithics* 11: 16-23.

Whallon, R.E. Jr (1973) Spatial analysis of palaeolithic occupation areas. The present problem and the 'functional argument'. In C. Renfrew (ed) *The Explanation of Culture Change*, 115-129. New York: Academic Press.

White, H. (1981) The narrativization of real events. *Critical Inquiry* 7: 793-798

White, L. (1991) Undergraduate competencies which faculty value. *Assessment and Evaluation in Higher Education* 16: 199-213

Whiten, A. & Byrne, R. W. (1988a) The Machiavellian intelligence hypotheses: editorial. In (Byrne, R. W. & Whiten, A., Eds) *Machiavellian Intelligence*, pp. 1-9. Oxford: Clarendon Press.

Whiten, A. & Byrne, R. W. (1988b) Taking (Machiavellian) intelligence apart: editorial. In (Byrne, R. W. & Whiten, A., Eds) *Machiavellian Intelligence*, pp. 50-65. Oxford: Clarendon Press.

Whiten, A. and Ham, R. (1992) On the nature and evolution of imitation in the animal kingdom: reappraisal of a century of research. *Adv. Stud. Behav.* 21: 239-283

Williams, G. (1992) British higher education in the world league. *Oxf. Rev. Econ. Policy* 8: 146-158

Winslow, J.T. & Insel, T.R. (1991) Endogenous opioids: do they modulate the rat pup's response to social isolation? *Beh. Neurosci.* 105:253-63

Wobst, M. (1974) Boundary conditions for Palaeolithic social systems: a simulation approach. *Amer. Antiq.* 39: 147-178

Wobst, M. (1976) Locational relationships in Palaeolithic society. *J. Hum. Evol.* 5: 49-58

Wolfe, A. (1990) Social theory and the second biological revolution. *Soc. Res.* 57:615-648

Wrangham, R.W. (1980) An ecological model of female-bonded primate groups. *Behaviour* 75, 262-300.

Wrangham, R.W. (1983) Ultimate factors determining social structure. In R.A. Hinde (ed) *Primate Social Relationships*, 255-262. Oxford: Blackwell Scientific.

Wrangham, R.W. (1986a) Ecology and social relationships in two species of chimpanzee. In (Rubenstein, D. I. & Wrangham, R. W., Eds) *Ecological Aspects of Social Evolution*, pp. 352-378. Princeton: Princeton University Press.

Wrangham, R.W. (1986b) Evolution of social structure. In (Smuts, B. B. *et al.*, Eds) *Primate Societies*, pp. 282-296. Chicago: University of Chicago Press.

Wright, P.W.G. (1988) Rethinking the aims of higher education. In H. Eggins (ed) *Restructuring Higher Education*, . Milton Keynes: Open U. Press

Zimmerman, D.H. and Boden, D. (1991) Structure-in-action: an introduction. In Boden, D. and Zimmerman, D.H. (eds) *Talk and Social Structure*, 3-21. Cambridge: Polity.

Zuckerman, M. *et al.* (1981) Verbal and nonverbal communication of deception. *Adv. Exper. Soc. Psychol.* 14

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TWO VOLUMES.

VOLUME 2: FIGURES, TABLES, AND APPENDICES.

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CONTENTS

FIGURES

NEUROPSYCHOLOGICAL MODEL

1. Planning (or the elaboration of strategy) and execution of sequences of planned responses;
2. Self-regulation of behaviour in response to environmental contingencies (including one's own errors);
3. Maintenance ofa nonautomatic cognitive or behavioural set;
4. Spontaneity/sustained mental productivity;
5. Spatiotemporal segmentation and organization of events.

GOLDMAN-RAKIC'S MONKEY-BASED MODEL

1. Regulation of manual responses by verbal prefrontal representational memory;
2. Regulation of verbal responses by verbal prefrontal representational memory;
3. Regulation of manual responses by prefrontal visuospatial representational memory;
4. Regulation of simple responses by prefrontal representational memory on tasks which are both verbal and visual.

Features of two opposing models of prefrontal function
(after Daigneault et al. 1992).

Figure 2.1

Fuster (1991) on the role of the prefrontal cortex in organization of behaviour.

"that part of the neocortex that allows the organism to reconcile sensations and acts that are mutually contingent but temporally seoarate from each other"
"the prefrontal cortex mediuates those temporal gaps by critically supporting at least two cognitive functions that make that temporal bridging possible and, consequently, the temporal organization of behavior possible: (1) a temporally 'retrospective' function of short-term memory for sensory information, and (2) a temporally 'prospective' function of preparatory motor set. Both these functions appear represented in the dorsolateral prefrontal cortex of the primate."

de Bruin (1990) on the role of the prefrontal cortex in social behaviour.

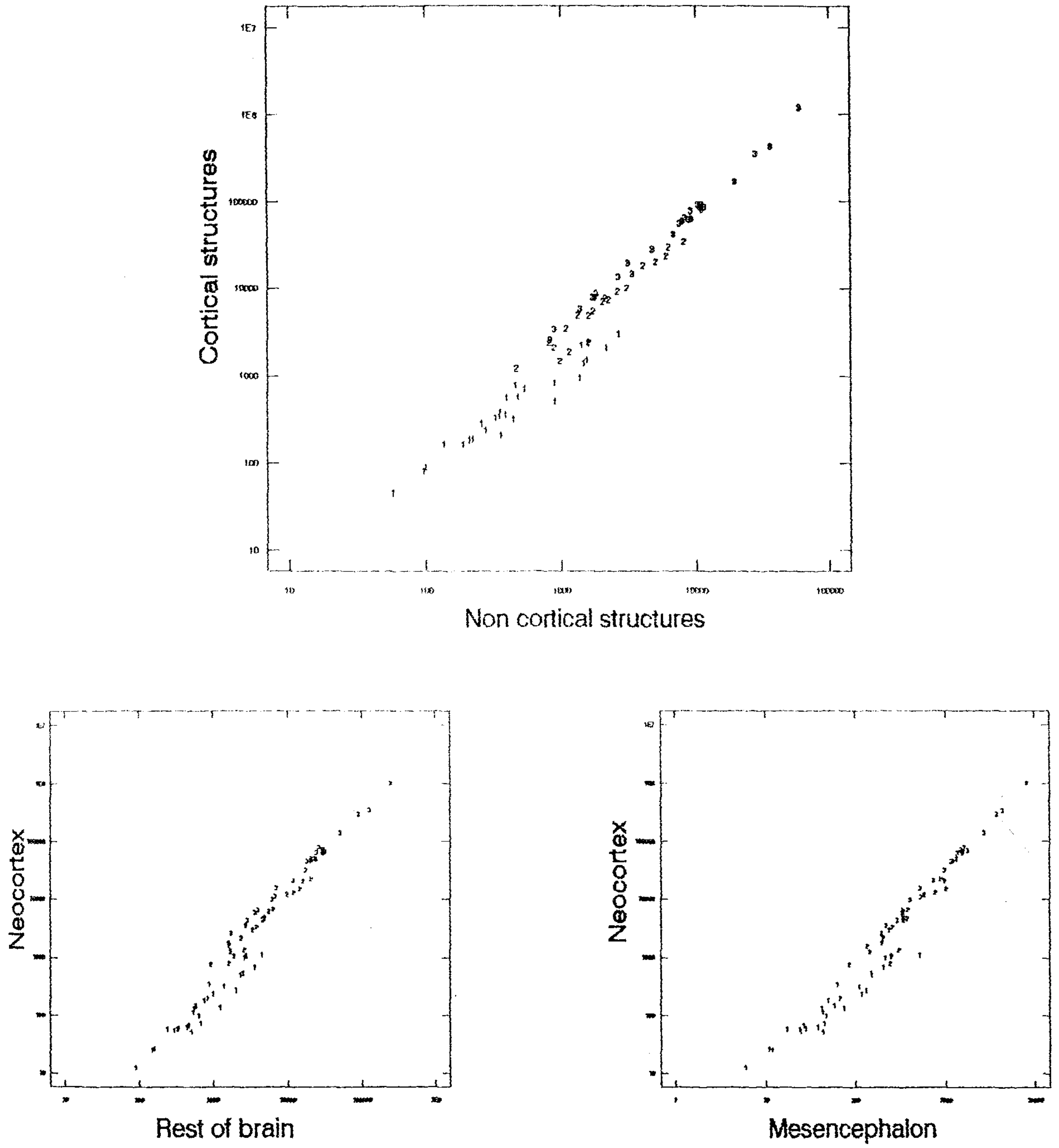
"PFC exerts an inhibitory control over hypothalamic sites from which aggression can be elicited by electrical stimulation"
"experimental data support an inhibitory role of the prefrontal cortex, especially its orbitofrontal part, in the control of aggressive behaviour. In addition, the ascending dopaminergic system strongly modulates this function, presumably by tonically exciting the PFC."

Davidson (1992) on lateral frontal asymmetry and emotions.

"the anterior regions of the two cerebral hemispheres are specialized for approach and withdrawal processes, with the left hemisphere specialized for the former and the right for the latter"
"individual differences in patterns of anterior asymmetry are stable over time and predict important features of *affective style* - an individual's dispositional emotional profile, including characteristic patterns of emotional reactivty as well as mood."

Three recent summaries of the role of the prefrontal system in behaviour.

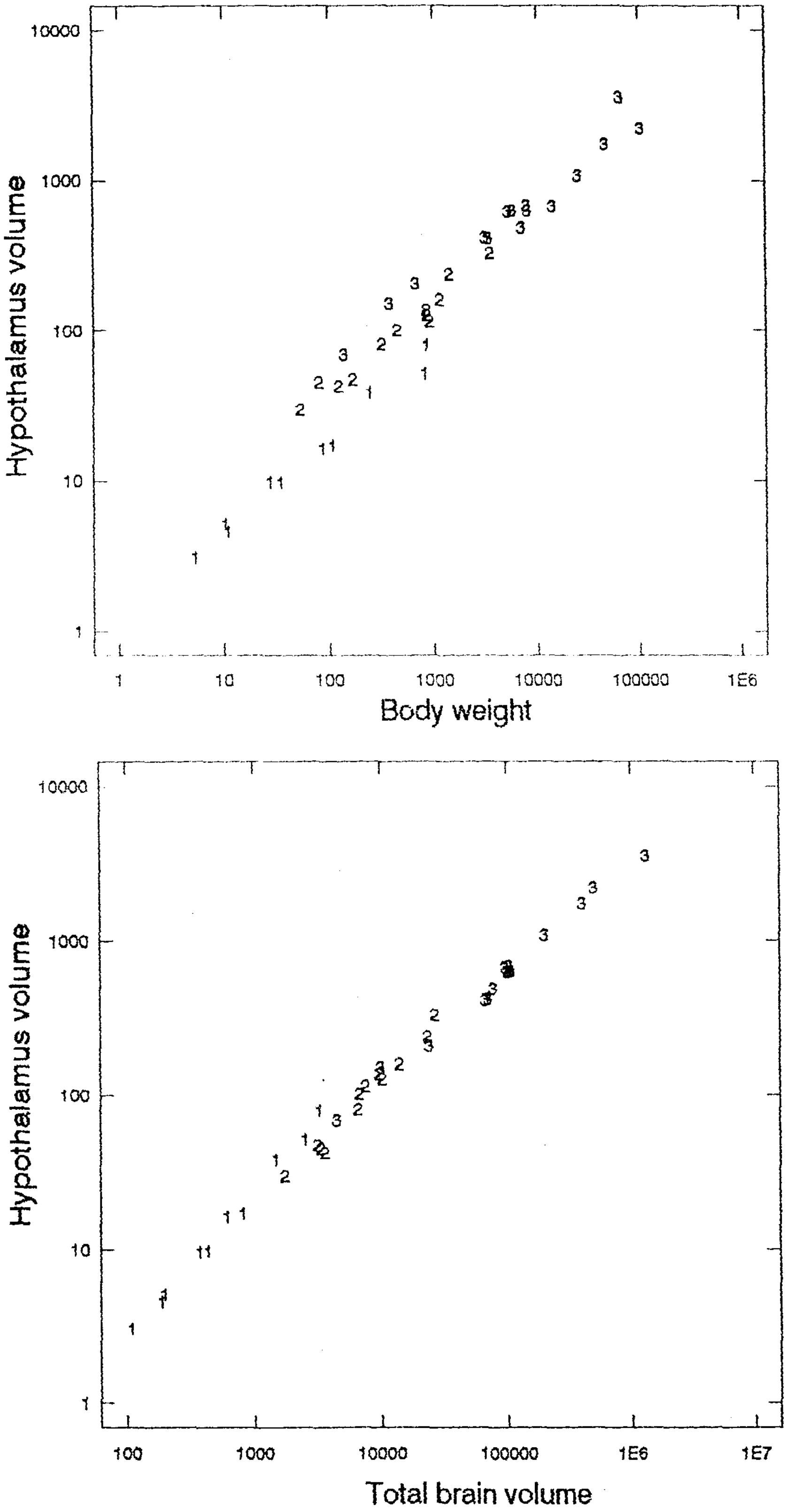
Figure 2.2



Brain structure allometry. Point codes: 1 = insectivores, 2 = prosimians, 3 = anthropoids.
Data from Stephan et al 1981.

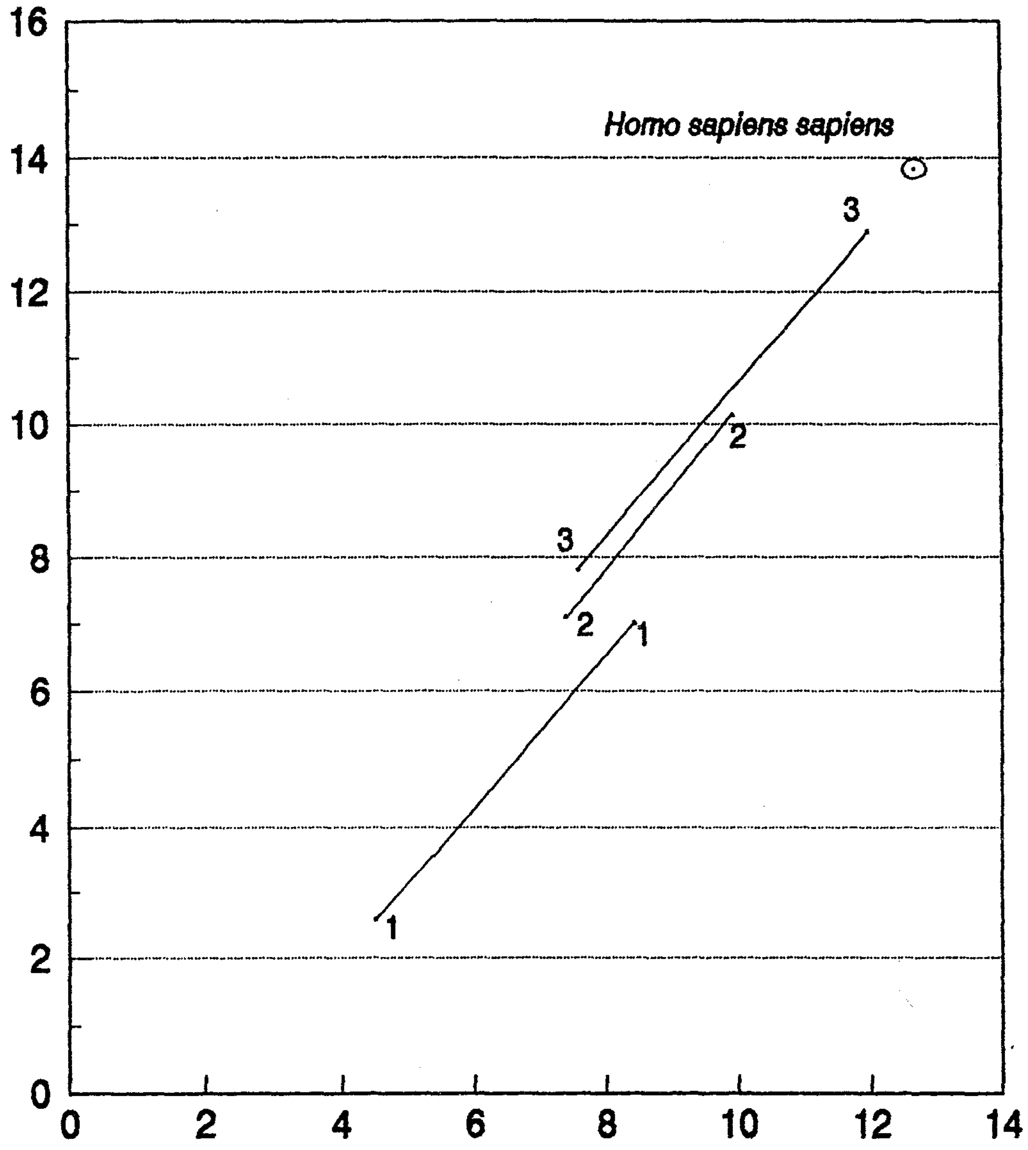
Cortical structures include telencephalon (less olfactory bulbs and piriform lobe), and cerebellum.

Figure 2.3



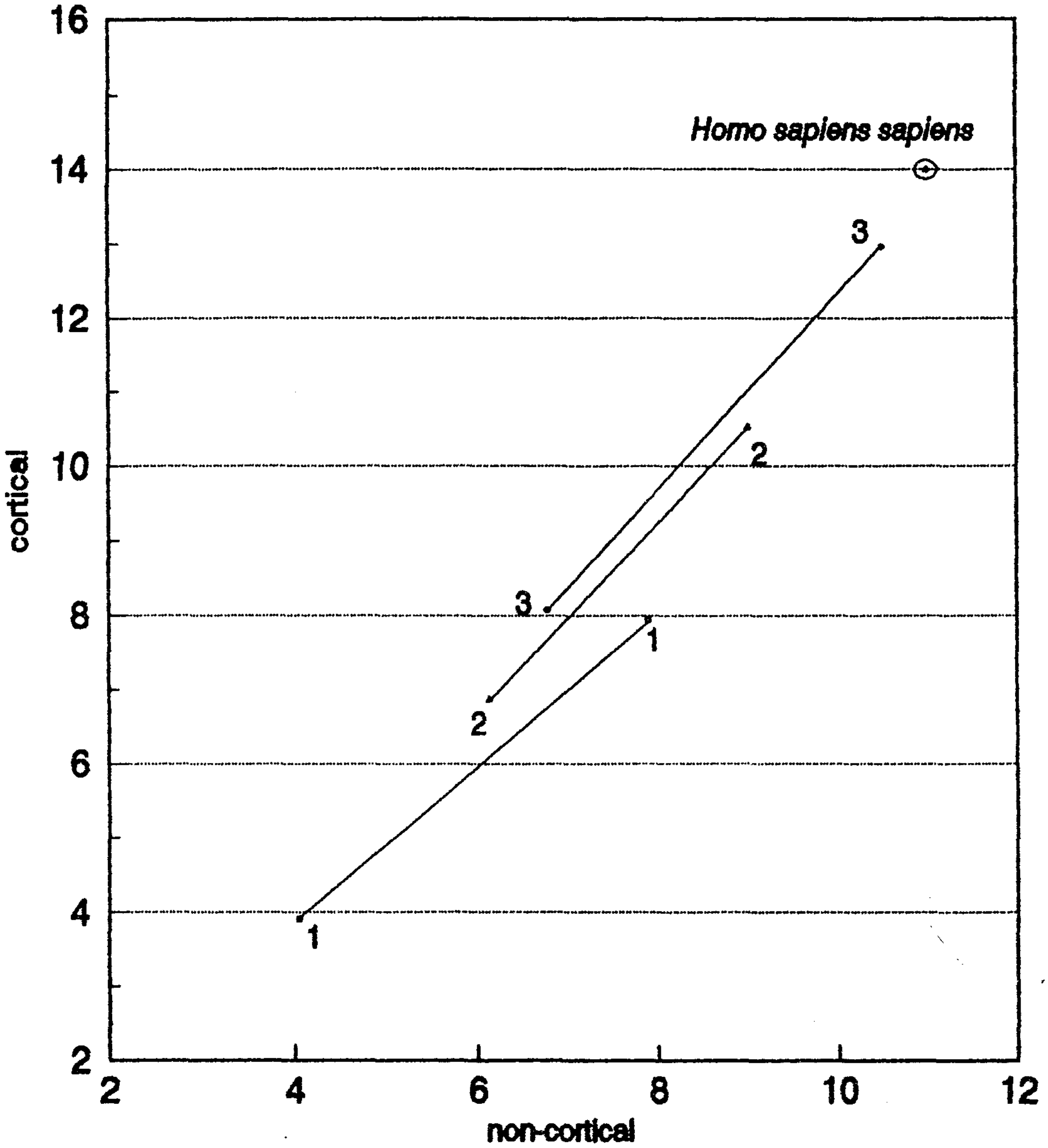
Scatterplots, hypothalamus against body and brain size. Point codes:
1 = insectivores, 2 = prosimians, 3 = anthropoids. Data: Stephan et al. 1981.

Figure 2.4



Regression slopes, neocortex against rest of brain volume.
Slope 1 = insectivores, slope = 1.13, r-sq. = 92.25.
Slope 2 = prosimians, slope = 1.19, r-sq. = 94.96.
Slope 3 = nonhuman anthropoids, slope = 1.16, r-sq. = 99.33.
Circled point = Homo sapiens sapiens.
Least squares regression model, all variables logged.
Data derived from Stephan et al. (1981).

Figure 2.5



Regression slopes, cortical against noncortical brain structures.

Slope 1 = insectivores, slope = 1.05, r-sq. = 93.89.

Slope 2 = prosimians, slope = 1.27, r-sq. = 93.44.

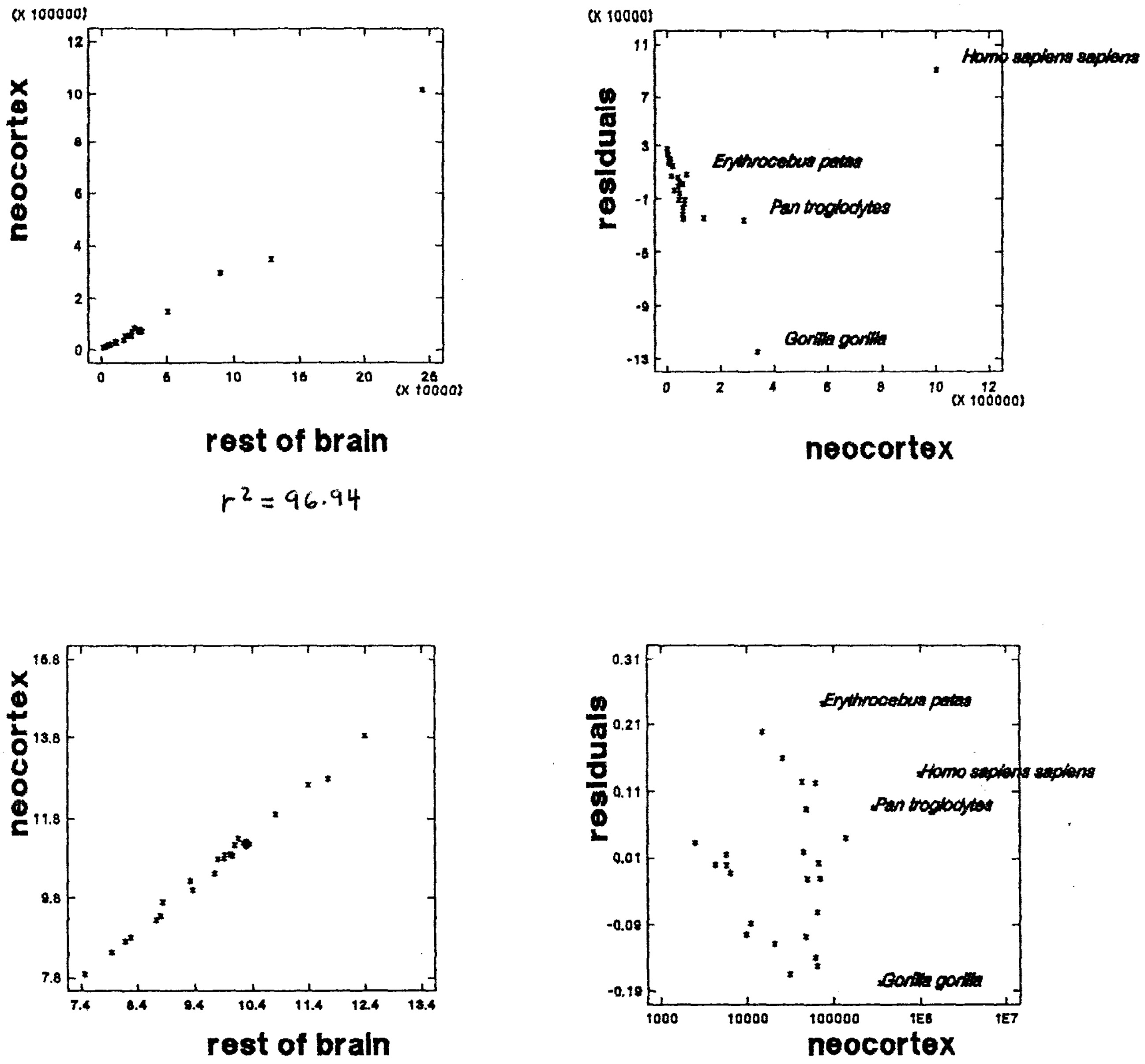
Slope 3 = nonhuman anthropoids, slope = 1.31, r-sq. = 99.45.

Circled point = Homo sapiens sapiens.

Least squares regression model, all variables logged.

Data derived from Stephan et al. (1981).

Figure 2.6

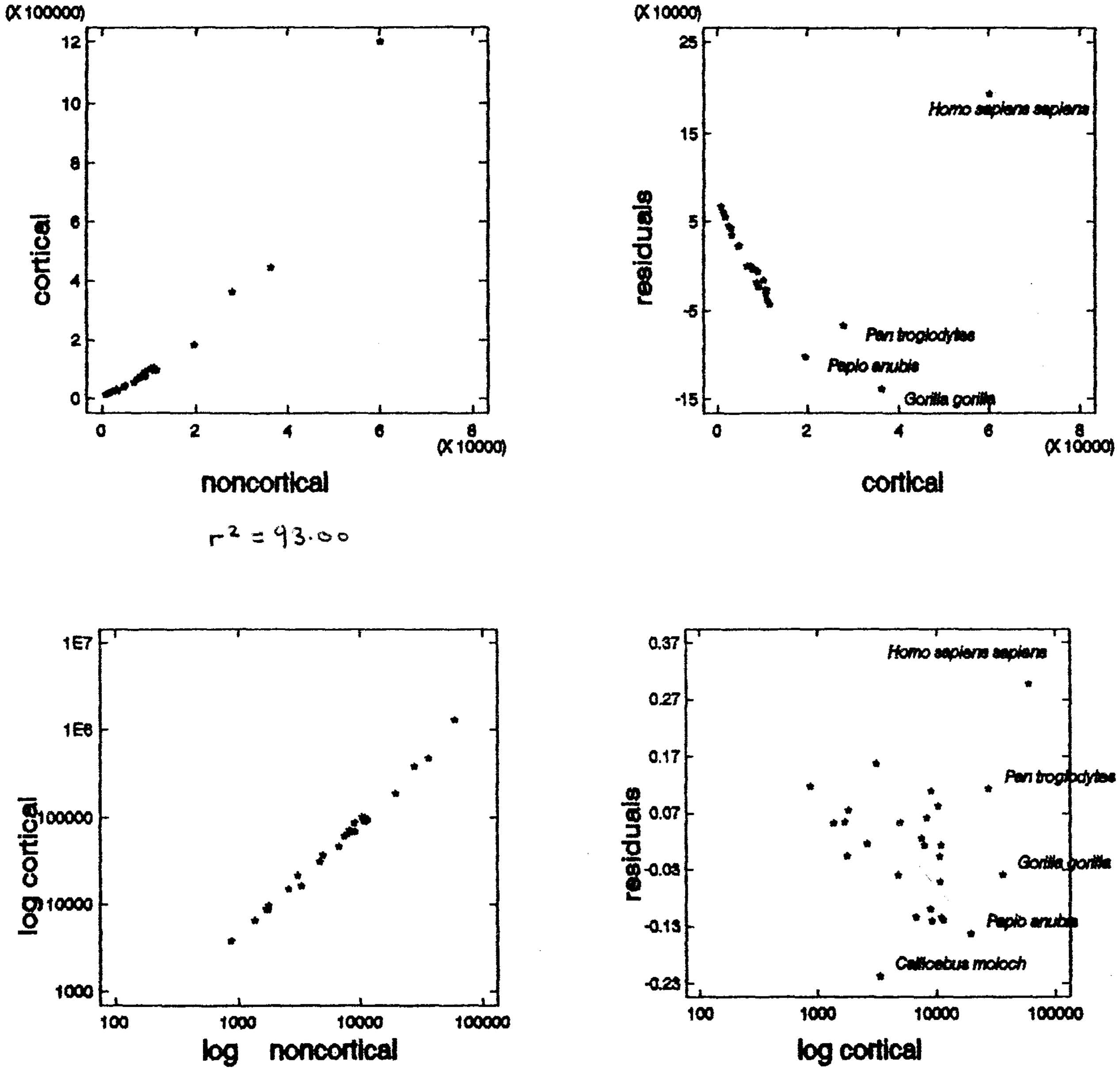


$r^2 = 96.94$

$r^2 = 99.32$

Regression analysis of neocortex volume and rest of brain volume, anthropoid primates (data from Stephan et al. 1981). The analysis shows the effect of logging both variables on patterning in the residuals.

Figure 2.7

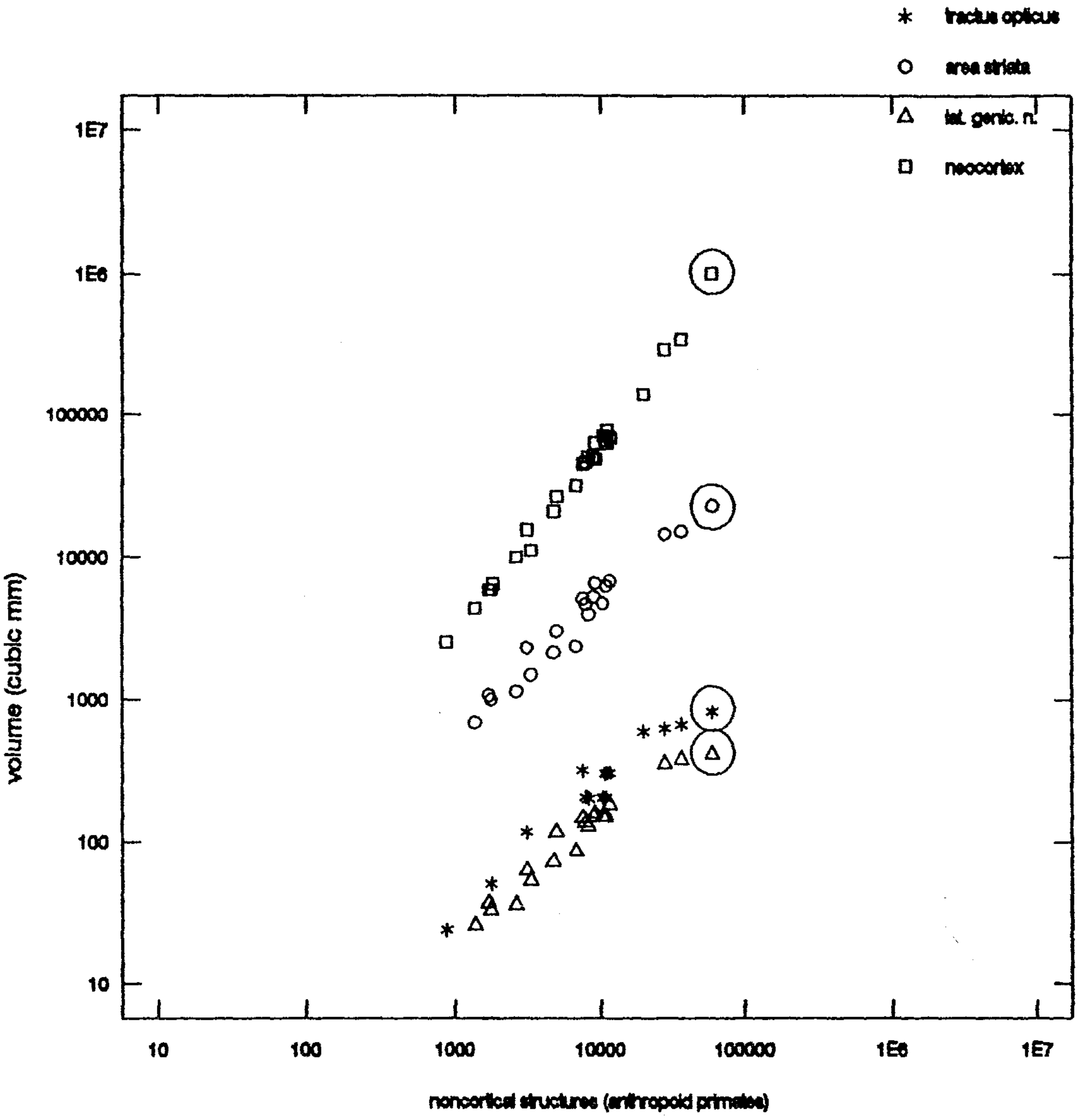


$r^2 = 93.00$

$r^2 = 99.35$

Regression analysis of cortical and noncortical structures, anthropoid primates (data from Stephan et al. 1981). The analysis shows the effect of logging both variables on patterning in the residuals.

Figure 2.8



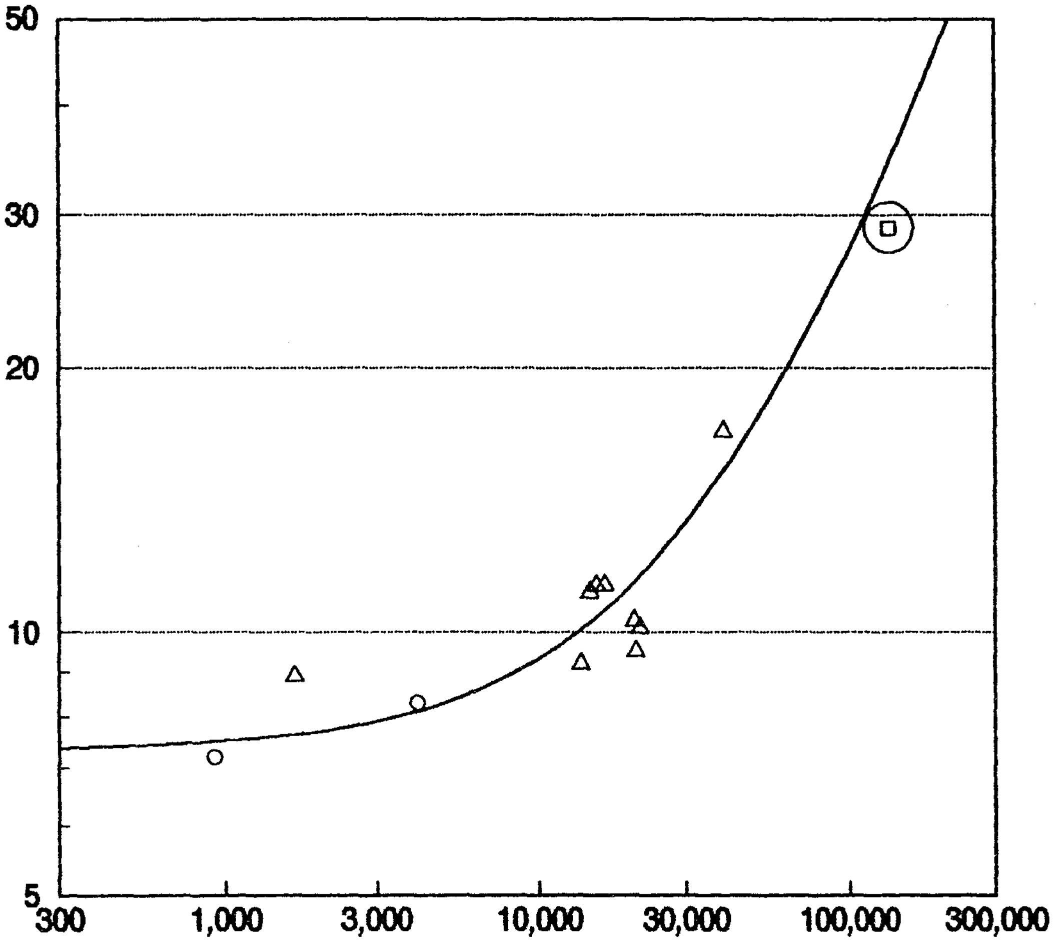
Scatterplot, neocortex and visual system components against noncortical structures, anthropoid primates (data from Stephan et al. 1981).
Both axis scales logged.
Circled markers = ***Homo sapiens sapiens***

Figure 2.9

	total cortical surface, one hemisphere (Brodmann)	frontal cortex (% of total (Brodmann)	frontal cortex (% of total) (Kononova)
Homo sapiens	135,470	29.0	24.4
Pan troglodytes	39,572	16.9	14.5
Pongo pygmaeus			13.7
[Gibbon]	16,302	11.3	13.7
[Mandrill]	21,3 21	10.1	
[Baboon]	20,594	9.5	12.2
[Baboon]	20,376	10.3	12.2
[Macaque]	15,308	11.3	12.4
[Guenon]	14,641	11.1	
Cebus	13,682	9.2	
Callithrix	1,649	8.9	
Lemur	4,054	8.3	
Cheirogaleus	921	7.2	

Table showing discrepancies between Brodmann's (1912) and Kononova's (1962) data on the proportion of primate neocortex which is contained in the frontal system Data fom Markowitsch (1988) and Blinkov and Glezer (1968).

Figure 2.10



Scatterplot, frontal cortex (proportional) against total cortical surface area.
Data from Brodmann 1912, reproduced in Markowitsch 1988:102.
The regression line is fitted to the nonhuman anthropoid data using least squares regression. Both axis scales logged. $R^2 = 69.00$
Circled data point: *Homo sapiens sapiens*
Marker codes: Circle = prosimian (n = 2), triangle = anthropoid (n = 9), square = Homo.

Figure 2.11

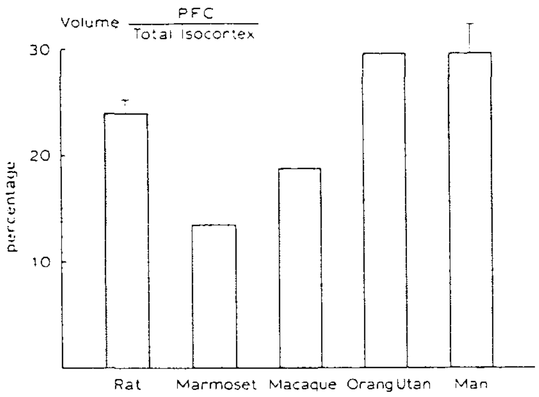


Fig. 5. A histogram of the ratio of prefrontal cortex volume and total isocortex volume in rat and several higher primate species. The isocortex is the neocortex and mesocortex.

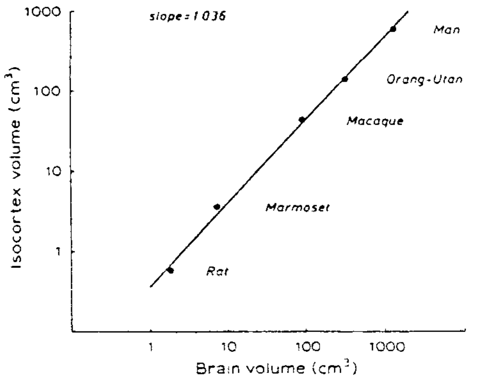


Fig. 7. The bivariate graph of isocortex volume and total brain volume in the species studied, together with the regression line, which resulted from the regression analysis (see text for further explanation).

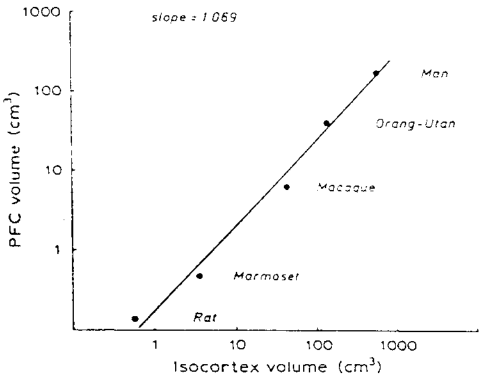


Fig. 6. The bivariate graph of PFC volume and isocortex volume in the species studied, together with the regression line, which resulted from the regression analysis (see text for further explanation).

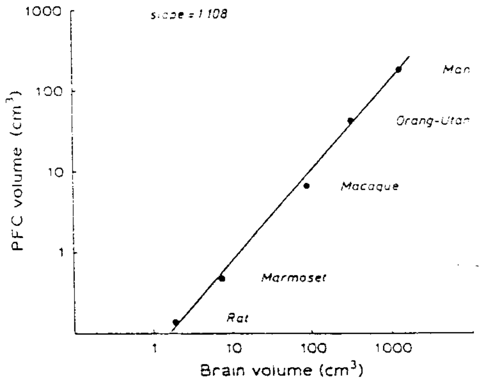
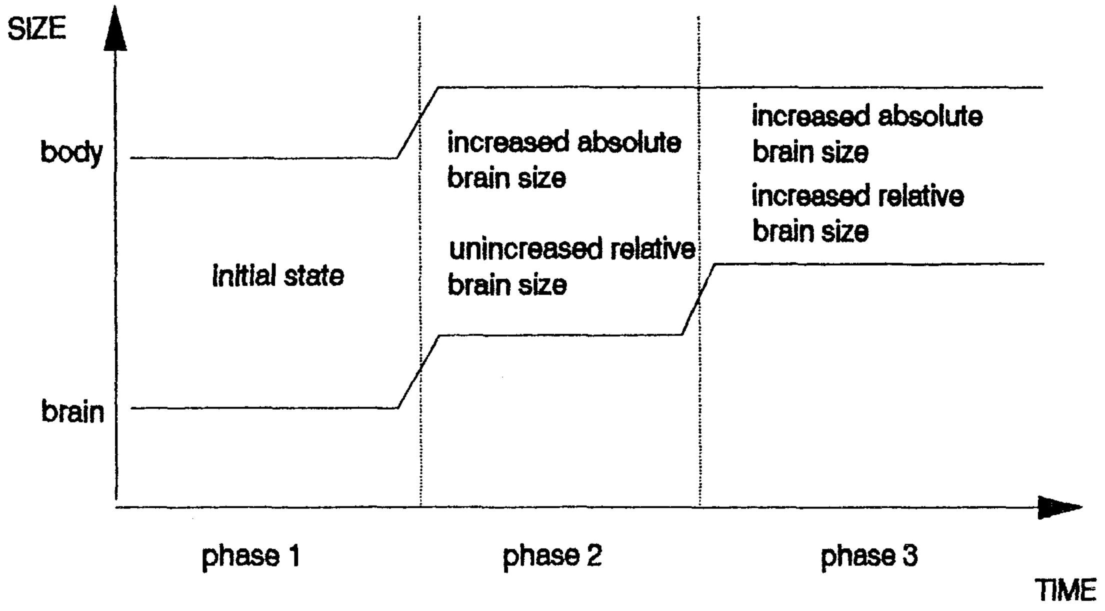


Fig. 8. The bivariate graph of PFC volume and total brain volume in the species studied, together with the regression line, which resulted from the regression analysis (see text for further explanation).

New quantitative analysis and comparison of human, primate and rat prefrontal cortex indicate a strong relationship with absolute brain and isocortex volumes across taxa. From Uylings et al. (1990:53), Figures 5-8.

Figure 2.12

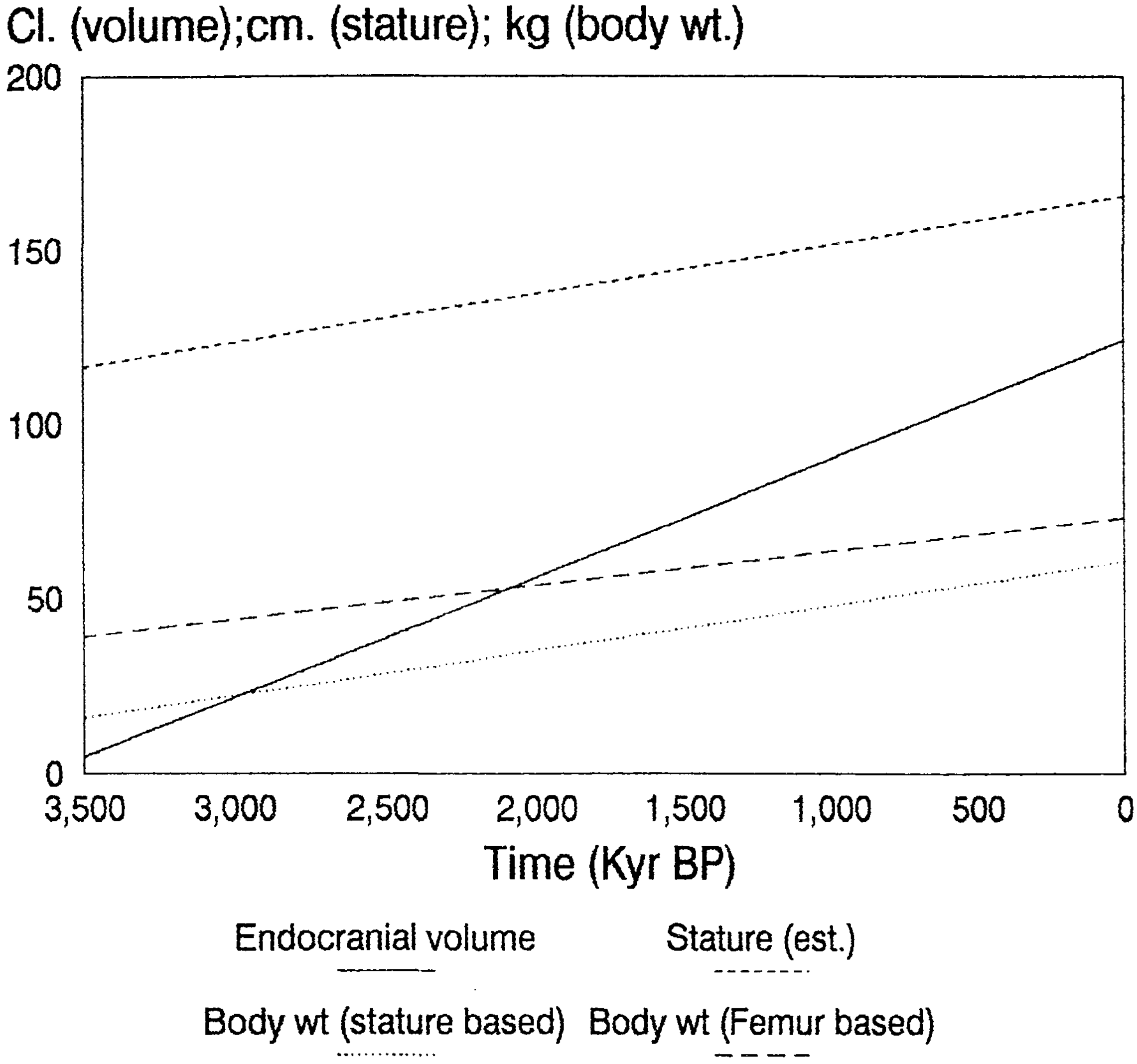


HYPOTHESIS 1:
Prefrontal cortex increases proportionally with absolute brain size.
PREDICTION 1:
Increasingly complex PFC-mediated behaviours in Phase 2.
Increasingly complex PFC-mediated behaviours in Phase 3.

HYPOTHESIS 2:
Prefrontal cortex increases proportionally with relative brain size.
PREDICTION 2:
No increase in complexity of PFC-mediated behaviours in Phase 2.
Increasingly complex PFC-mediated behaviours in Phase 3.

EXPERIMENTAL DESIGN FOR TESTING THE TWO HYPOTHESES OF HUMAN NEOCORTICAL EVOLUTION USING ARCHAEOLOGICAL DATA.

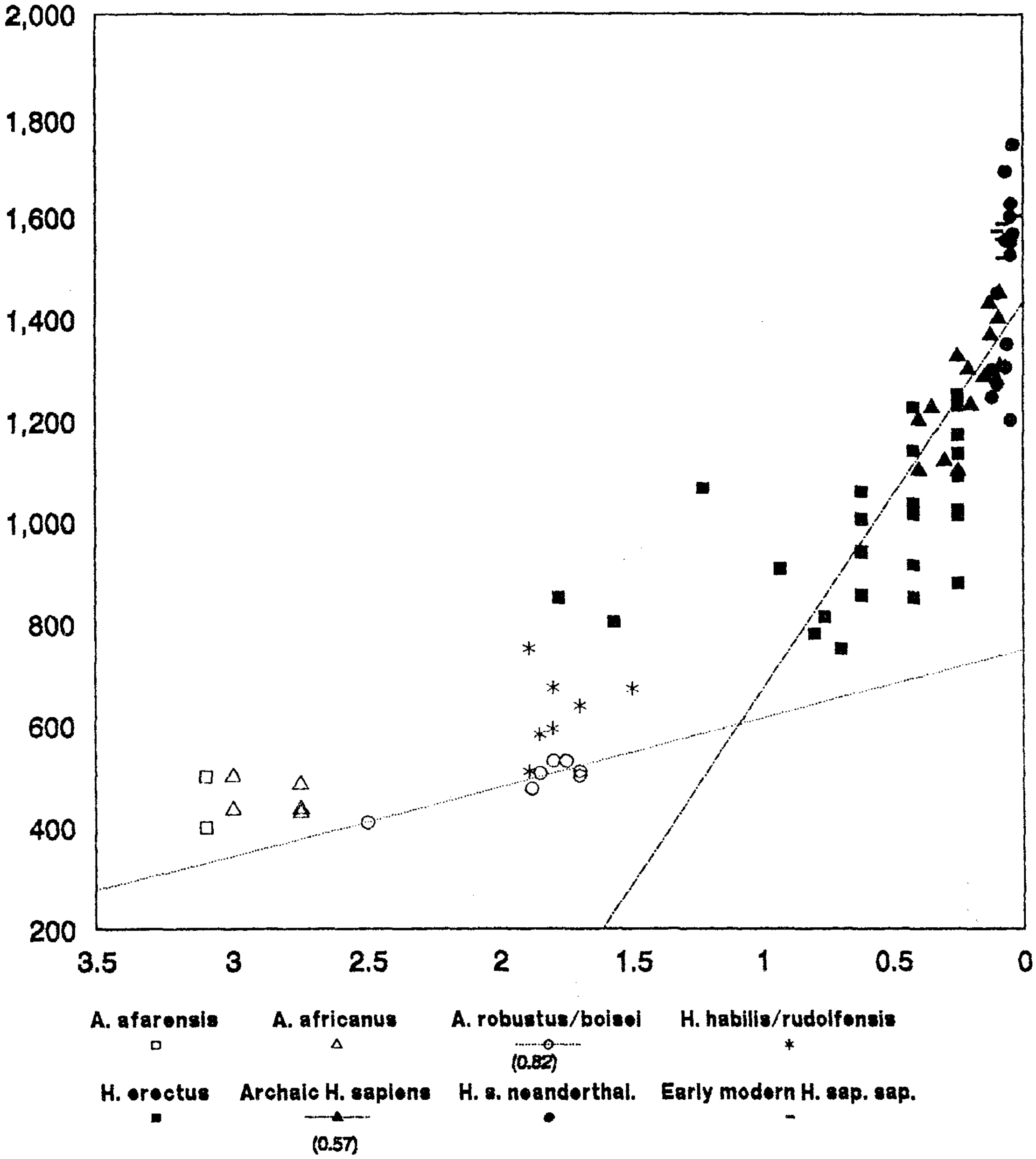
Figure 2.13



Plot of linear regression slopes against time for four data sets: endocranial volume, stature, stature-based weight estimate, and femoral cross section based weight estimate for selected hominid fossils. Data as in scatterplots. NOTE: regression coefficients for the postcranial data are weak.

R-squared: Endo. vol. 0.77; Stature 0.37; Body wt (stature) 0.36;
Body wt (Femur) 0.19.

Figure 2.14



Scatterplot, cranial capacity (mm-cubed) against time (mya).
Data from Aiello and Dunbar 1993, Table 1.
Squared
^
Regression correlation coeficients in brackets after species codes.

Figure 2.15

Plots of estimated stature and estimated endocranial volume for selected hominid fossils. Data: Aiello & Dean 1990:264-7; Holloway 1983:220; Day 1986 passim.

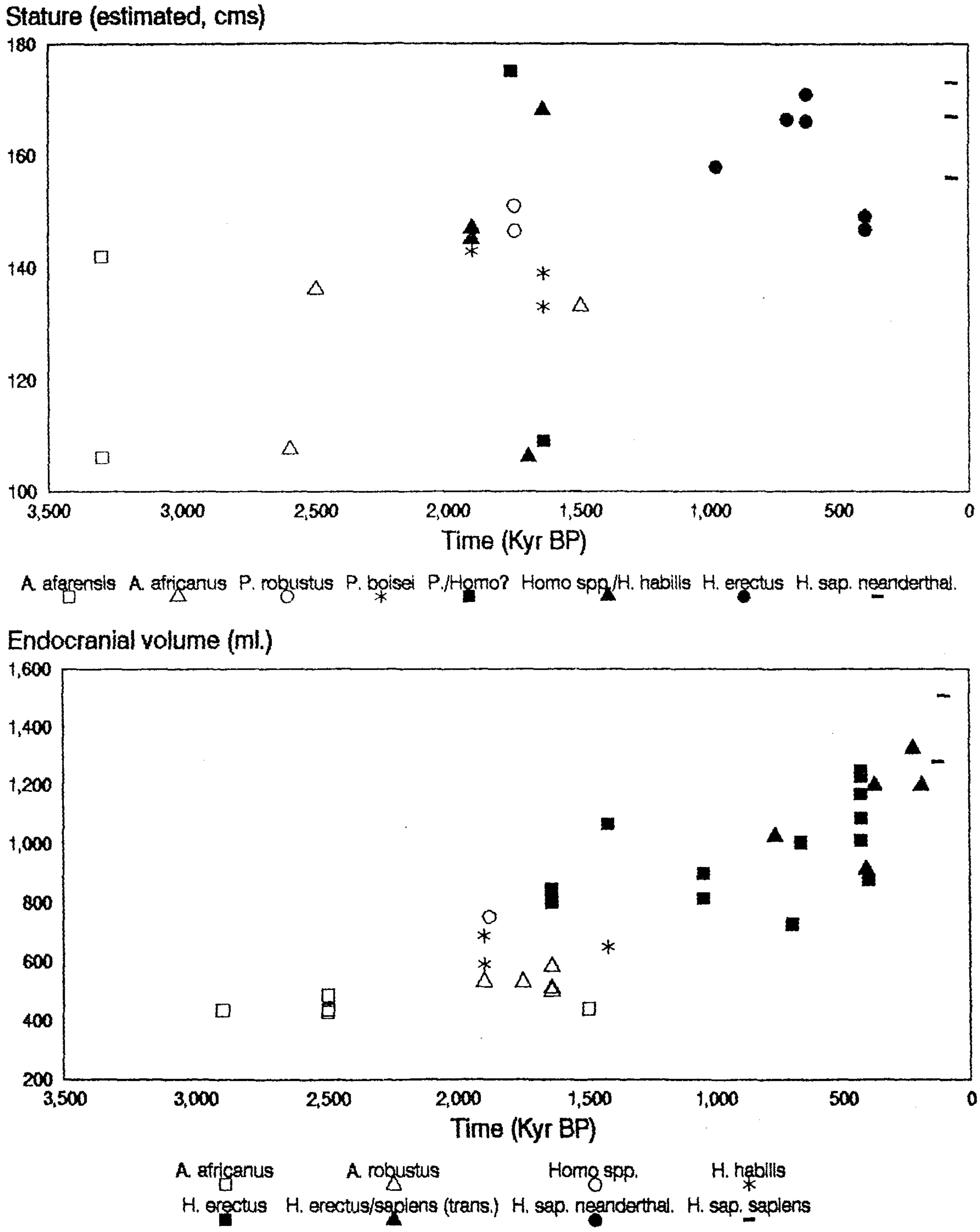


Figure 2.16

Estimates of body weight (kg) for selected hominid fossils, based on (a) stature and (b) African ape/human interspecific allometry of femoral cross section. Source: Aiello & Dean 1990:267.

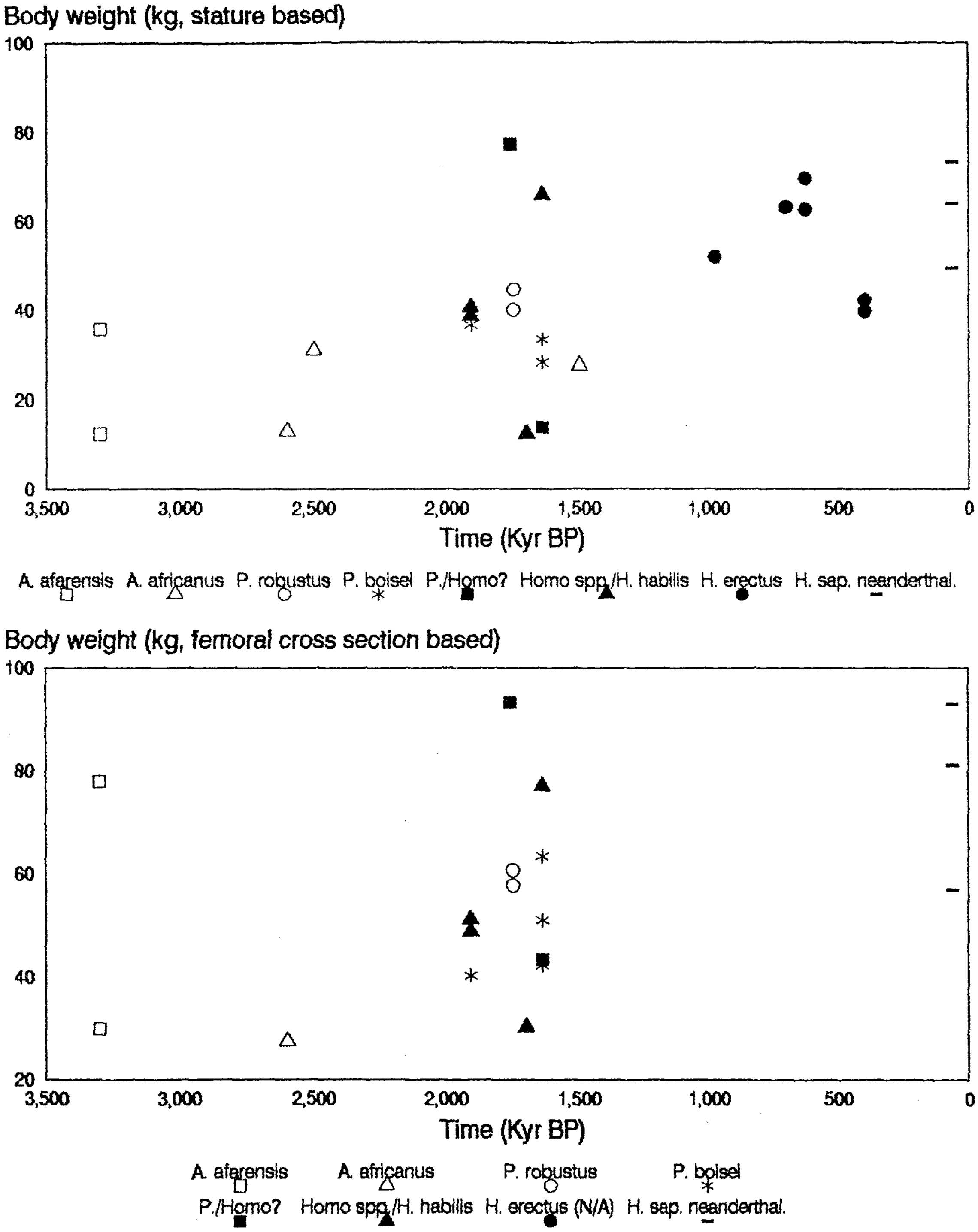
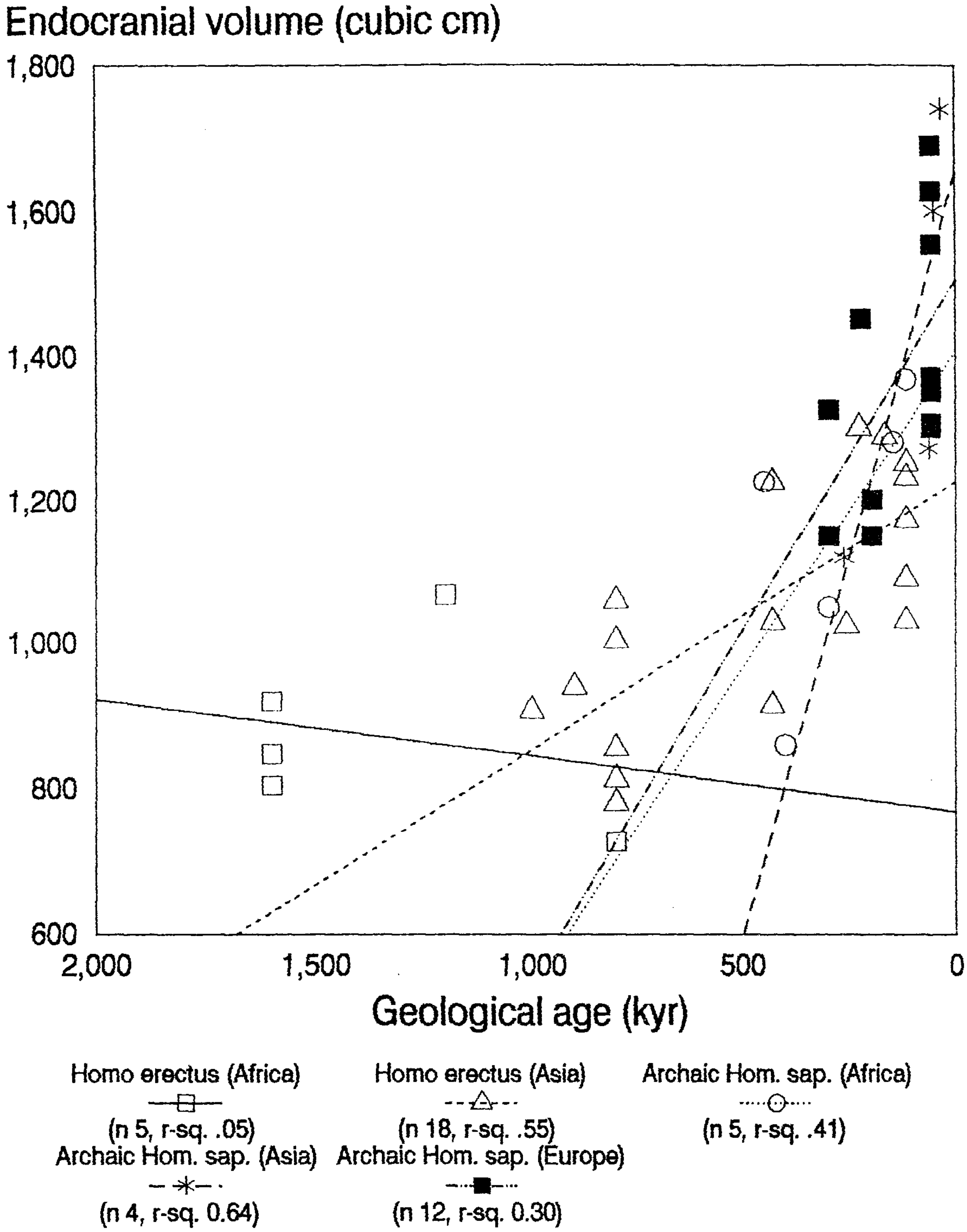
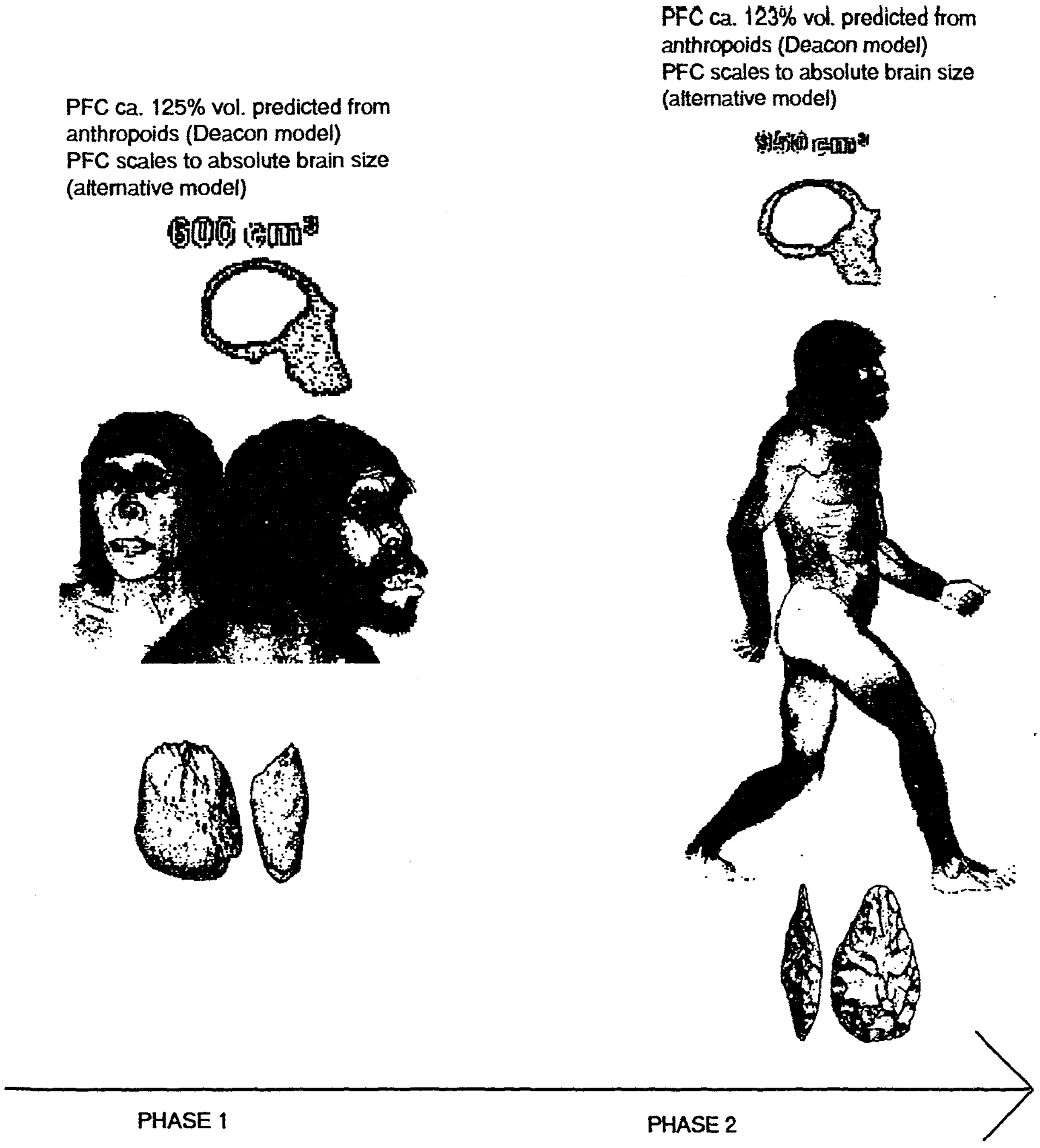


Figure 2.17



Scatterplot and linear regression lines, hominid endocranial volume against time
Data from Pilbeam (1988).

Figure 2.18



An iillustration of the different models of hominid brain evolution.
Left: Homo habilis, Right: Homo erectus.

A composite illustration made up of scanned images from various sources.

Figure 2.19

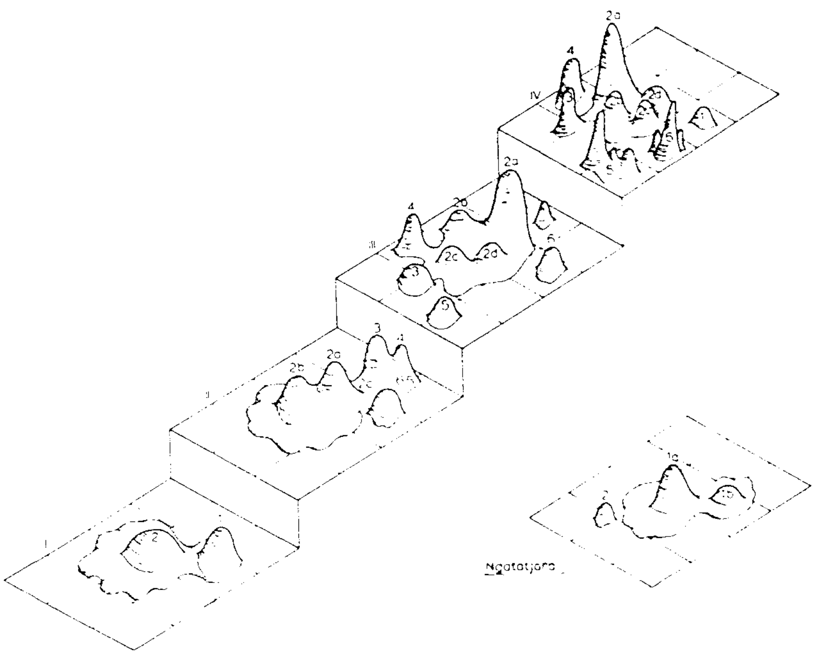


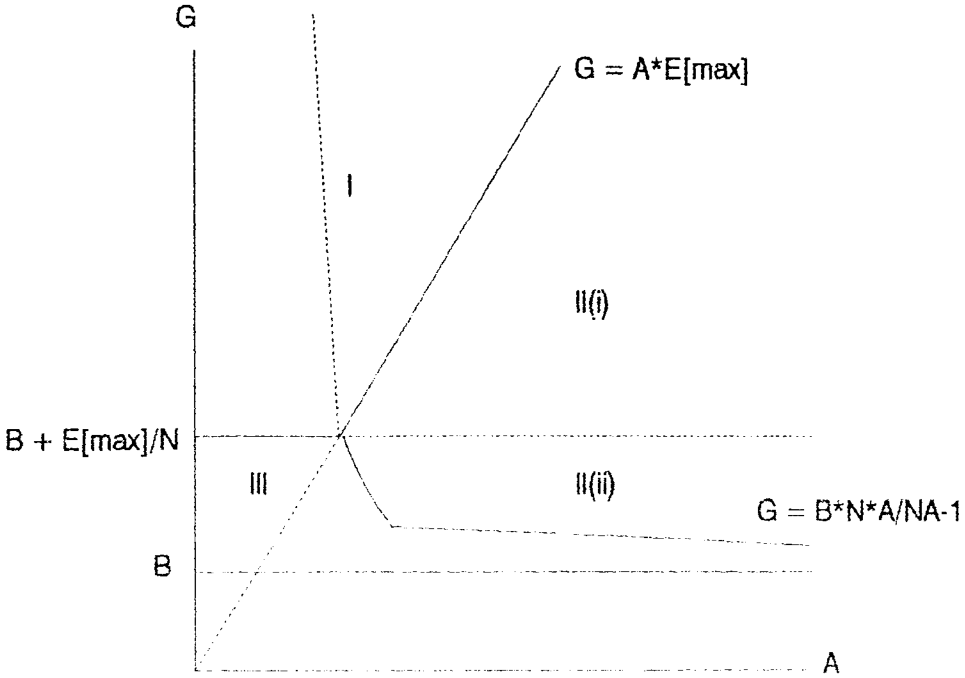
FIGURE 4. A diagrammatic representation illustrating increasing degrees of stone-artefact elaboration and differentiation. The number of topographic humps denotes the number of distinguishable modalities; the height and pointedness of the peaks denote the degree of standardization within the modality. The recent Australian Data (Ngatatjara) is based on the account of Gould *et al.*[29]

I. eg Oldowan: 1 = core-choppers, 2 = casual scrapers; II. eg Acheulian (Olorgesailie): 2a = scrapers, 2b = nosed scrapers, 2c = large scrapers, 3 = handaxes, 4 = cleavers, 5 = picks, 6 = discoids; III. eg Mousterian: 2a = racloir, 2b = grattoir, 2c = r. convergent, 3 = percoir, 4 = point, 5 = burin, 6 = biface; IV. Upper Paleolithic: 2a = grattoir, 2b = nosed scraper, 2c = raclette, etc., 3 = percoir, 4 = point, 5 = burins, 6 = backed blades, etc.

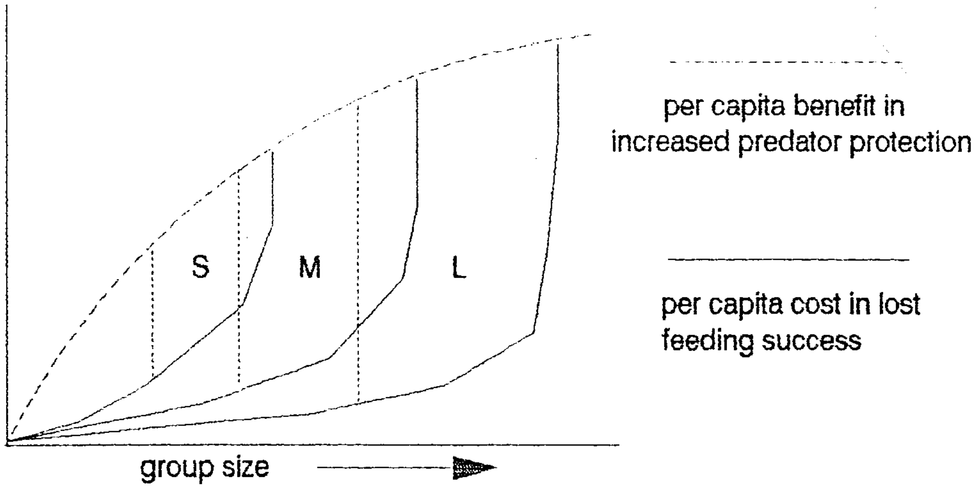
Ngatjara: 1a = hafted adzes (purpunpa), 1b = scrapers (purpunpa), 2 = bec. (pitjuru pitjuru).

Isaac's representation of the elaboration and differentiation of successive Palaeolithic stone tool industries over evolutionary time.
From Isaac (1976:280), Figure 4.

Figure 2.20

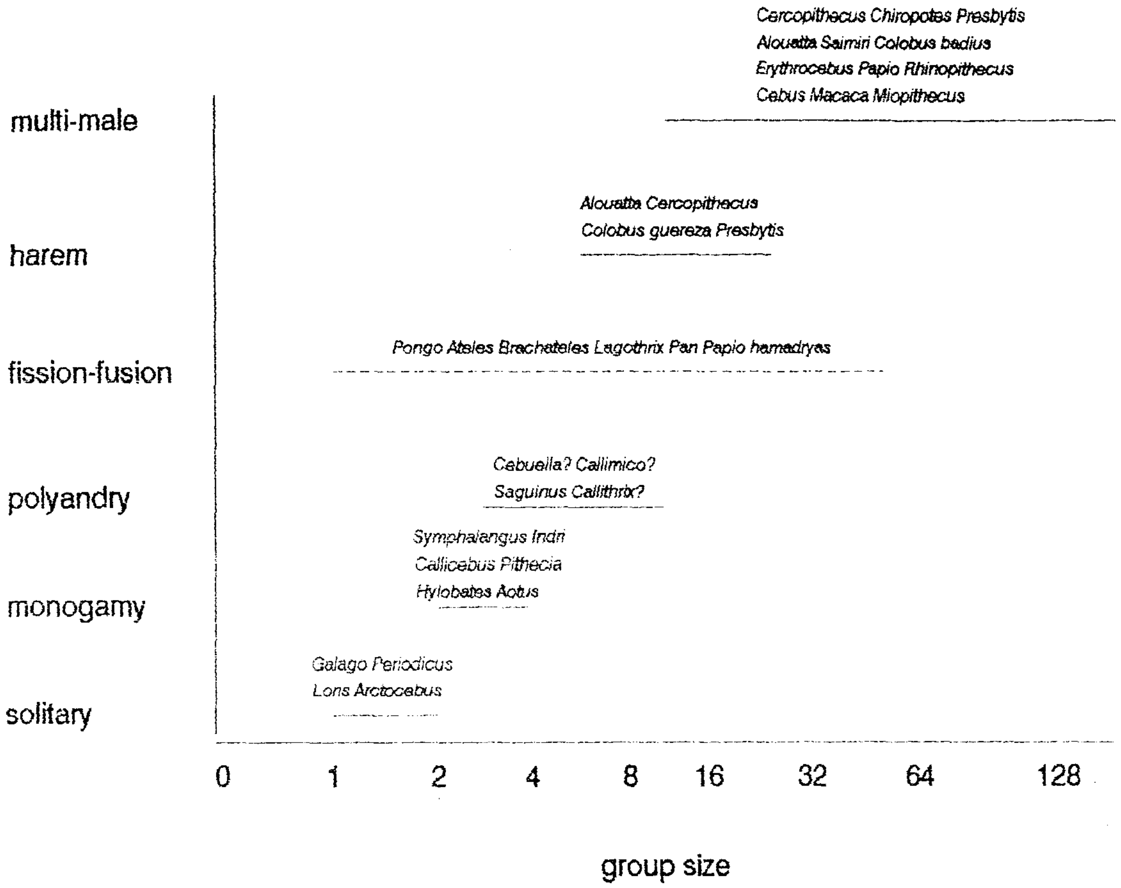


A theoretical model of ungulate socioecology: the regions for the study of optimal herd size as a function of A and G, for assigned values of E[max], B, and N.
From Focardi and Paveri-Fontana (1992:129, fig. 2).



A model for the optimization of group size in primates via evolutionary compromise between benefits derived from enhanced safety from predators and costs in decreased access to preferred feeding sites as a function of increasing group size. The dotted lines labelled S, M, and L correspond, respectively, to group sizes that maximize the differences between benefits and costs of sociality (technically, in fitness units) for species feeding onsmall, medium, and large resources. From Terborgh and Janson (1986:119, fig. 1).

Figure 3.1



Primate social systems versus group size. Horizontal bars indicate ranges of group sizes for the corresponding social systems. Genera representing each social system are listed above the bars. From terborgh and janson (1986:120, fig. 2).

Figure 3.2

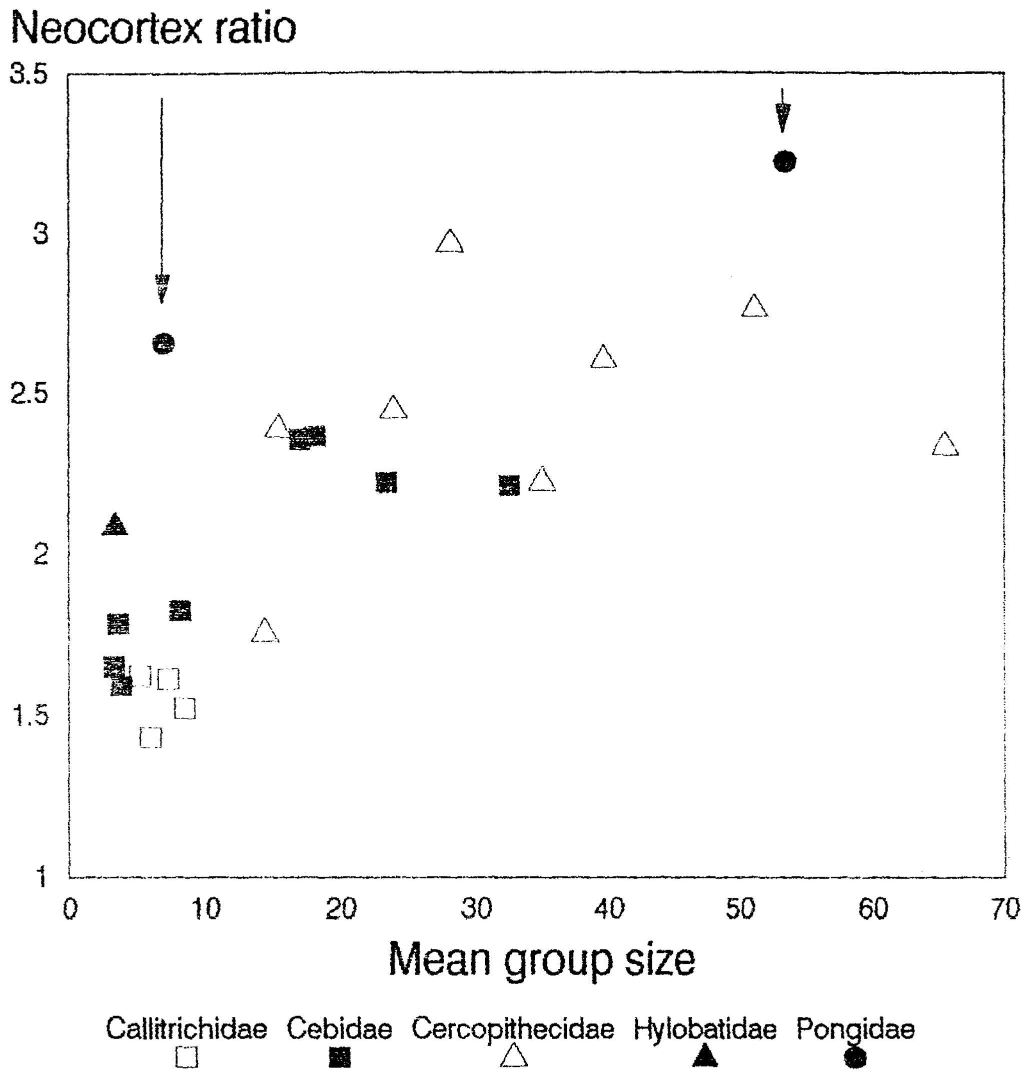
Taxon	Habitat	Habitus	Group size	N
Mangabey	Forest	Arboreal	17.8	2
Mangabey	Forest	Terrestrial	26.0	1
Macaques	Forest	Terrestrial	24.3	13
Mandrill,drill	Forest	Terrestrial	20.0	2
Baboon	Forest	Terrestrial	31.1	2
Baboon	Woodland	Terrestrial	38.1	7
Baboon	Open savannah	Terrestrial	48.4	18
Gelada	Grassland	Terrestrial	144.7	3

Mean group sizes of baboons and their allies, listed in descending order of dependence on trees. Group size = Mean of all sampled populations, N = Number of sampled populations or species. From Dunbar (1988:298, Table 13.3). Data sources in idem.

	Habitat type:					
Party type:	Forest (3%)	Woodland (37%)	Plateau (28%)	Grassland (27%)	Bamboo (5%)	Totals (100%)
Mixed	65 (45%)	60 (42%)	14 (10%)	5 (3%)	0 (-%)	144 (100%)
Lone	31 (67%)	6 (13%)	3 (7%)	5 (1%)	1 (2%)	46 (100%)
Mothers	33 (73%)	9 (20%)	1 (2%)	2 (4%)	0 (-%)	45 (99%)
Adult+Male	6 (50%)	3 (25%)	2 (17%)	1 (8%)	0 (-%)	12 (100%)
Totals	135 (54%)	78 (32%)	20 (8%)	13 (5%)	1 (<1%)	247 (100%)

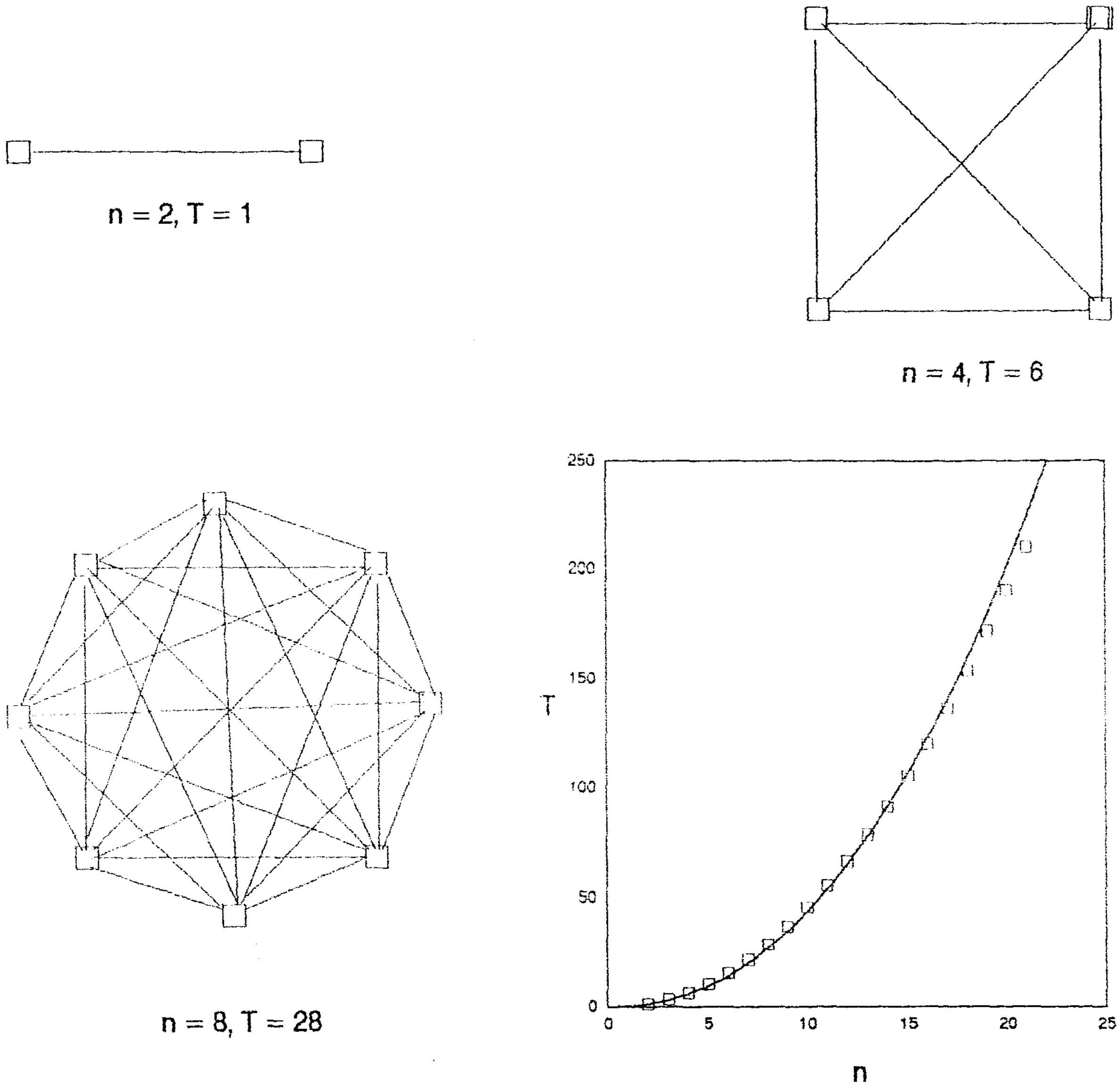
Relative frequencies of different types of party in the five principal habitat-types at Mt Assirik, Senegal. The difference in use of forest and woodland by mixed versus lone and mother parties is statistically significant (chi-squared=17.65, df=2, p<.001). The median size of mixed parties were 7 (N=42) in woodland, 8 (N=52) in forest, and 11 (N=15) for grassland and plateau combined (N.S.) Table and analyses from Tutin et al. (1983:165, Table 7).

Figure 3.3



Scatterplot of neocortex ratio against mean group size for five anthropoid families. Data points are generic means. Data from Dunbar (1992:474-5, Table 1).

Figure 3.4



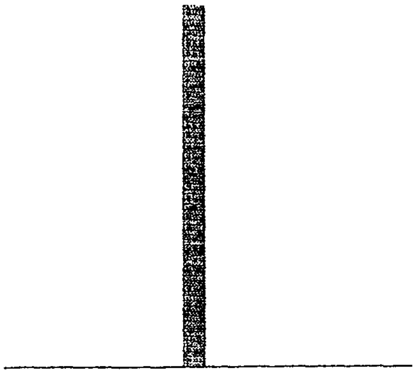
n = 2, T = 1

n = 4, T = 6

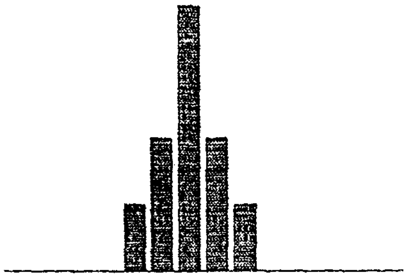
n = 8, T = 28

Number of potential dyads (T) is a power function of number of individuals in a social network.

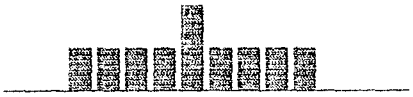
Figure 3.5



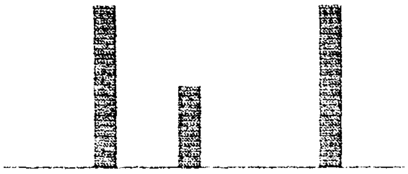
N = 7, N/i = 6



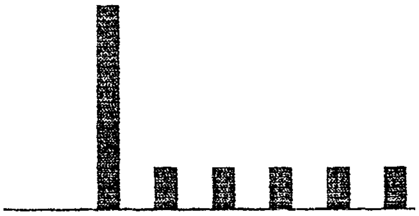
N = 7, N/i = 6.17



N = 7, N/i = 6.9



N = 7.1, N/i = 8.83



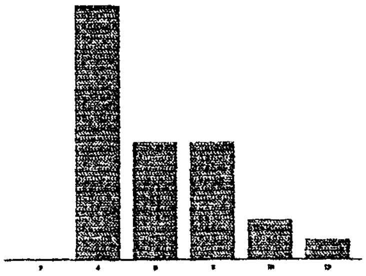
N = 7, N/i = 7.86

Effects of distributional shape on mean number of interactants per individual, for a given mean group size.

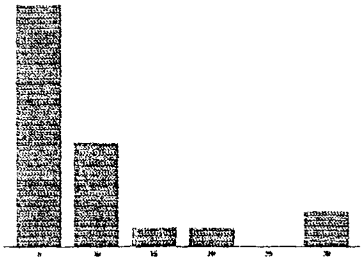
MEAN GROUP SIZE = N, MEAN INTERACTANTS PER INDIVIDUAL = N/i

Figure 3.6

CEBIDAE



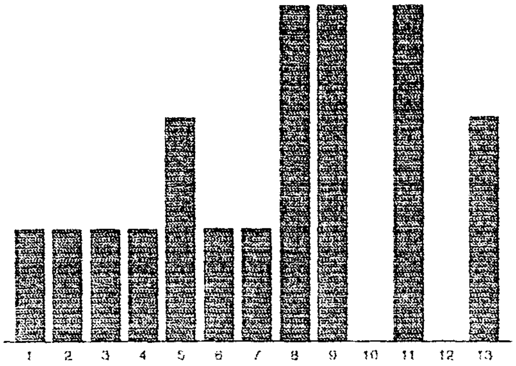
Alouatta seniculus (Izawa 1976)
N = 5.4, N/i = 5.3



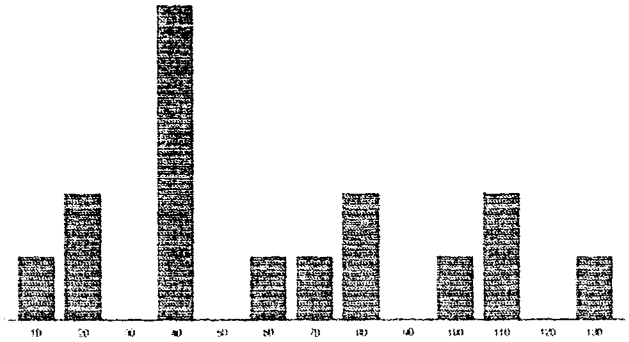
Ateles belzebuth
(Izawa 1976)
N = 6.7, N/i = 15.1

Figure 3.7

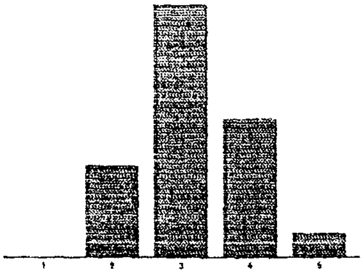
CERCOPITHECIDAE



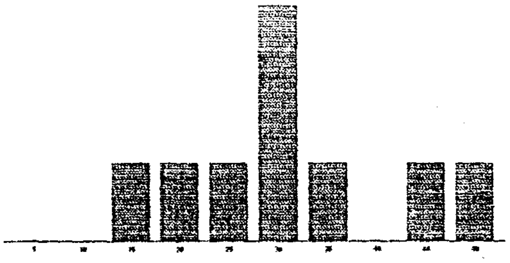
Colobus guereza (Marler 1969)
N = 7.5, N/i = 8.1



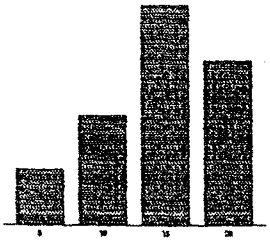
Papio ursinus (Hamilton et al. 1976)
N = 59.1, N/i = 80.1



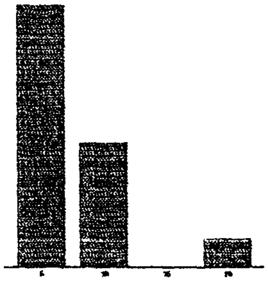
Presbytis potenziani N = 3.2, N/i = 2.4
(Watanabe 1981)



Macaca fuscata (Maruhashi 1982)
N = 29.7, N/i = 32.5



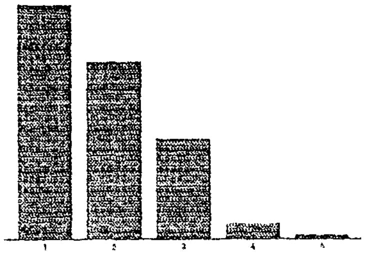
Presbytis geei
(Mukherjee and Saha 1974)
N = 12.5, N/i = 12.7



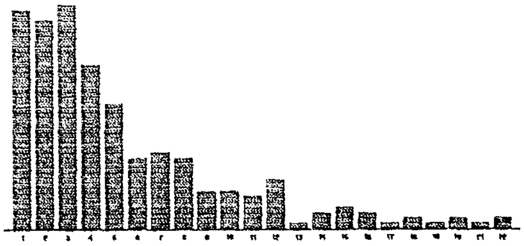
Simias concolor
(Watanabe 1981)
N = 5.5, N/i = 7.4

Figure 3.8

PONGIDAE



Pongo pygmaeus (Mackinnon 1974)
N = 1.8, N/i = 1.2



Pan troglodytes (Tutin et al. 1983)
N = 5.3, N/i = 11.1

Figure 3.9

Linear least-squares regression, dietary quality on log body weight, anthropoid primate species (n=43). R-sq.=28.5, p<0.001. Data from Sailer et al. 1985, Harvey and Clutton Brock 1986.

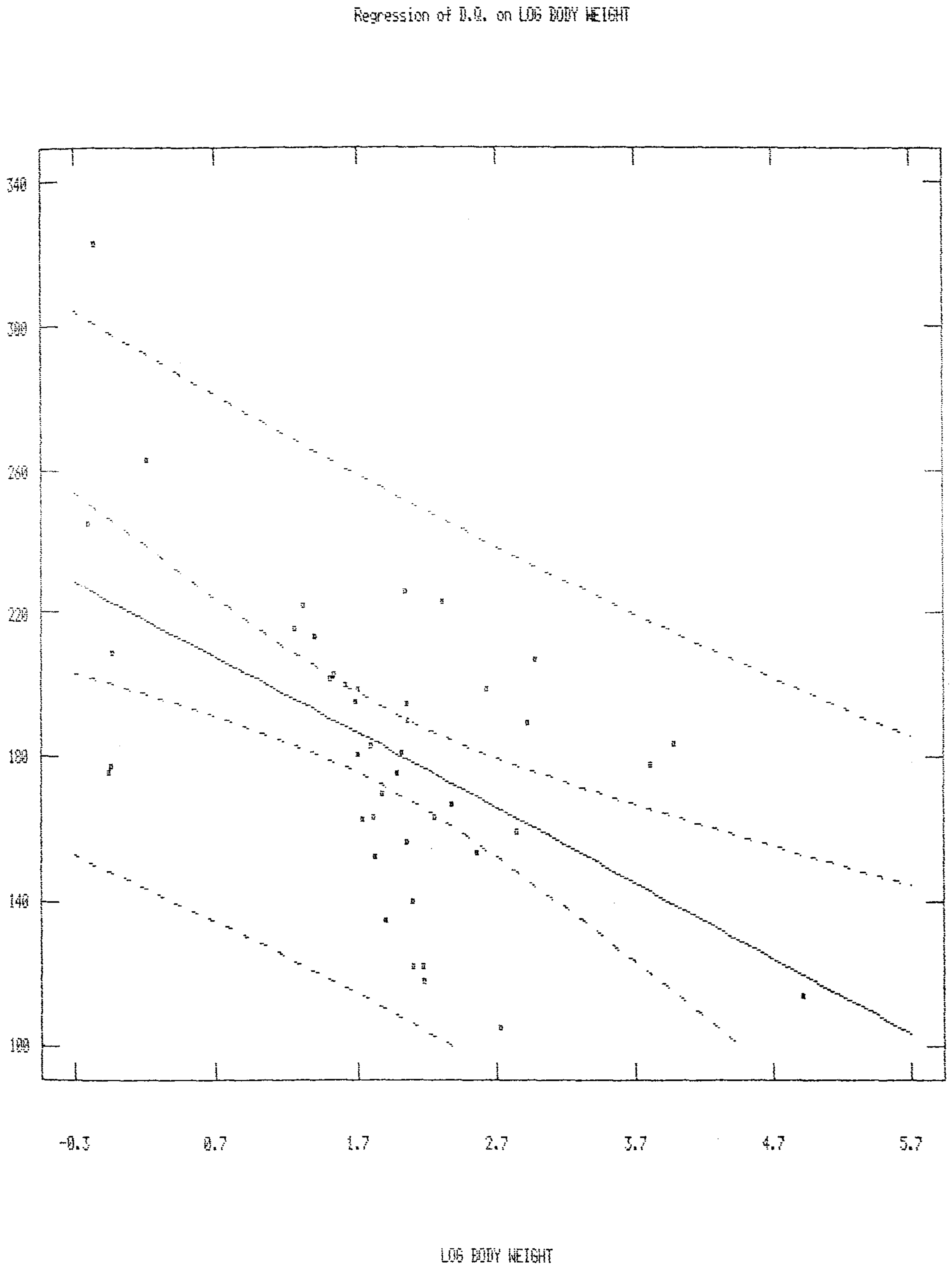


Figure 3.10

Linear least-squares regression, dietary quality on log brain weight, both variables controlled for body weight effects. Data from anthropoid species (n=43). R-sq.=29.38, p<0.001. Data from Sailer et al. 1985, Harvey and Clutton Brock 1986.

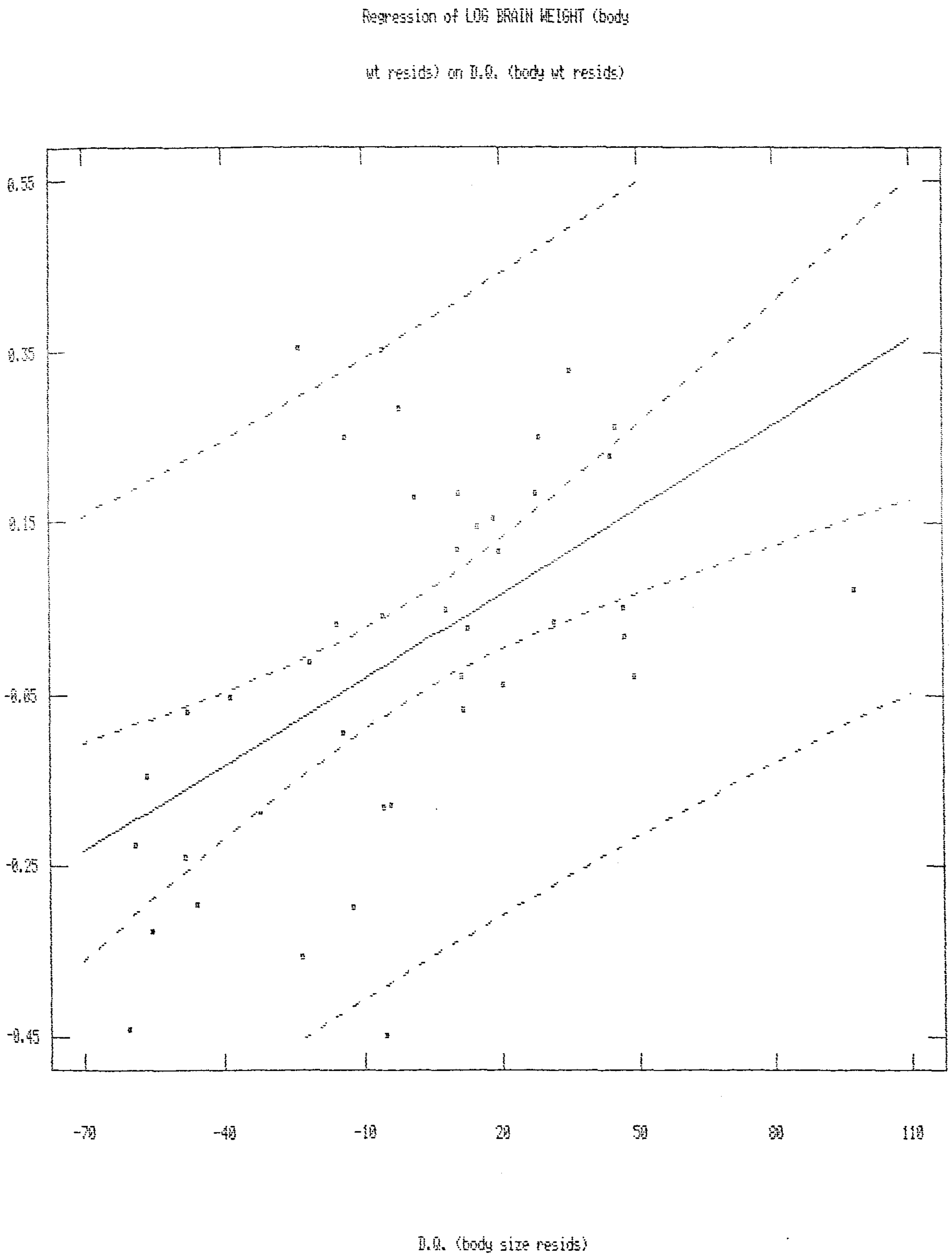
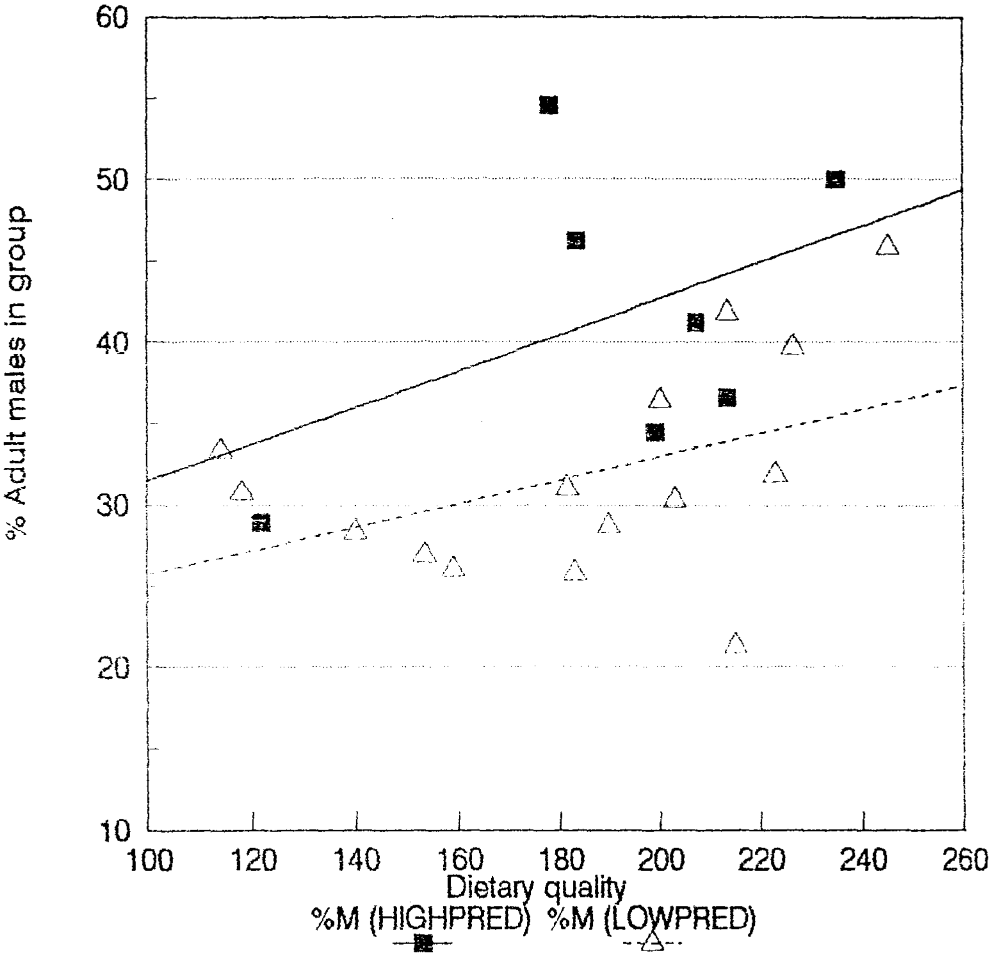
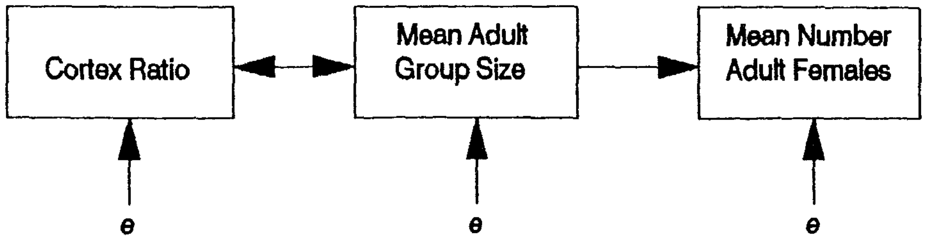


Figure 3.11

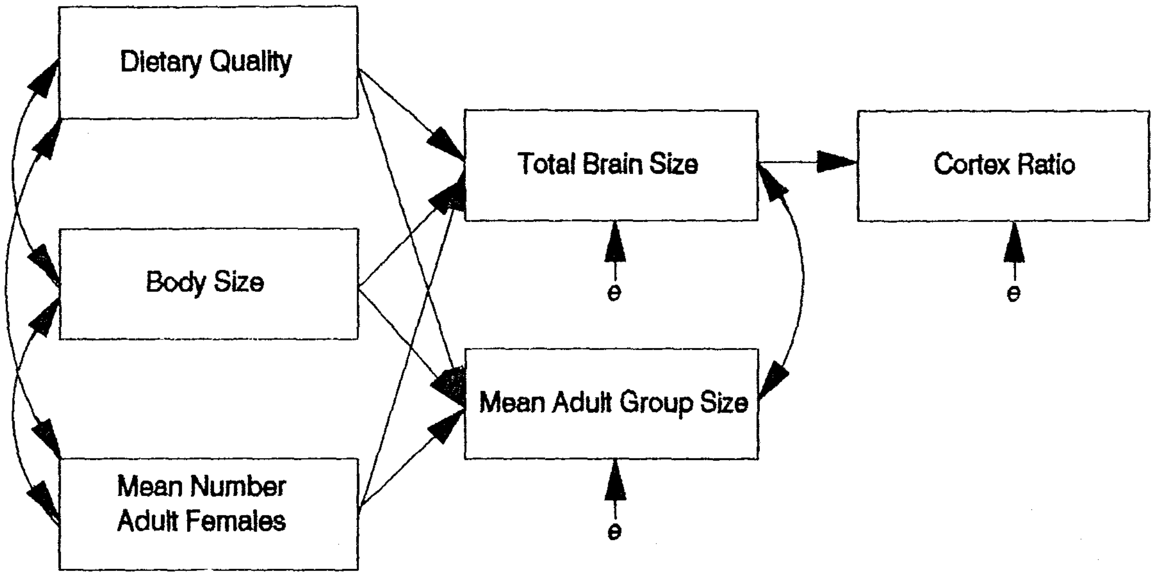


Relationship between adult composition of groups by sex, and dietary quality, for high and low/zero predation-level anthropoid species.
High predation set, n=7, r-sq.=0.20. Low/zero predation set, n=15, r-sq.=0.19.
Data from Anderson (1986), Sailer et al. (1985).

Figure 3.12



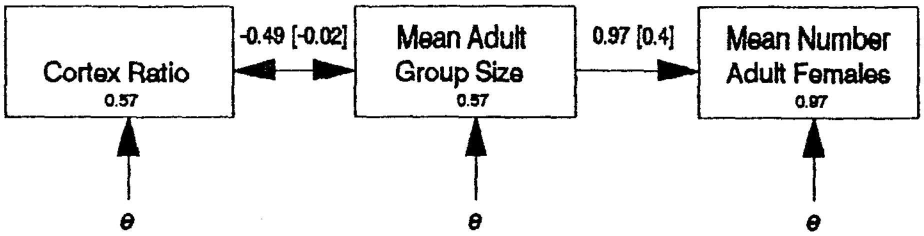
Path Diagram of Dunbar's (1992) model of primate neocortical evolution.



Path Diagram of an alternative model of primate neocortical evolution.

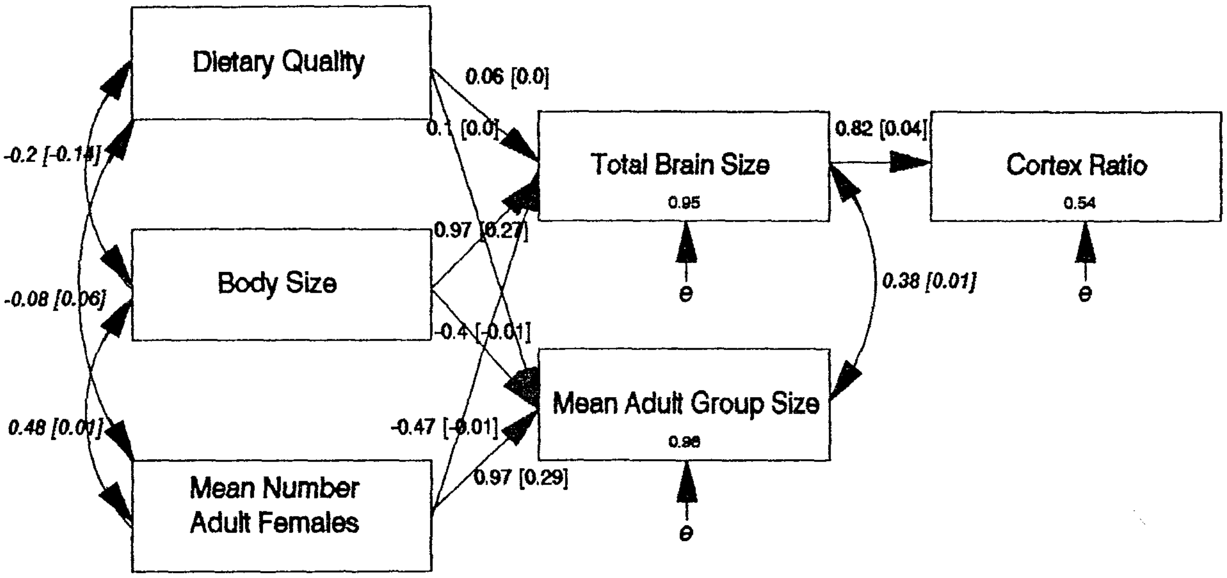
e denotes the residual variance or error term, arcs indicate unanalyzed correlations.

Figure 3.13



Path Diagram of Dunbar's (1992) model of primate neocortical evolution.

Pred$pMAF_{CR.MAGS}$ = 0 Obs$pMAF_{CR.MAGS}$ = 0.65



Path Diagram of an alternative model of primate neocortical evolution.

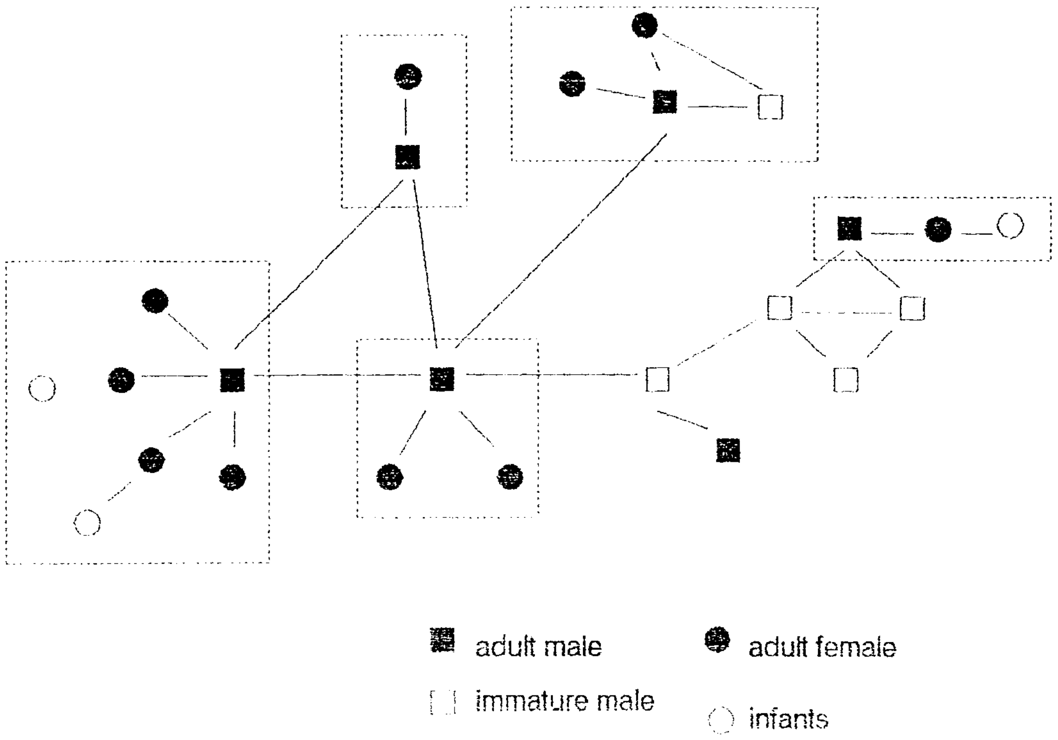
Pred. $pMAF_{CR.TBS}$ = 0 Obs. $pMAF_{CR.TBS}$ = 0.81 Pred. $pMAGS_{CR.TBS}$ = 0 Obs. $pMAGS_{CR.TBS}$ = 0.74

Unstandardised partial correlation coefficients added; italics for partial correlations for some paths not specified by the model.

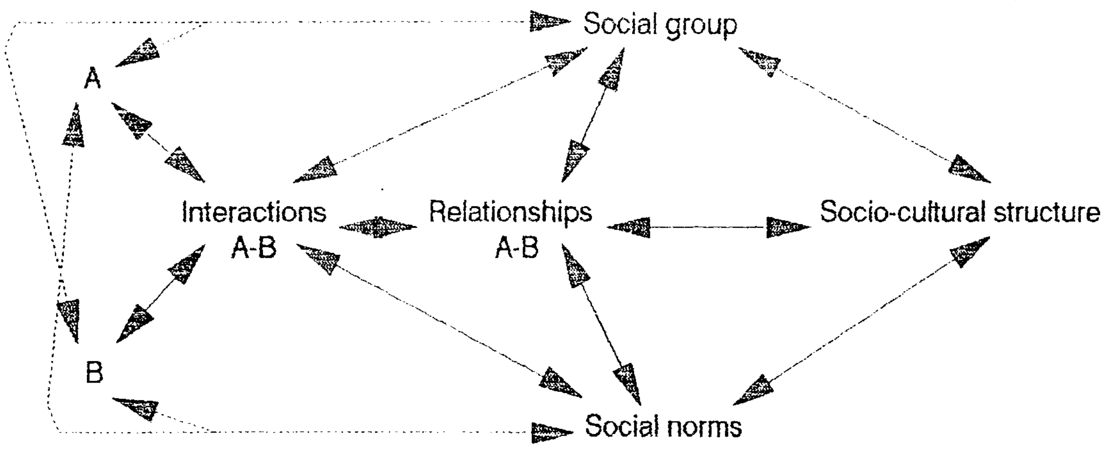
e denotes the residual variance or error term, arcs indicate unanalyzed correlations.

Path coefficients followed by percentage variation accounted for by the bivariate relationship controlled for other variables (p(1-multiple r-sq. of other variables).
Figure in box is multiple r-sq. for the compound relationships specified in the path models.

Figure 3.14



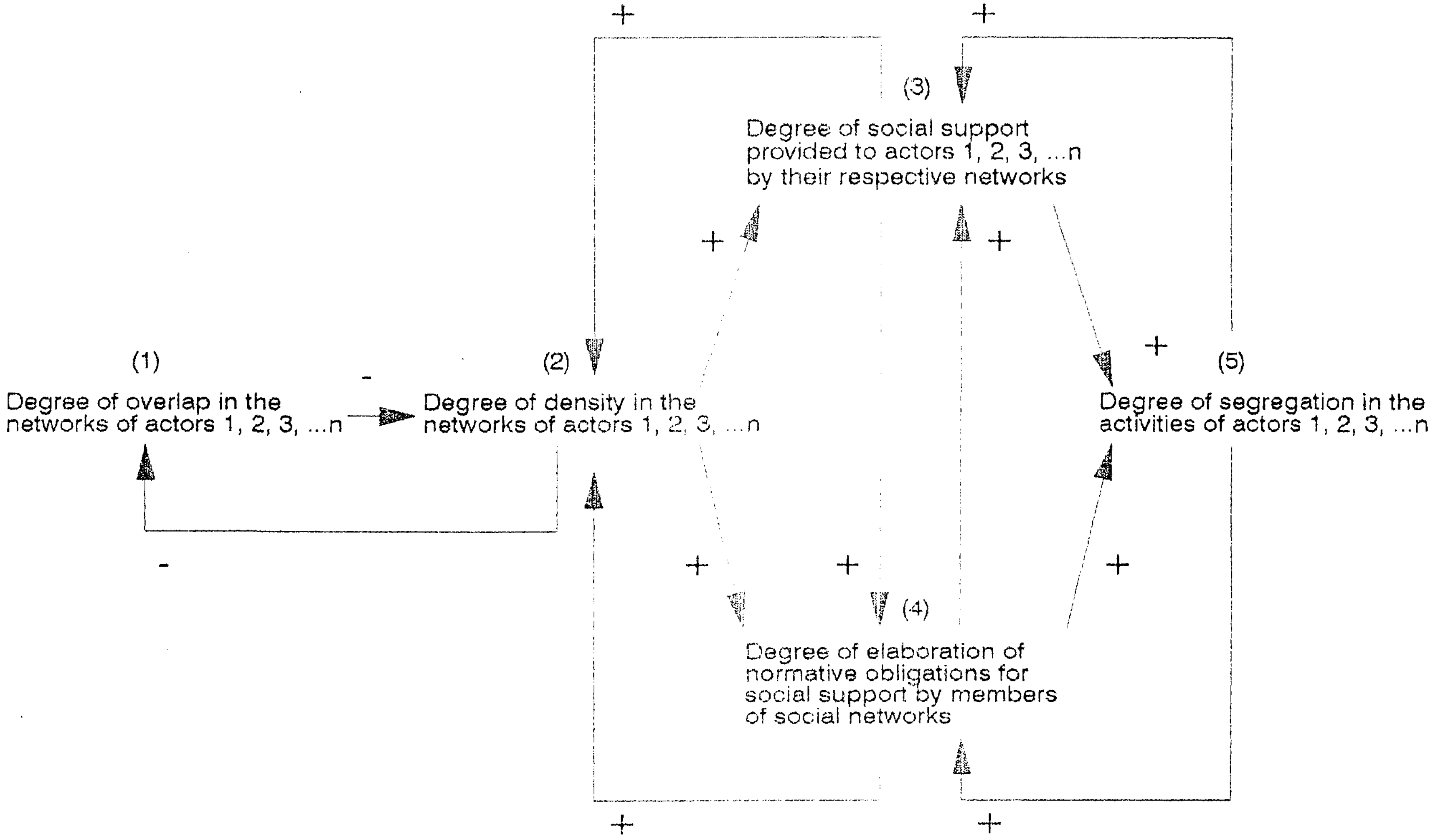
Schematic sociogram of social organization in Papio hamadryas, showing relations within and between one-male units. After Kummer (1968), in Poole (1985).



The dialectics between successive levels of social complexity (dashed lines may represent dialectics of less importance than those marked by solid lines). From Hinde (1985:xv, Fig. Int. 1)

Figure 4.1

Figure 4.2



A causal model of Bott's (1971) theory of role segregation in social networks. From Maryanski and Ishii-Kuntz (1991:409, Fig. 1).

ROLE SEGREGATION	DENSITY: High/medium	DENSITY: Low
High	*Erythrocebus patas* *Theropithecus gelada* *Papio hamadryas* *Pan troglodytes*	
Medium	*Papio anubis, ursinus, papio, cynocephalus*	*Gorilla gorilla*
Joint		*Hylobatidae spp.*

Categorization of a selection of anthropoid primate social systems in relation to role segregation and network density. From Maryanski and Ishii-Kuntz (1991).

Figure 4.3

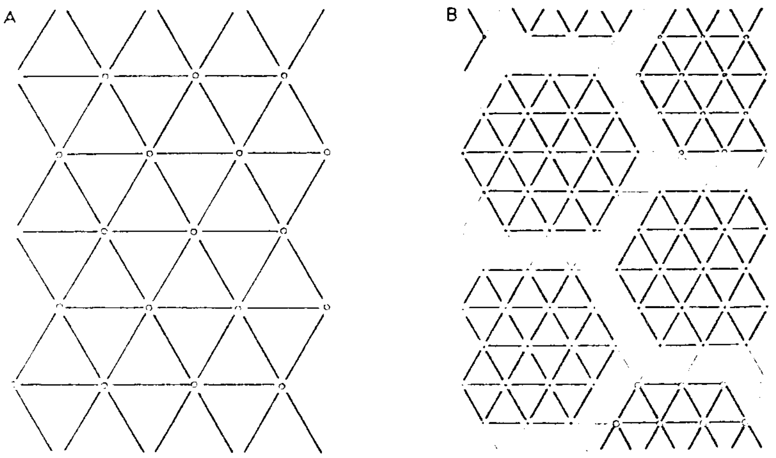
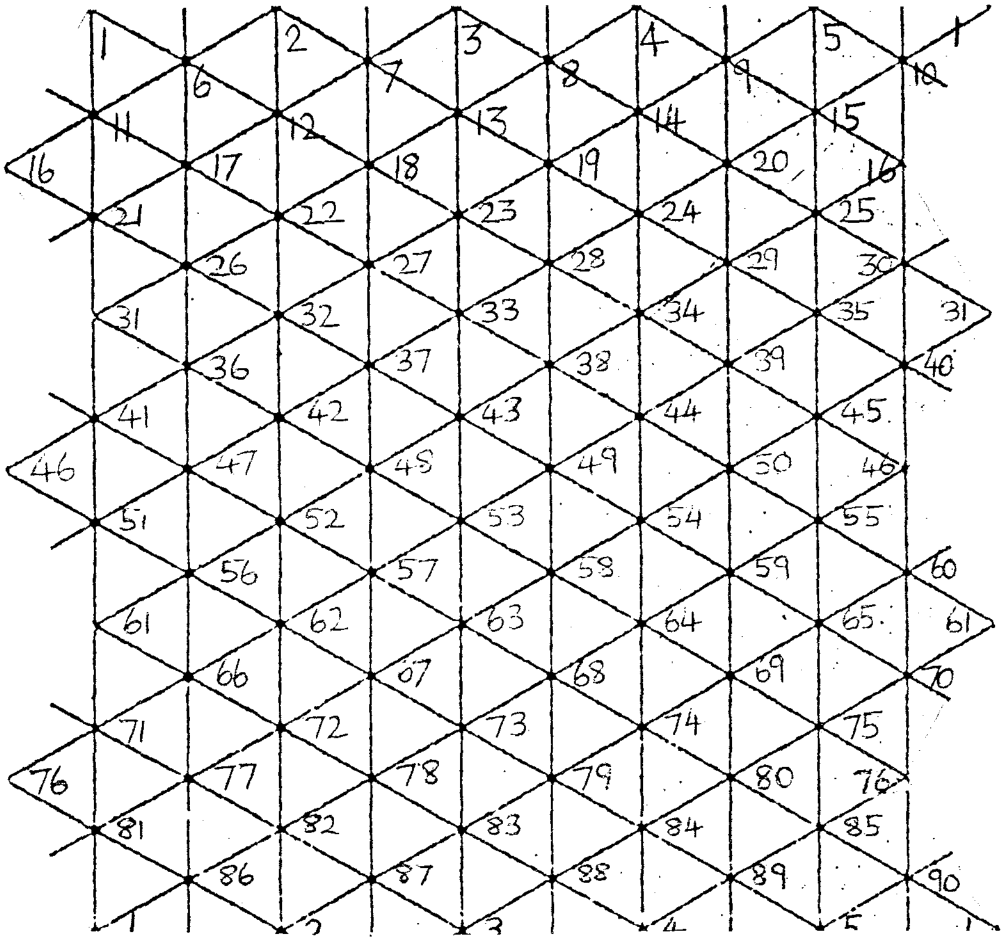


FIG. 4.6. Diagrammatic representation of differing systems of interaction between human groups. Line thickness denotes increasing frequency of exchanges. 'A' depicts a low density arrangement in which linguistic and cultural factors do not create differentials in the extent of interaction and in which there is a constant tendency toward equalization between nodes. 'B' represents a hypothetical situation of higher density in which linguistic and other cultural factors affect interaction frequency. Short-term 'partial cultural isolates' result.

Isaac's two ideal-type social networks, from Isaac (1972), Fig. 4.6.

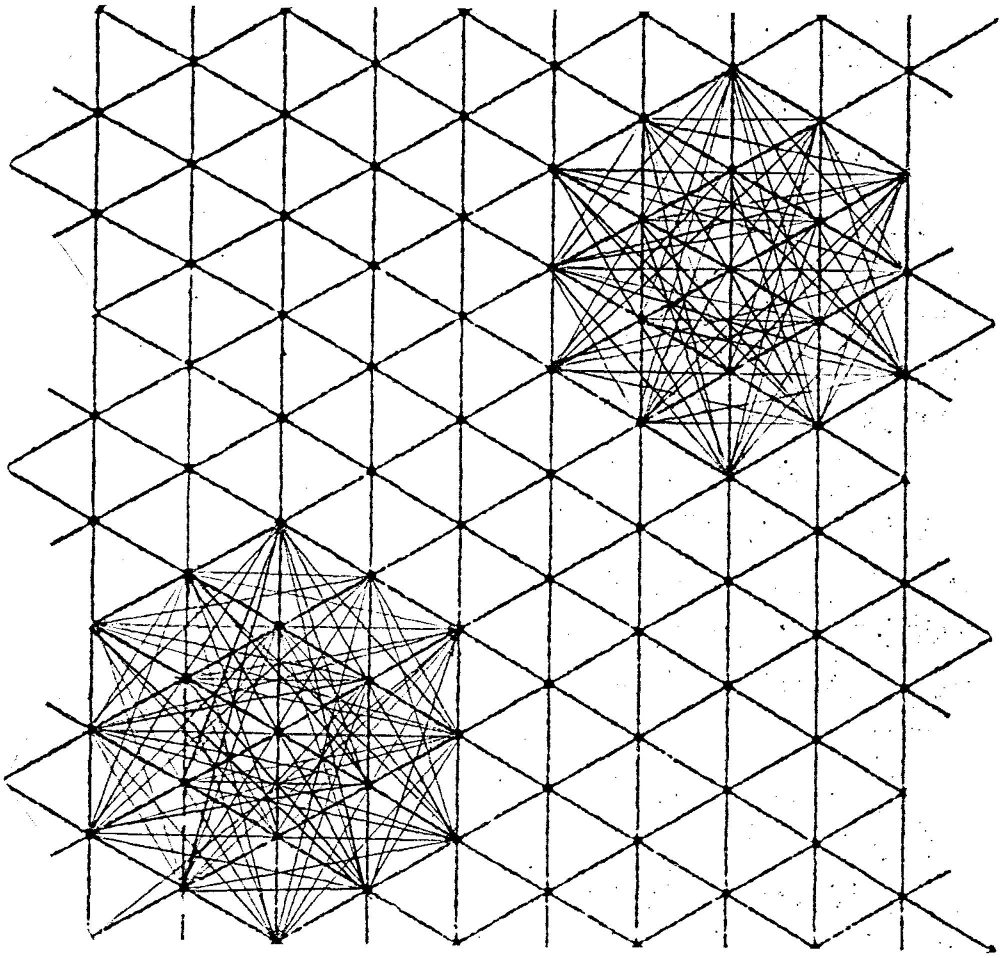
Figure 4.4



Social Network 1 (low density), the analogue of Isaac's first model network used in the simulation experiments. The point labels (numeric) are also shown to demonstrate the nature of this model network as a closed system mapped onto the surface of a torus.

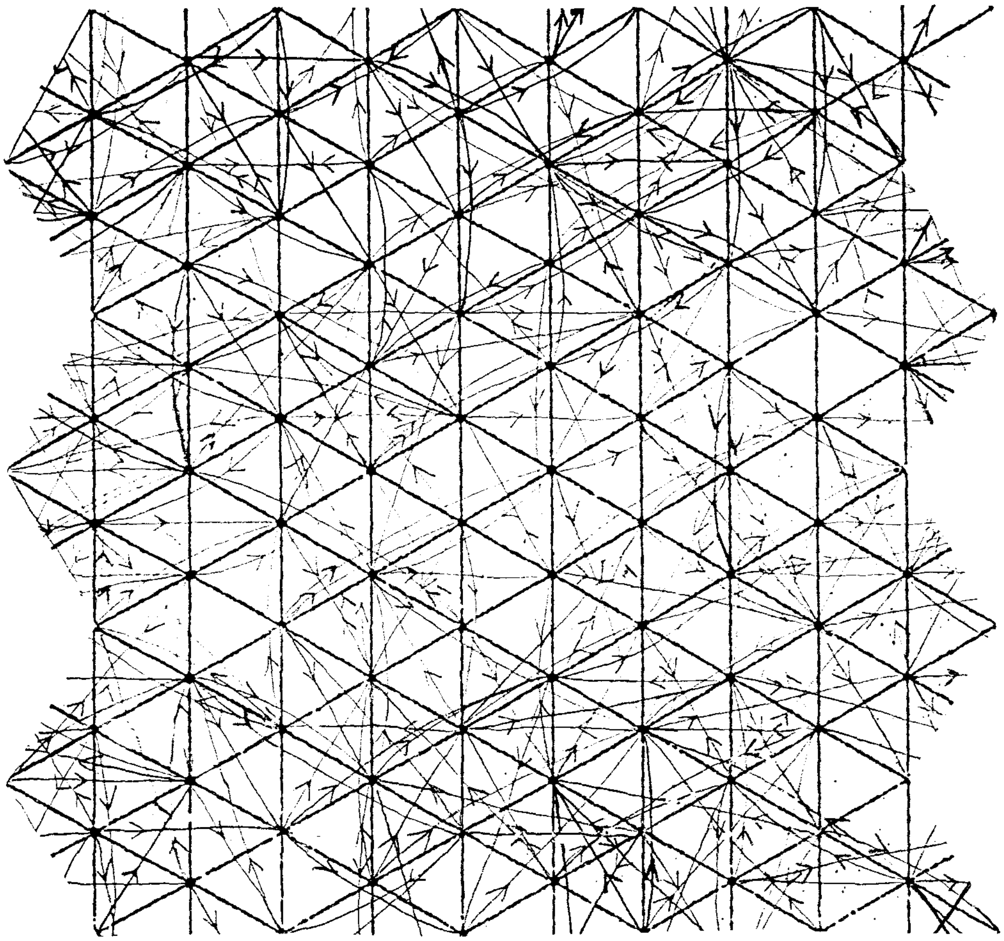
The basic lattice is also used for the other two Model Networks, 2 and 3.

Figure 4.5



Social Network 2 (high density groups on a low density background lattice).
The analogue of Isaac's second model network used in the simulation experiments.
Instead of valuing the ties the group has been connected by making direct links between all members, to comply with the structure of the simulation program.

Figure 4.6



Social Network 3 (Poisson distribution of ties). The analogue of Rowell's model of African monkey population structure based on male dispersal distances. Each node has six ties to its six nearest neighbours, two ties to nodes at two removes from it, and a single further direct tie to one node at three removes from it. The latter ties are directed (shown by the arrows) and were randomly selected for each node using a matrix of distance data for each pair.

Figure 4.7

Net 1 Condition 1, 10 its.

Net 2 Condition 1, 10 its.

Net 1 Condition 2, 10 its.

Net 2 Condition 2, 10 its.

Net 1 Condition 3, 10 its.

Net 2 Condition 3, 10 its.

Frequency histograms, Number of 1s after 10 iterations, 10 iteration simulation run. Columns: Left = Net 1, Right = Net 2. Rows: Top = Condition 1, Middle = Condition 2, Bottom = Condition 3. X-axis = Number of 1s, Y-axis = Number of simulation runs (n = 50 for each graph).

Figure 4.8

Net 1 Condition 1, 20 its.

Net 2 Condition 1, 20 its.

Net 1 Condition 2, 20 its.

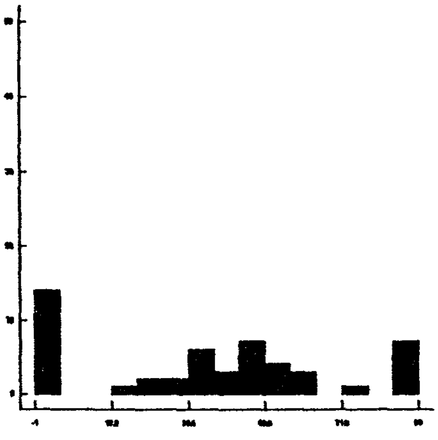
Net 2 Condition 2, 20 its.

Net 1 Condition 3, 20 its.

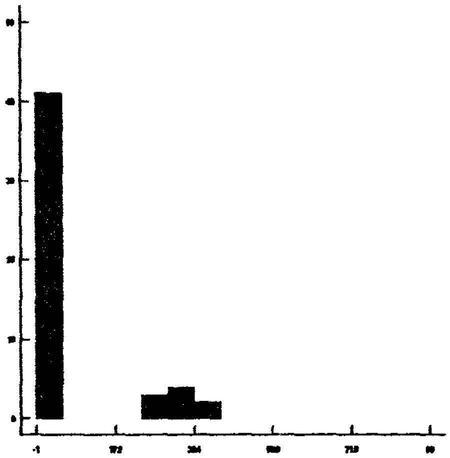
Net 2 Condition 3, 20 its.

Frequency histograms, Numbers of 1s after 20 iterations, 20 iteration simulation run. Columns: Left = Net 1, Right = Net 2. Rows: Top = Condition 1, Middle = Condition 2, Bottom = Condition 3. X-axis = Number of 1s, Y-axis = Number of simulation runs (for each graph, n = 50).

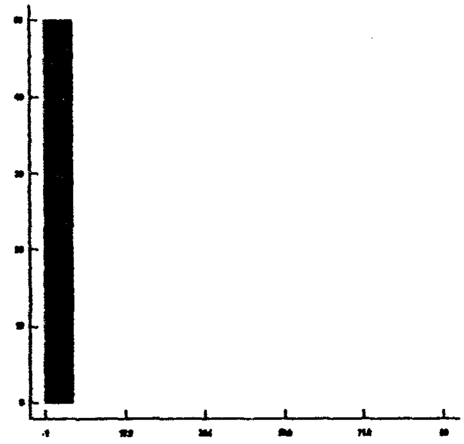
Figure 4.9



Net 3 Condition 1, 20 its.



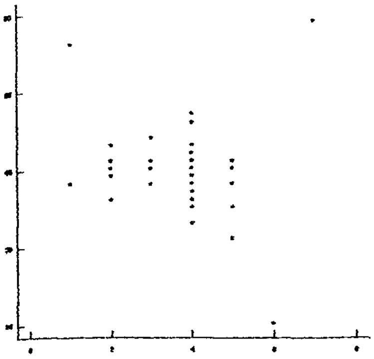
Net 3 Condition 2, 20 its.



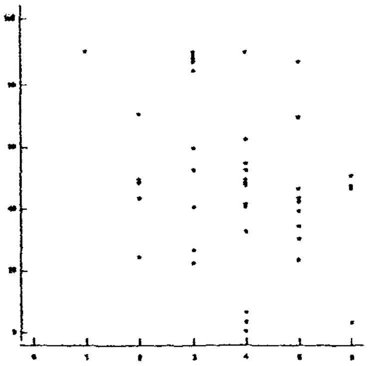
Net 3 Condition 3, 20 its.

Frequency histograms, Numbers of 1s after 20 iterations, Network 3. 20 iteration simulation run. Rows: Top = Condition 1, Middle = Condition 2, Bottom = Condition 3. X-axis = Number of 1s, Y-axis = Number of simulation runs (for each graph, n = 50).

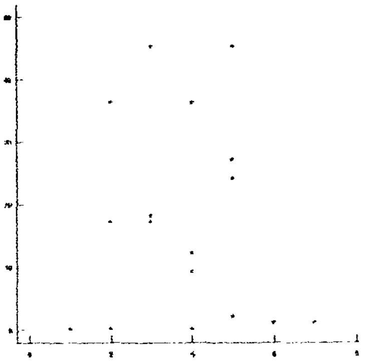
Figure 4.10



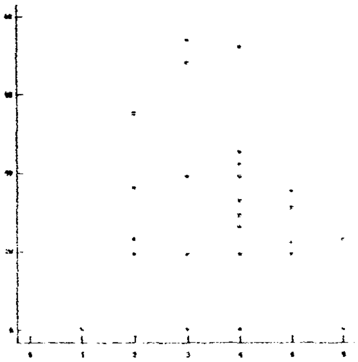
Net 1 Condition 1, 10 it.



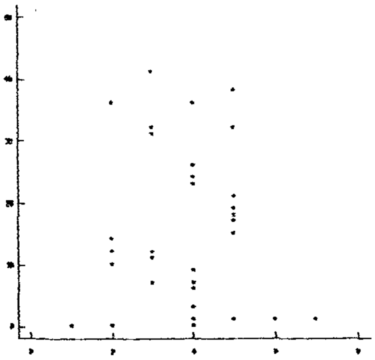
Net 2 Condition 1, 10 it.



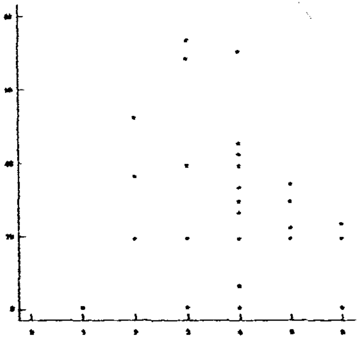
Net 1 condition 2, 10 it.



Net 2 Condition 2, 10 it.



Net 1 Condition 3, 10 it.



Net 2 Condition 2, 10 it.

Effects of distance between seeded nodes on trait frequencies after 10 iteration simulation run. Net 1 to left, Net 2 to right. Conditions (from top to bottom): Condition 1, Condition 2, Condition 3. X-axis = distance, Y-axis = number of 1s.

Figure 4.11

Net 1 Condition 1, 20 its.

Net 2 Condition 1, 20 its.

Net 1 Condition 2, 20 its.

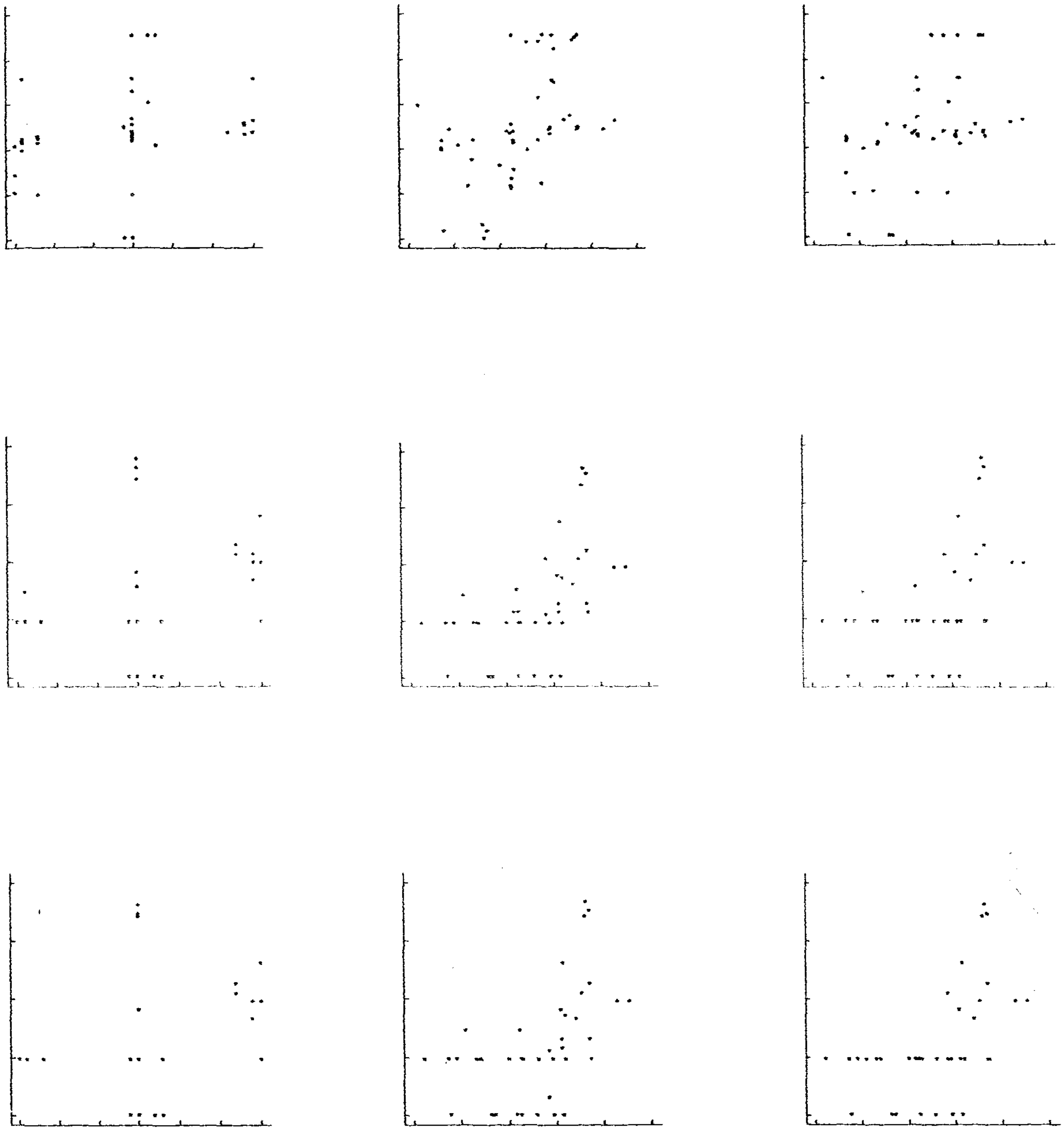
Net 2 Condition 2, 20 its.

Net 1 Condition 3, 20 its.

Net 2 Condition 3, 20 its.

Effects of distance between seeded nodes on trait frequencies after 20 iteration simulation run. Net 1 to left, Net 2 to right. Conditions (from top to bottom): Condition 1, Condition 2, Condition 3. X-axis = distance, Y-axis = number of 1s.

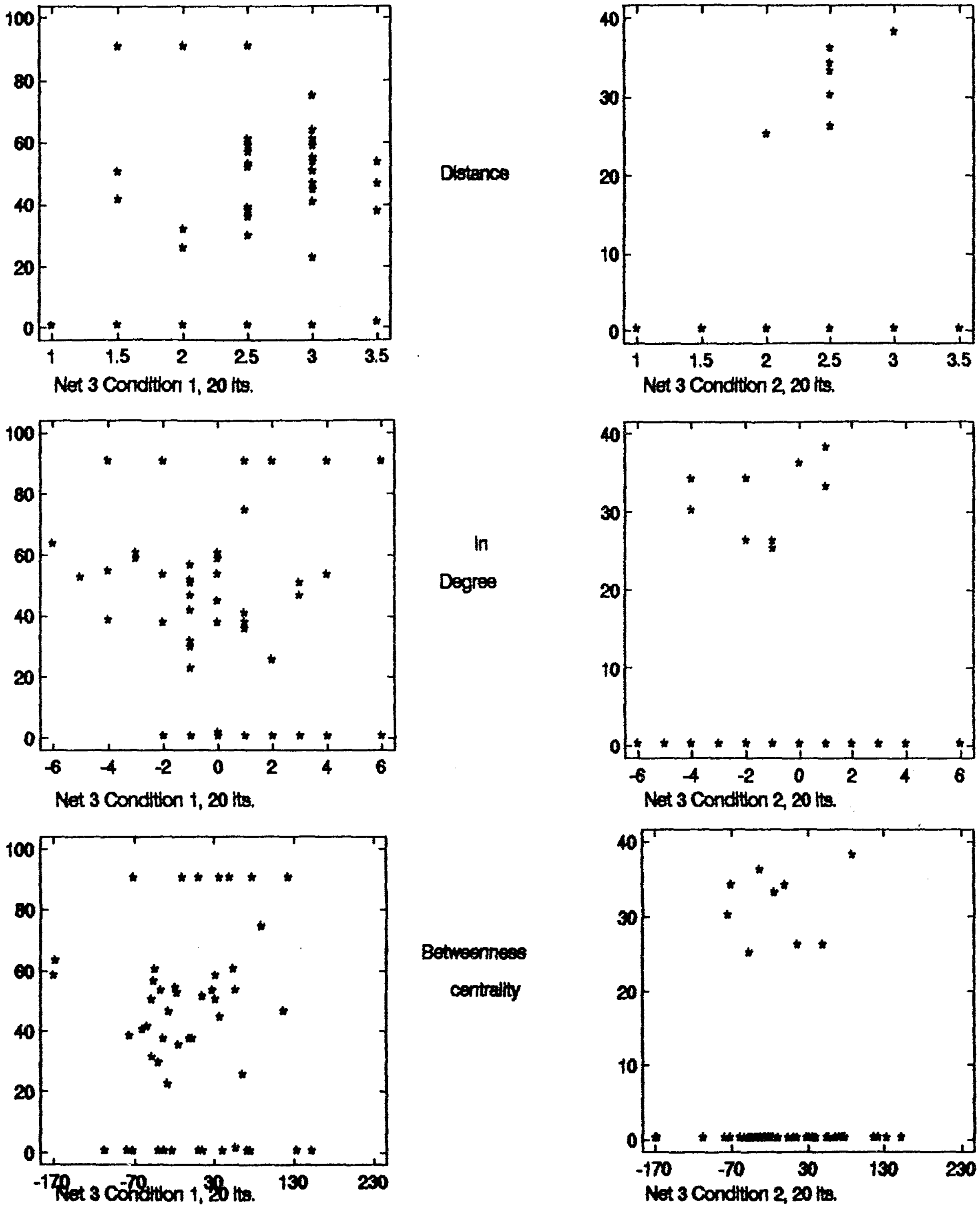
Figure 4.12



NETWORK 2: ANALYSES.
Effects of seed-node centrality on trait frequencies.
Rows (top to bottom): Conditions 1-3.
Columns (left to right): (1) Differences in degree (seeded 1 - seeded 2).
(2) Differences in closeness (seeded 1 - seeded 2), 10 iteration run.
(3) Differences in closeness (seeded 1 - seeded 2), 20 iteration run.

X-axis = difference in centrality measure (seeded 1 - seeded 2).
Y-axis = number of 1s at end of simulation (20 its for [1] and [3], 10 for [2])

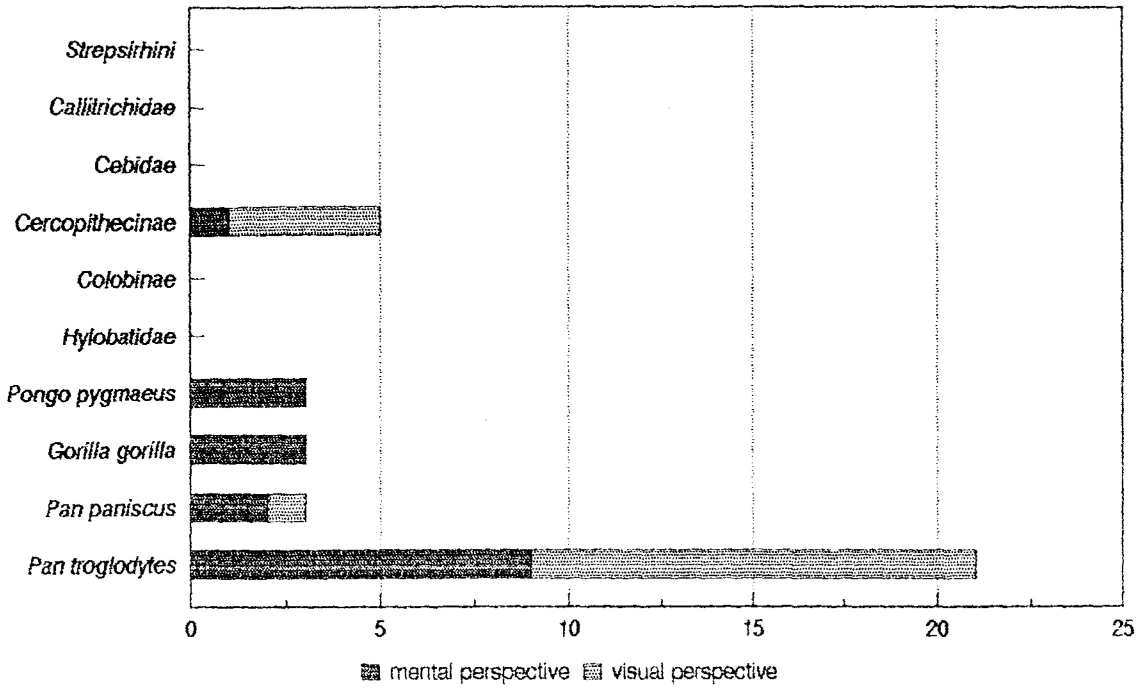
Figure 4.13



NETWORK 3: ANALYSIS.

Effects of distance and relative seed node centrality on trait frequencies. 20 iteration simulation run. Conditions: left = Condition 1, right = Condition 2. Rows: Top = Distance, Middle = Difference in degree (seeded 1 - seeded 2), Bottom = Difference in betweenness (seeded 1 - seeded 2). X-axis = distance/centrality measure, Y-axis = number of 1s.

Figure 4.14

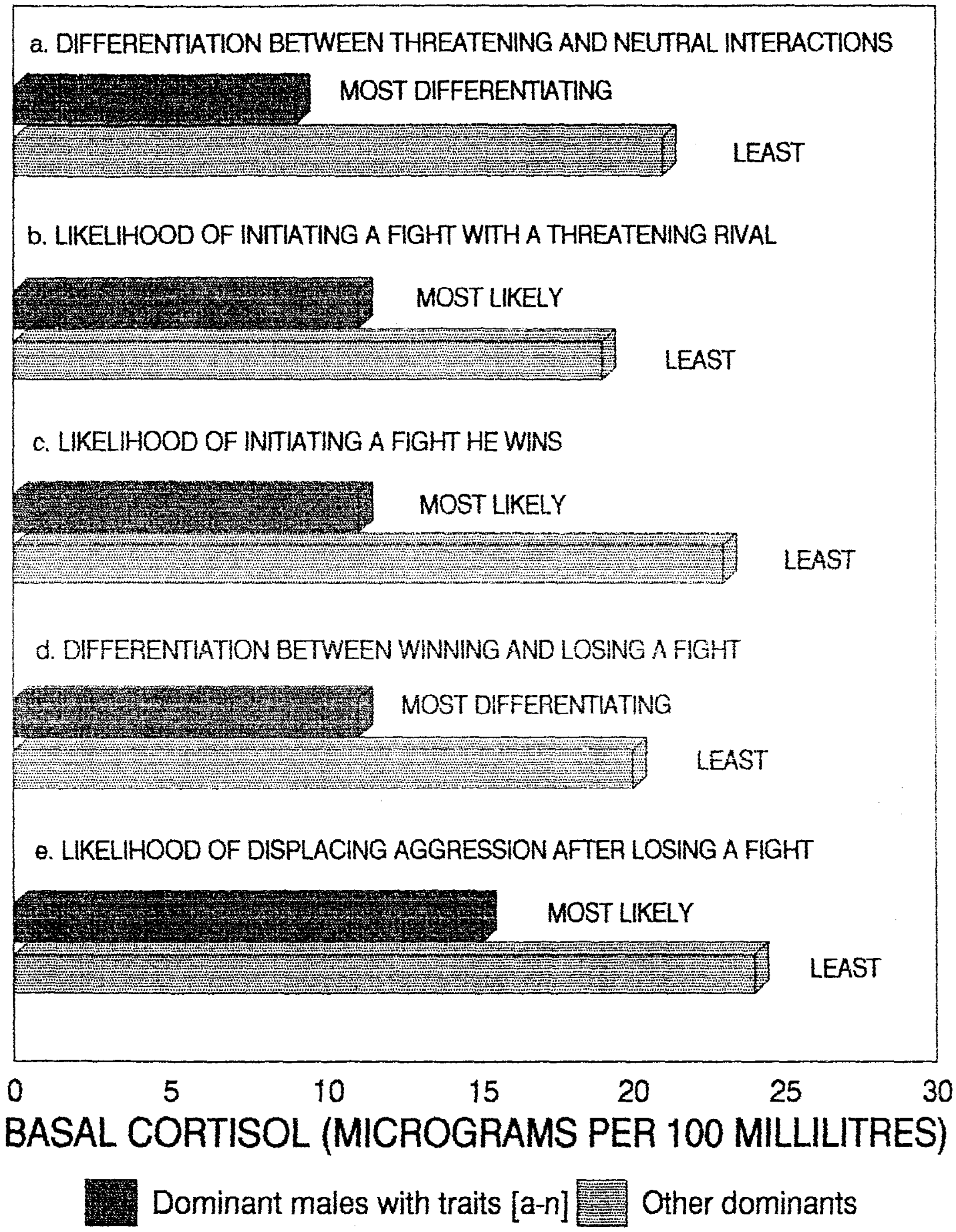


Numerical distribution of records of 'higher-order' tactical deception across taxa of primates, showing evidence that individuals can adopt the perspectives of others. From Byrne and Whiten (1992:621, fig. 2).

Macaca	13 cases: 7 ?SE, 2 ?T&E, 3 ?SF, 5 ?OC.
Cercopithecus	1 case: ?T&E, ?SE
Papio	3 cases: 2 ?T&E, 2?SE
Ateles	i case: ?SE
Cebus	1 case: ?T&E, ?SE
Pan	21 cases: 5 ?T&E, 9 ?SE, 1 ?OC, 13 ?I

Summary of cases of reported imitation in nonhuman primates, with possible explanations (T&E = trial-and-error; SE = stimulus enhancement; SF = social facilitation; OC = observational conditioning; I = imitation). Extracted from Whiten and Ham (1992).

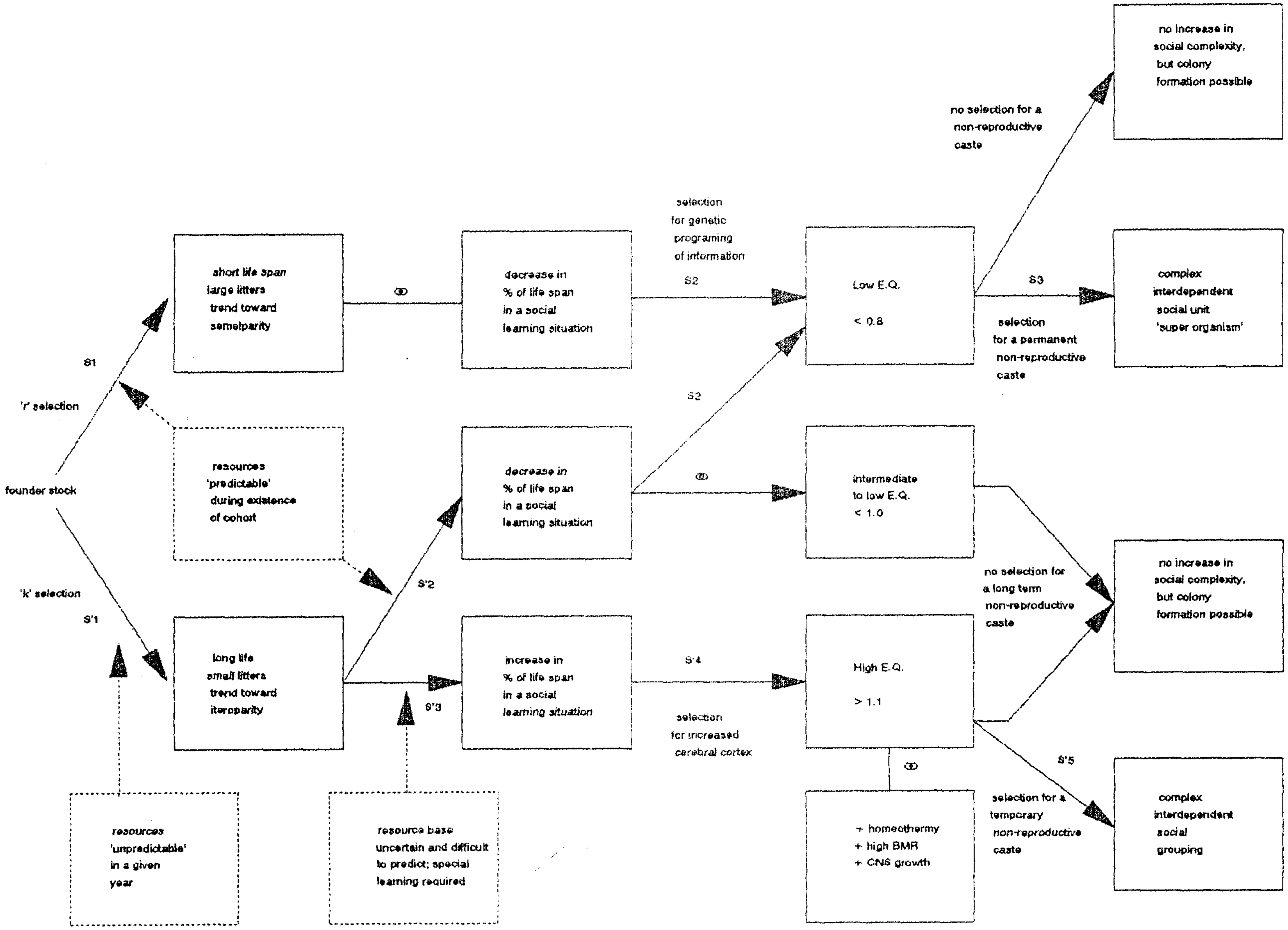
Figure 5.1



Among dominant males in a wild olive baboon troop, a cluster of 'personality traits' differentiate individuals by their hormonal reactivity to stress. These traits correspond to ability to control the outcome of social interactions and displace tensions. From Sapolsky (1990:112).

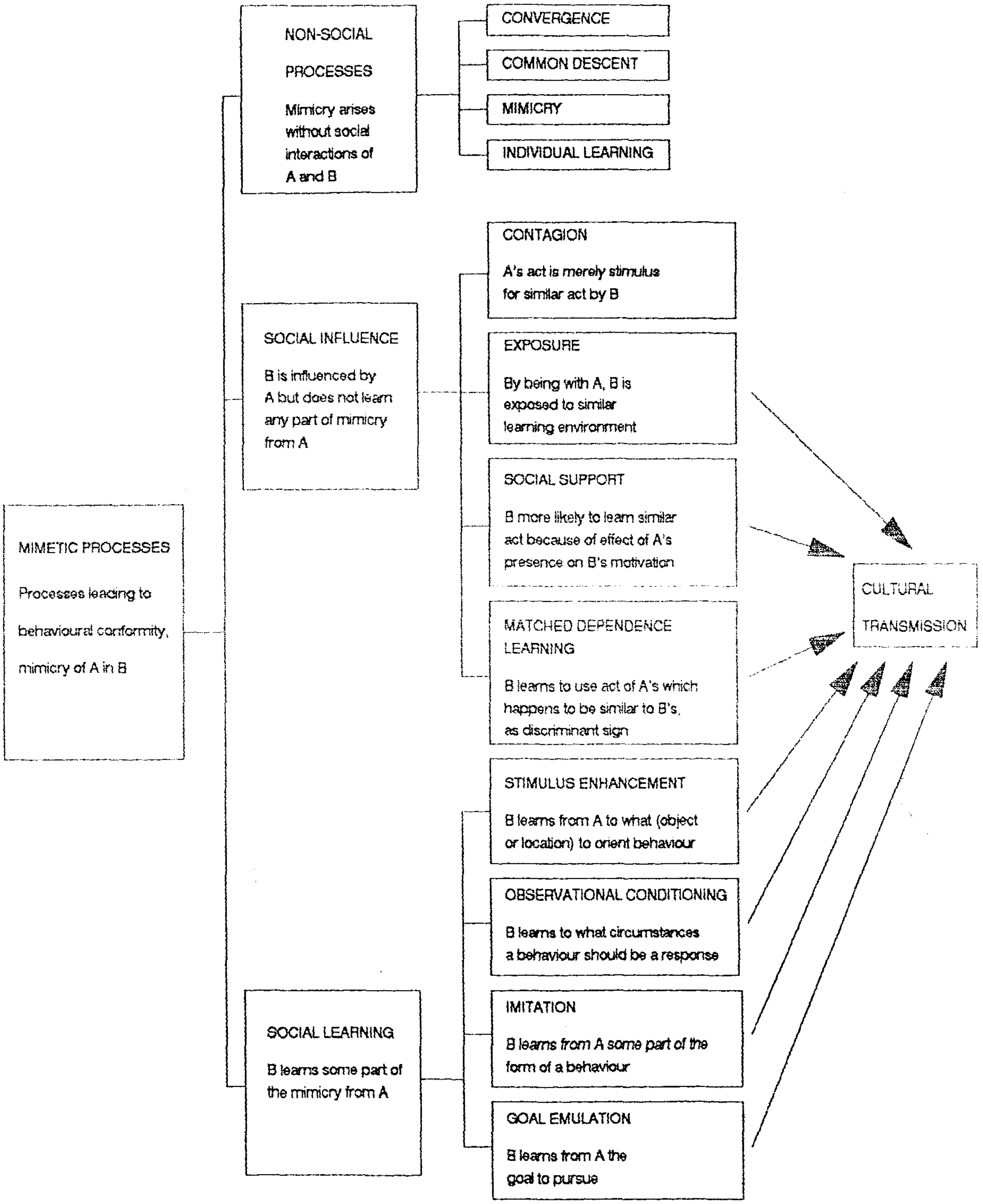
Figure 5.2

Figure 5.3


founder stock
'r' selection
S1
'k' selection
S'1
short life span
large litters
trend toward
semelparity
resources
'predictable'
during existence
of cohort
long life
small litters
trend toward
iteroparity
resources
'unpredictable'
in a given
year
resource base
uncertain and difficult
to predict; special
learning required
S'2
S'3
decrease in
% of life span
in a social
learning situation
decrease in
% of life span
in a social
learning situation
increase in
% of life span
in a social
learning situation
selection
for genetic
programing
of information
S2
S2
S'4
selection
for increased
cerebral cortex
Low E.Q.
< 0.8
intermediate
to low E.Q.
< 1.0
High E.Q.
> 1.1
+ homeothermy
+ high BMR
+ CNS growth
no selection for a
non-reproductive
caste
S3
selection
for a permanent
non-reproductive
caste
no selection for
a long term
non-reproductive
caste
S'5
selection for a
temporary
non-reproductive
caste
no increase in
social complexity,
but colony
formation possible
complex
interdependent
social unit
'super organism'
no increase in
social complexity,
but colony
formation possible
complex
interdependent
social
grouping

Hypothetical pathways toward the evolution of complex societies: consequences of different forms of selection as a result of specialization for different reproductive rates. Note that the formation of complex interdependent social groupings is one outcome of at least five different selective pressures. From Eisenberg (1981:442, fig.156).

⚭ = linkage of two traits
S1 = r selection
S'1 = K selection
S2 = selection for high genetically controlled programming of the CNS
S'2 = selection for decreased association of parents and young
S3 = selection for non-reproducing caste
S'3 = selection for a prolonged association between parent and young
S'4 = selection for increased volume of cerebral cortex
S'5 = selection for delayed sexual maturation



A taxonomy of mimetic processes, where 'mimetic' means the process whereby some aspect of the behaviour of one animal, B, comes to be like that of another, A. *From Whiten and Ham (1992:247, fig. 1).*

Figure 5.4

Type of learning	Tool use	Communication
Individual	√ Environmental shaping	√Conventionalization
Social	√ Stimulus enhancement	-
	√ Emulation	√ Emulation of attention getters
Cultural	√ ? Imitation	√ ? Second-person imitation
	-	√ ? Third-person imitation
	X Instructed learning	X Instructed learning

Tomasello's (1990) restrictive definition of cultural transmission,and parsimonious explanation of observed learning patterns, for chimpanzees. (1990:303, Table 10.2)

	interaction type			
mode of social information transfer	age disparity (immature-adult)	kin-kin	dominant-subordinate	broadcast
passive	observing experienced foragers	proximity-based enhancement	observing other dyads	'emotional' calls and facial expressions
active	shaping infant foraging shaping tool-use	recruiting agonistic aid	aggression conciliation	some cases of food calling alarm calling

A matrix of types of social information transfer in monkeys and apes, based on King (1991) with modifications. If 'active transfer' is defined to denote only intentional shaping of another animal's behaviour towards the non-social environment (tool-use, foraging information), the observed occurrence of such transfer becomes minimal.

Figure 5.5

	Actor modifies its behaviour in presence of naive observer	Demonstrated cost (or no benefit) to observer	Demonstrated benefit to naive observer
OPPORTUNITY TEACHING			
Various carnivores	W		
Cheetah	S	S	
Domestic cat	S		S
California sea lion	W		
Killer whale	W		
Chimp (wild) (s&f)	S	S	W
Yellow-eyed junco	W		
Various raptors	W		
Osprey	S		W
COACHING			
Var. nonh. primates	W		
Chimp (Laboratory)	S		
Chimp (wild) (AT)	S		W
Vervet monkey	W#,S*		W*
Cowbird	W		W

From Caro and Hauser 1992:166, Table 3.

Summary table of putative cases of teaching in nonhuman animals, from Caro and Hauser (1992). For wild chimpanzees, s=stimulation, f=facilitation, AT=active teaching. For vervet monkeys, *=punishment, #=encouragement.

Figure 5.6

CHANCE (E.G. 1988) AND STRUM (1987):
DICHOTOMOUS CATEGORIZATIONS OF PRIMATE SOCIETIES

Chance (e.g. 1988) Two modes of primate sociality

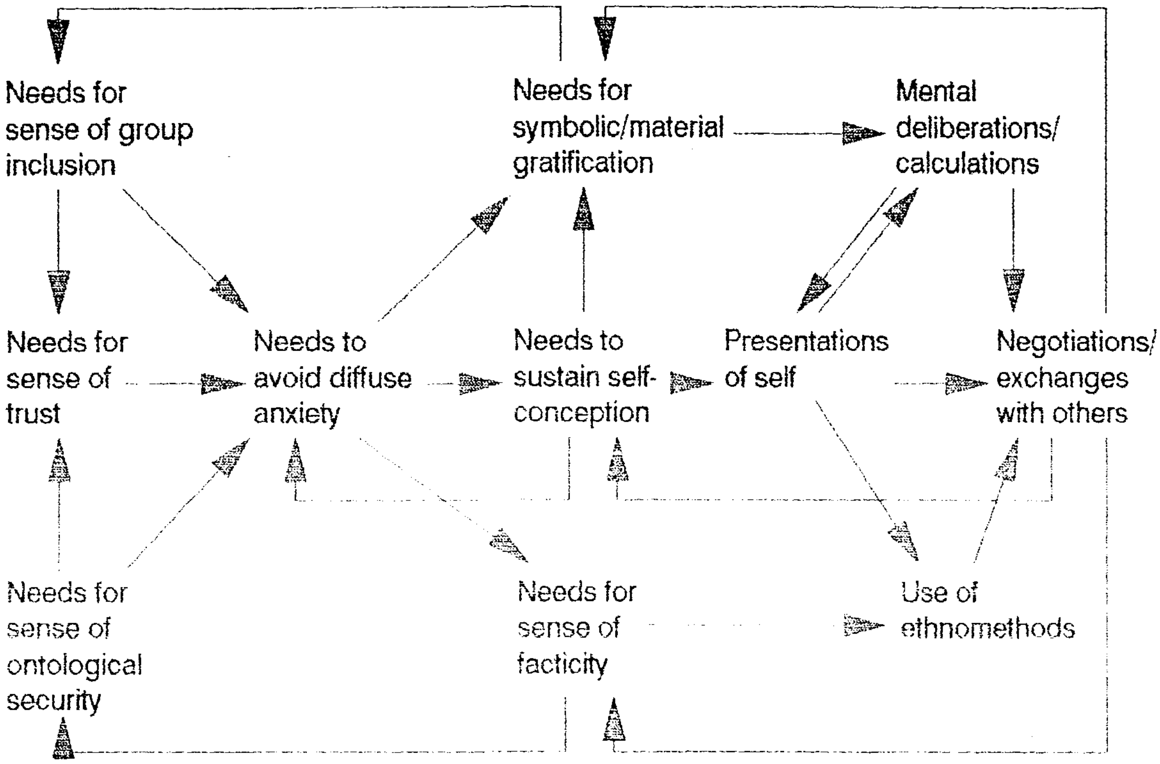
AGONIC	HEDONIC
Savannah baboons, rhesus macaques	Chimpanzees
Cohesion through linear dominance hierarchy, centric direction of attention. Constant tension, high arousal. Inhibited avoidance pattern	Flexibile association Reconciliation, mutual dependence. Attention freed for object manipulation and observation of physical environment Low arousal. Positive, approach behaviour

Strum (1987) Two pathways to primate social complexity

Baboons	Chimpanzees
Large groups Constant association Impossibility of escape High density Costs of aggression	Fission-fusion grouping Assessment problems in social encounters
↓	↓
Selection for social manipulation, systems of social reciprocity	Selection for elaborate reassurance and appeasement repertoire, social intelligence, social manipulation within subgroups

Figure 5.7

Turner's (1987) set of social motivations



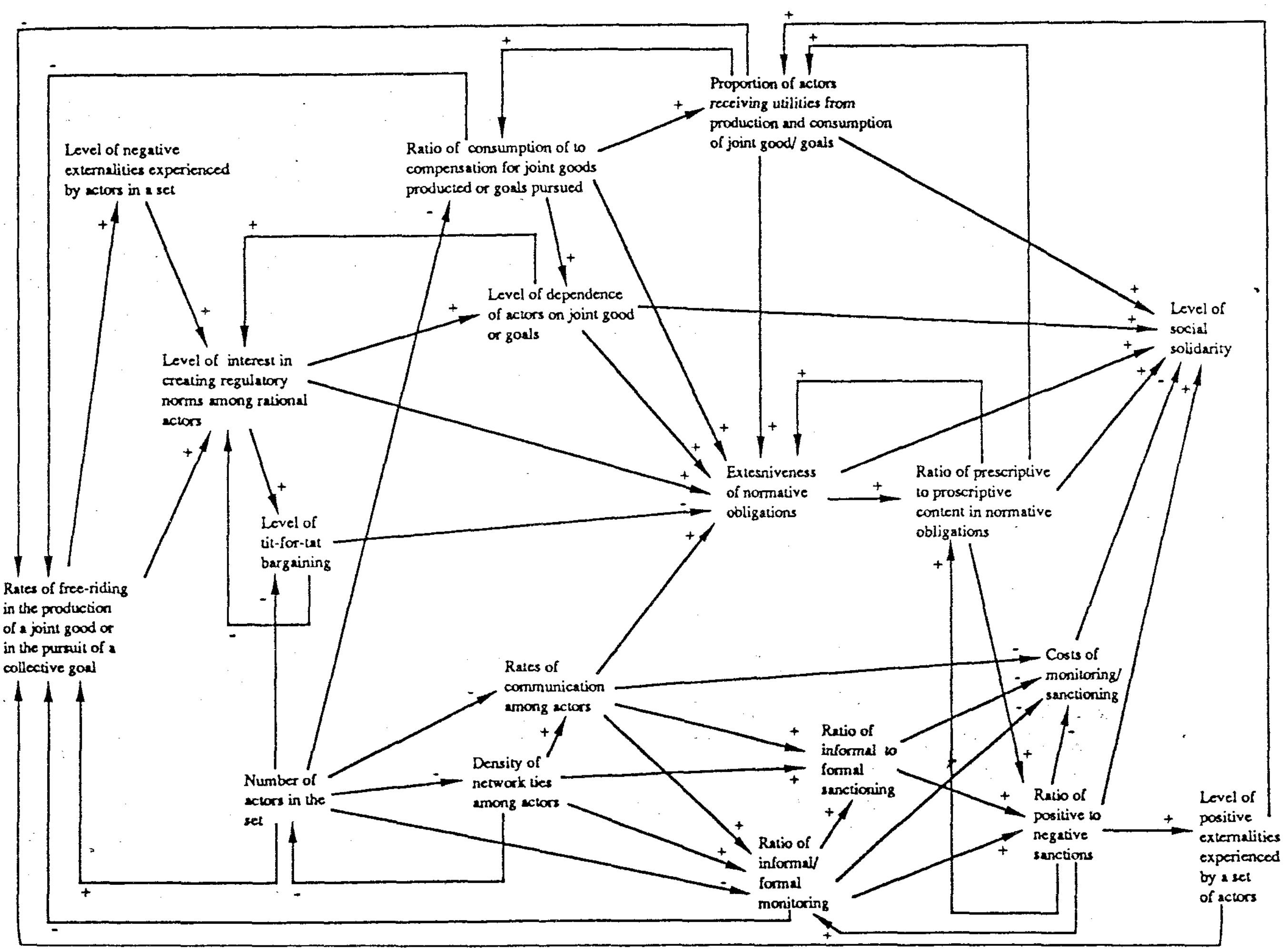
Fiske's four elementary forms of human sociality:
the elementary components of social relationships

FORMAL MODEL	RELATIONSHIP STRUCTURE
Undifferentiated equivalence set (nominal scale)	Communal sharing
Linear ranking (ordinal scale)	Authority ranking
Ordered Abelian group (interval scale)	Equality matching (Tit-for-Tat)
Archimedean ordered field (ratio scale)	Market pricing
[-]	[Asociality]
[-]	[Null interactions]

(cf Fiske 1992)

Figure 6.1

Figure 3: A Synthetic Model of Social Solidarity



Turner's (1992) composite model of the conditions for evolution of solidaristic group behaviour. From Turner (1992:323), Fig. 3.

Figure 6.2

Part of your new clerical job at the local secondary school is to make sure that student documents have been processed correctly. Your job is to make sure the documents conform to the following alphanumeric rule:

"If a person has a 'D' rating, then his documents must be marked code '3'".

You suspect the secretary you replaced did not categorize the pupils' documents correctly. The cards below have information about the documents of four people who are enrolled at this secondary school. Each card represents one person. One side of a card tells a person's letter rating and the other side of the card tells that person's number code.

Indicate only those card(s) you definitely need to turn over to see if the documents of any of these people violate this rule.

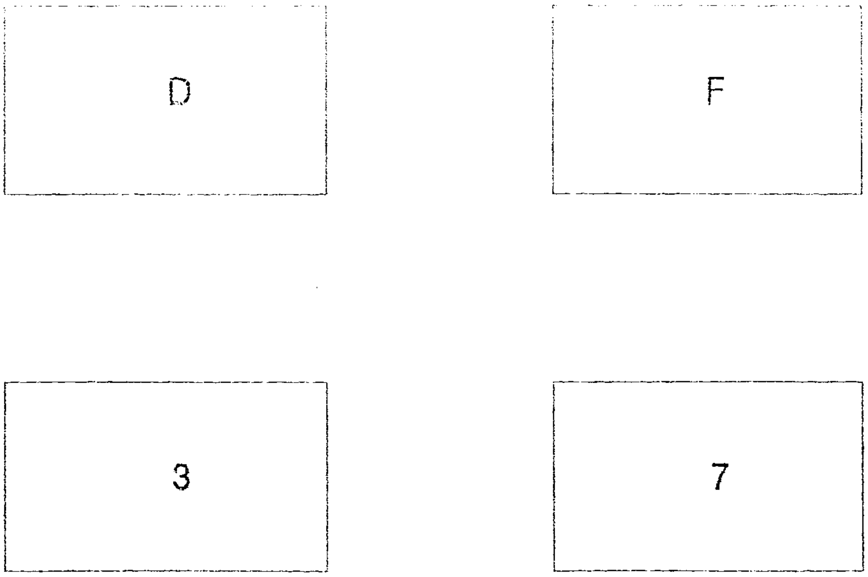
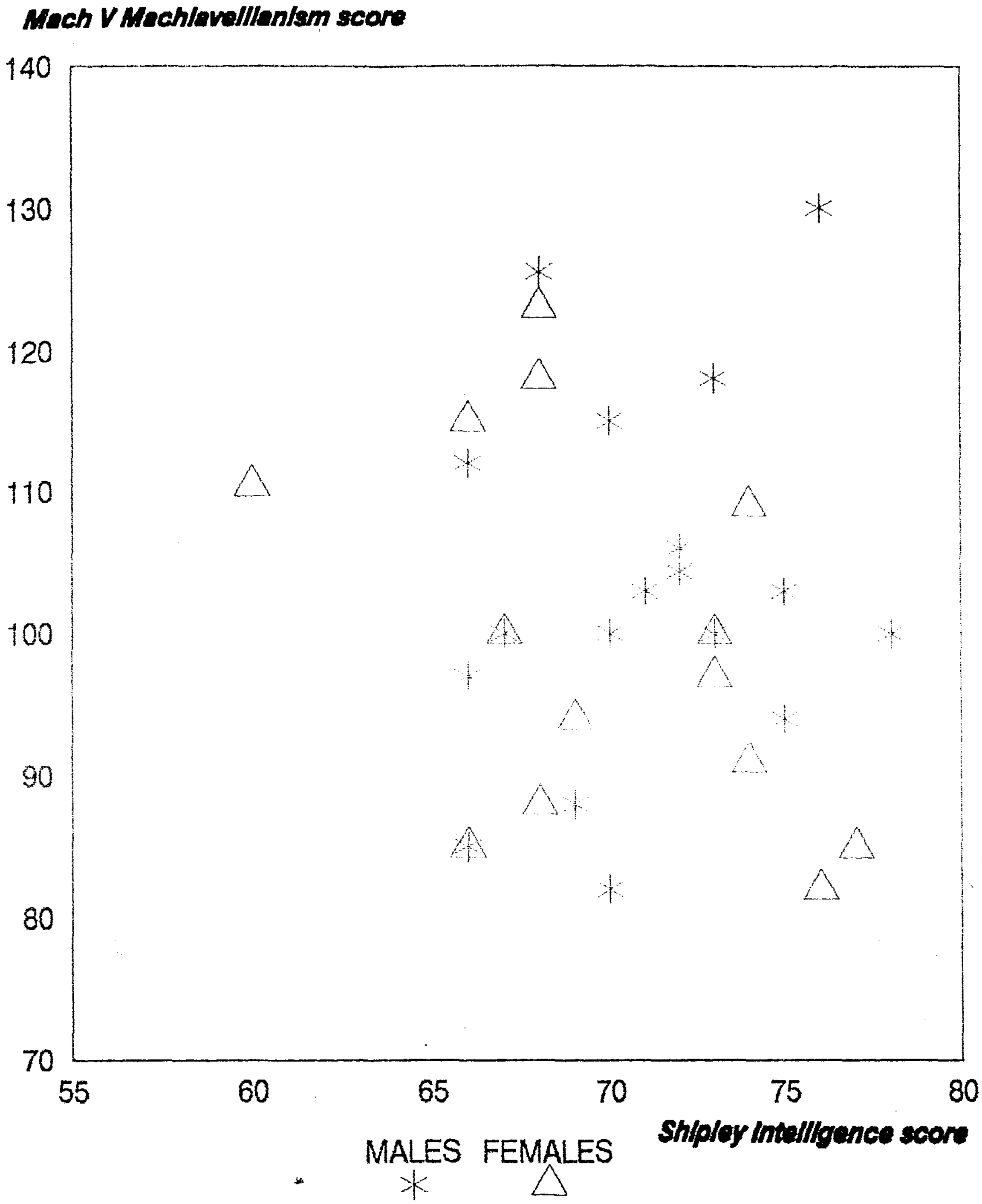
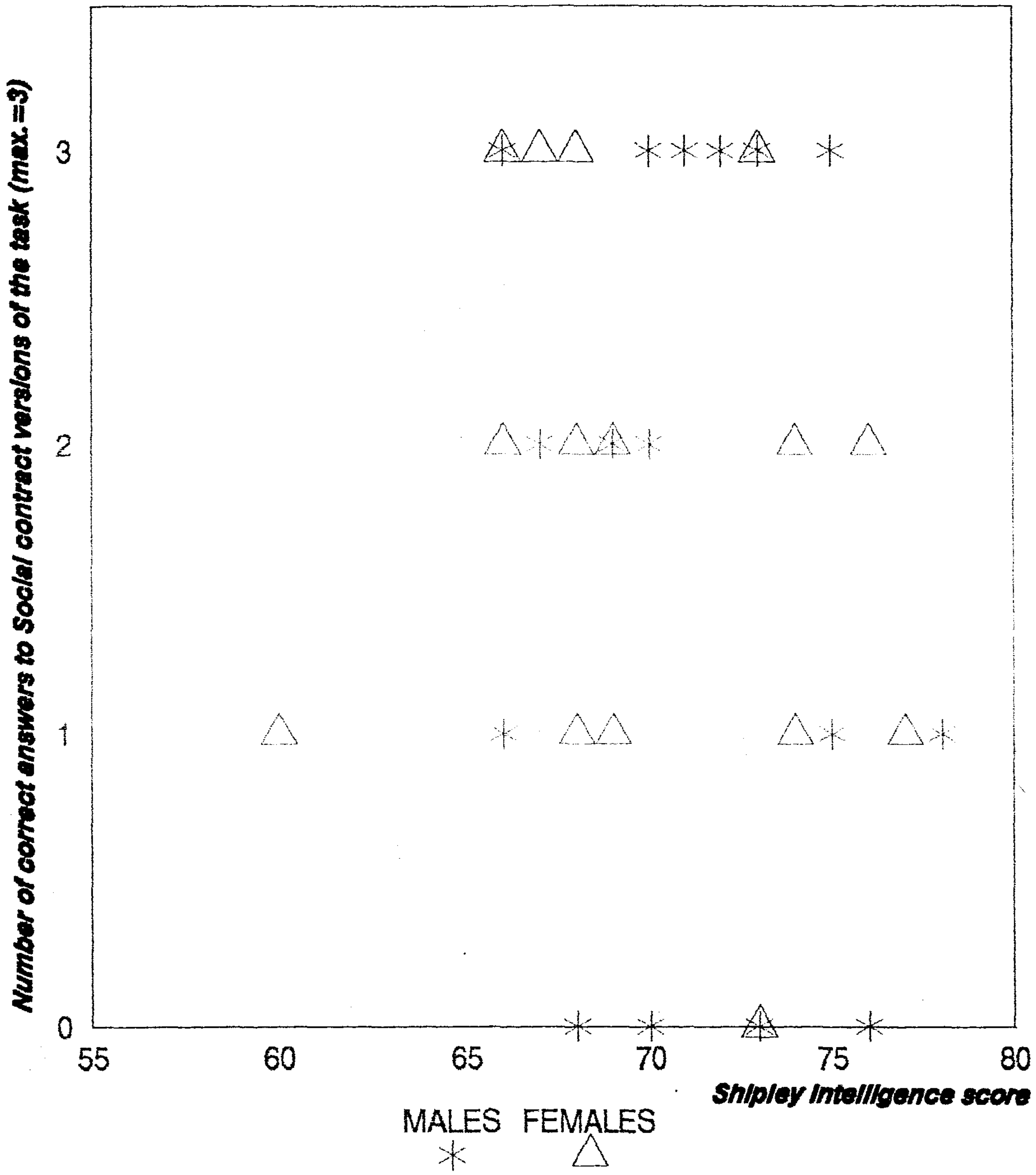


Figure 6.3



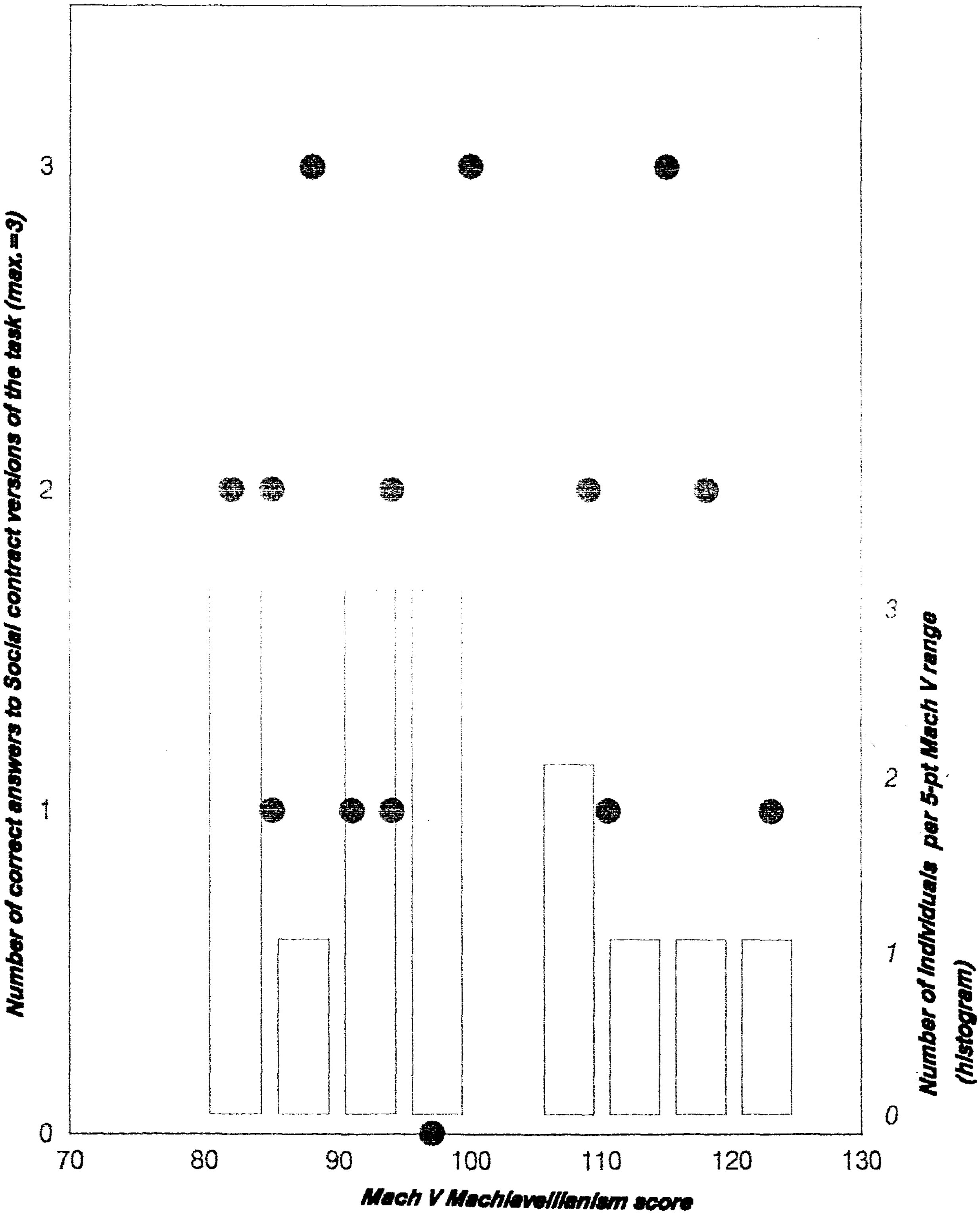
Scatterplot, Mach V against Shipley scores, males (n=18) and females (n=15).

Figure 6.4



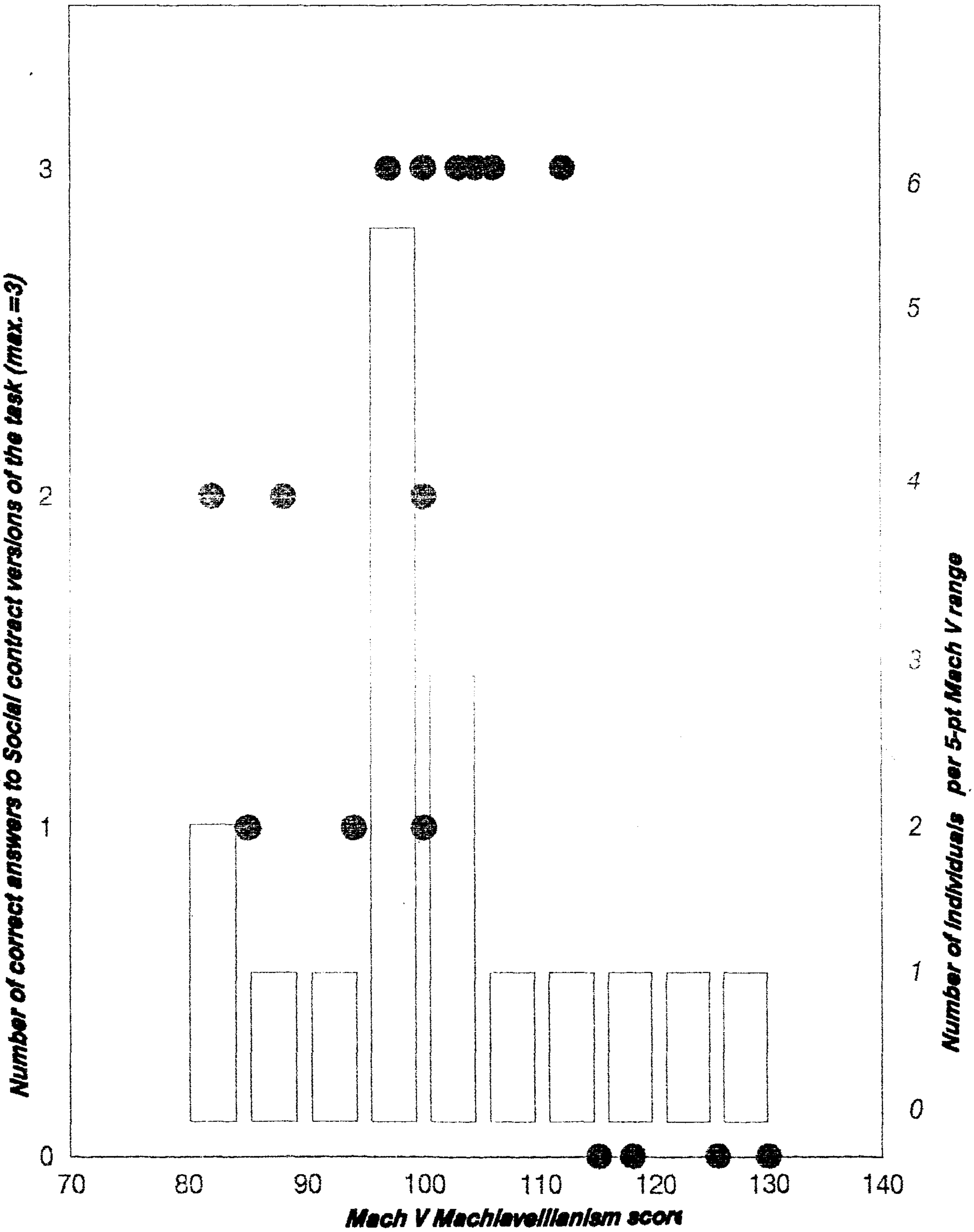
Scatterplot, SC score against Shipley score, males (n=18) and females (n=15).

Figure 6.5



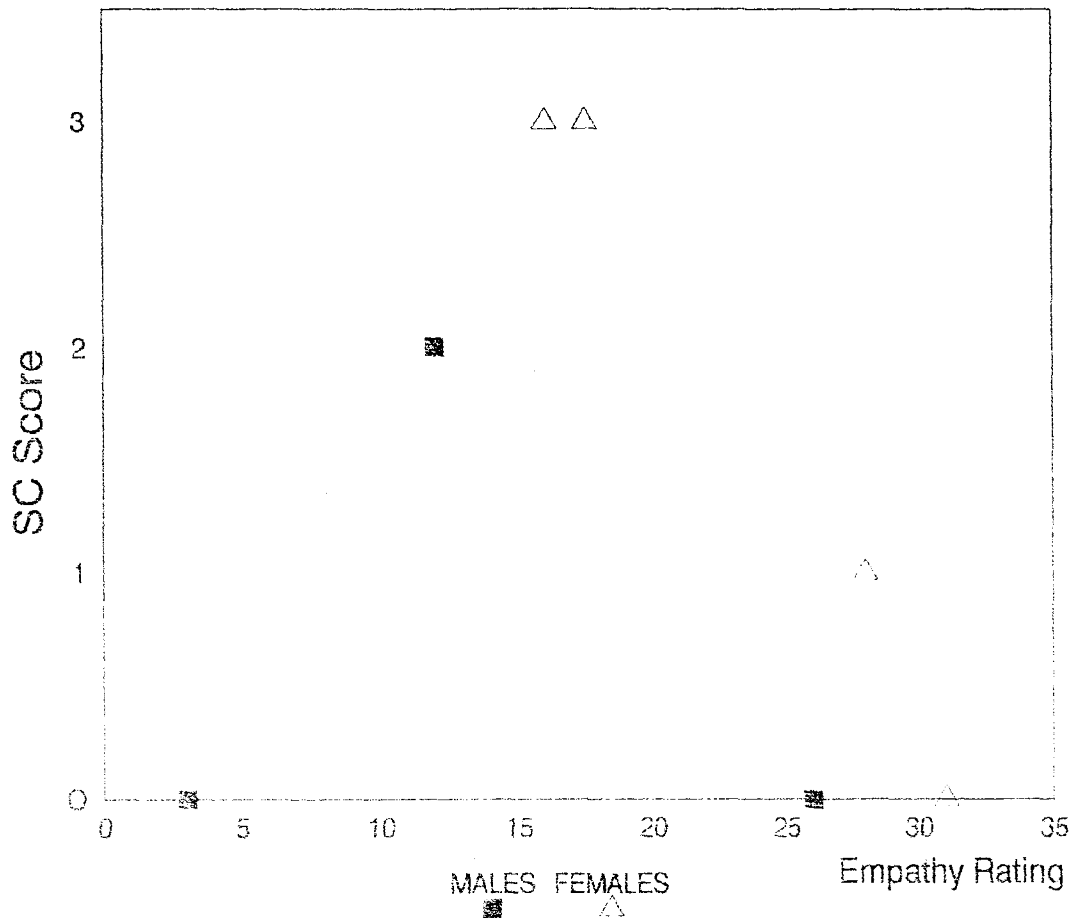
Females

Figure 6.6



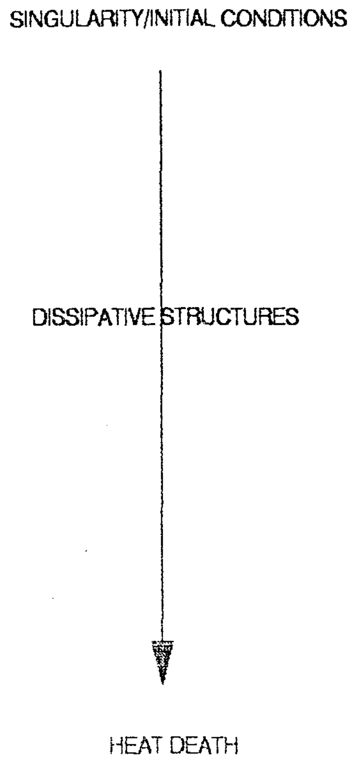
Males

Figure 6.7

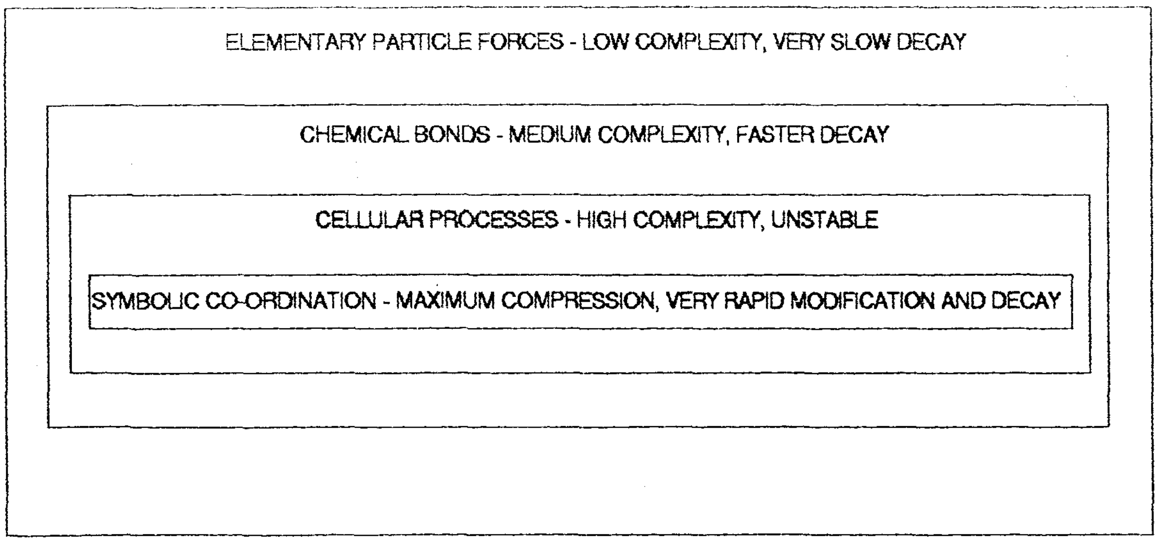


Scatterplot of SC score against Emotional Empathy rating (Hogan Empathy Scale),Experiment 2, n = 7.

Figure 6.8



Time's arrow in a model universe, constrained by the laws of thermodynamics.



Levels of organization as a hierarchy of dissipative structures

Figure 8.1

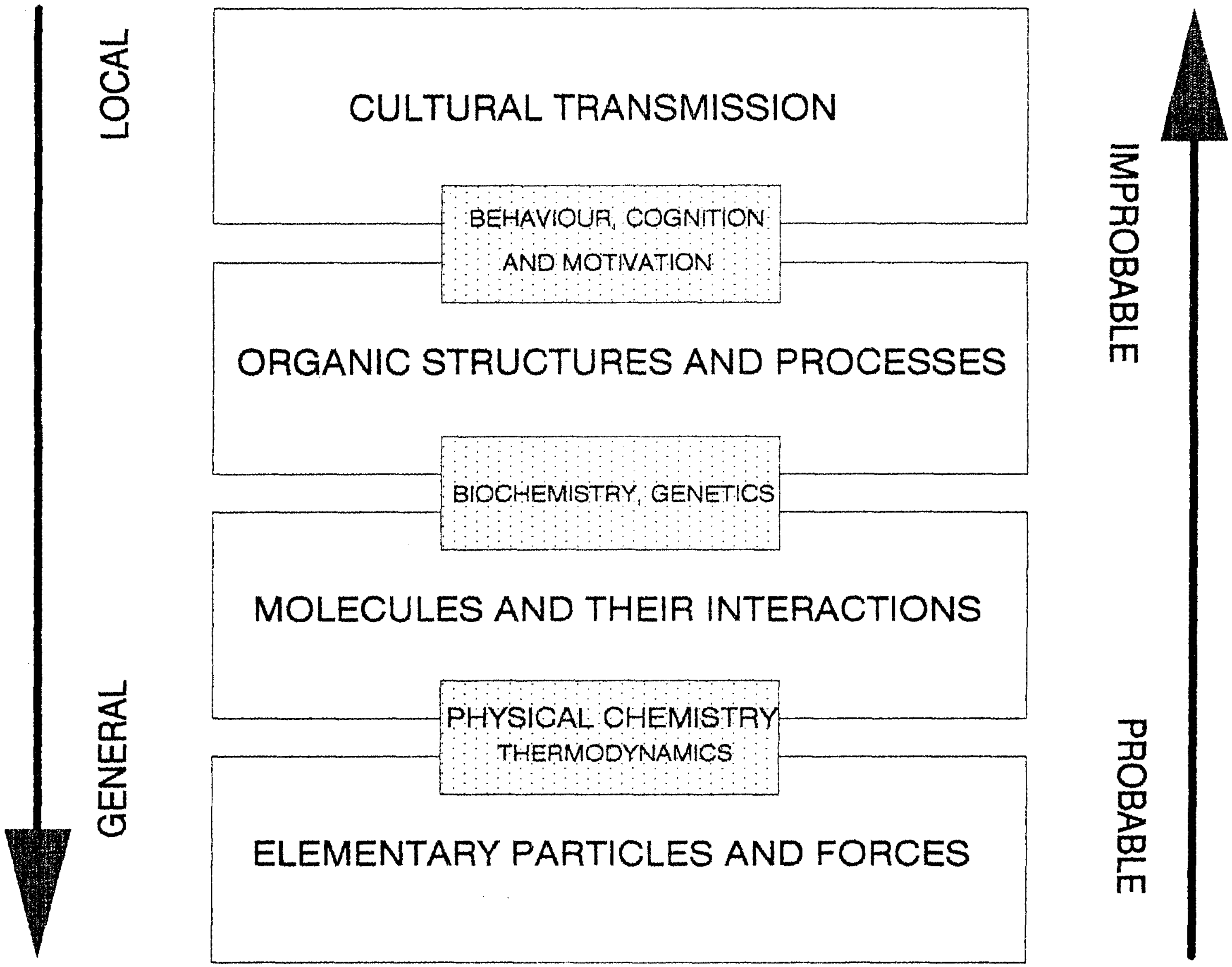

LOCAL
GENERAL
CULTURAL TRANSMISSION
BEHAVIOUR, COGNITION AND MOTIVATION
ORGANIC STRUCTURES AND PROCESSES
BIOCHEMISTRY, GENETICS
MOLECULES AND THEIR INTERACTIONS
PHYSICAL CHEMISTRY THERMODYNAMICS
ELEMENTARY PARTICLES AND FORCES
IMPROBABLE
PROBABLE

Figure 8.2

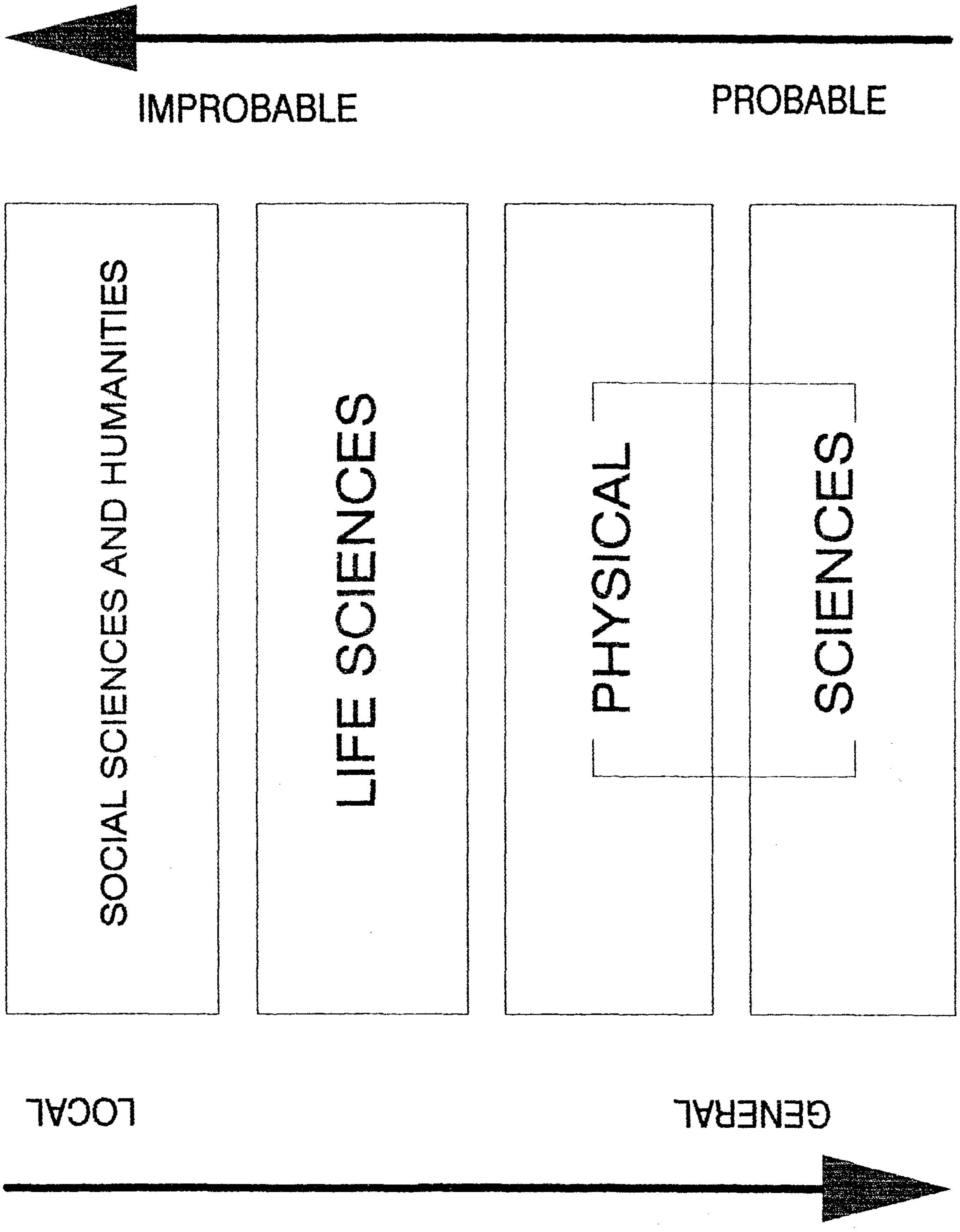

LOCAL
GENERAL
SOCIAL SCIENCES AND HUMANITIES
LIFE SCIENCES
PHYSICAL
SCIENCES
IMPROBABLE
PROBABLE

Figure 8.3

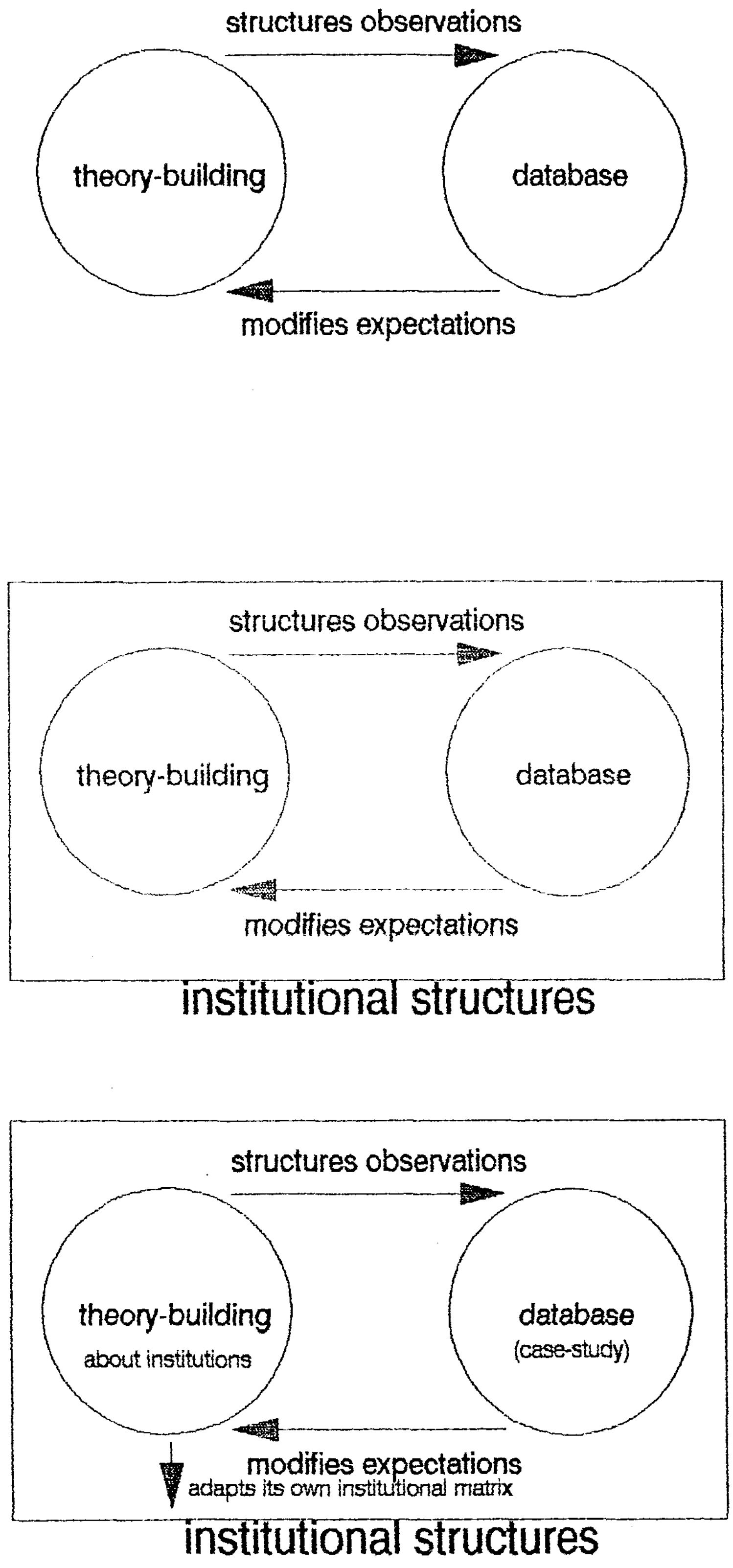
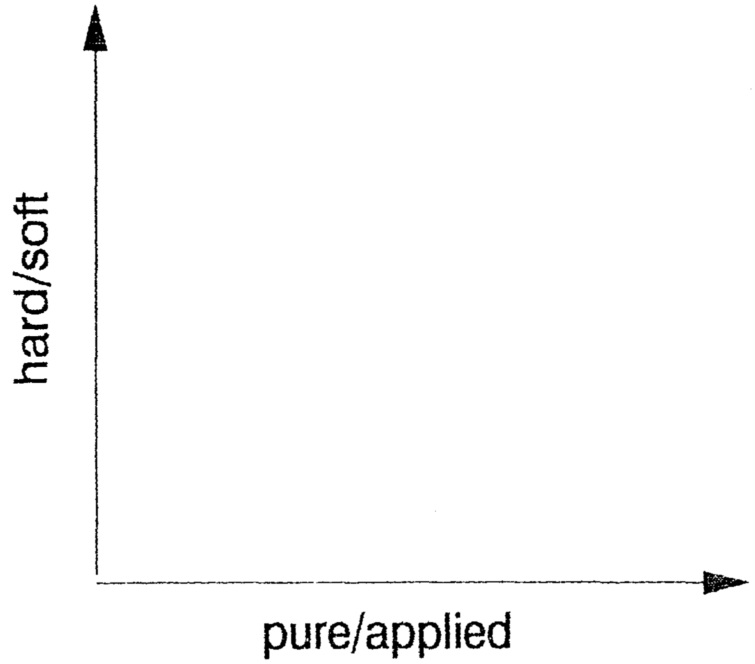
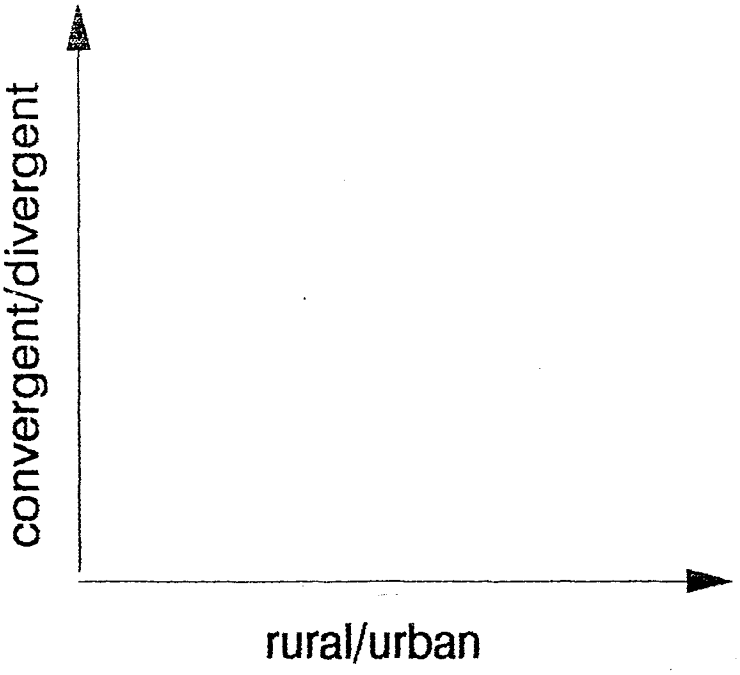

structures observations
theory-building
database
modifies expectations
structures observations
theory-building
database
modifies expectations
institutional structures
structures observations
theory-building
about institutions
database
(case-study)
modifies expectations
adapts its own institutional matrix
institutional structures

Figure 8.4



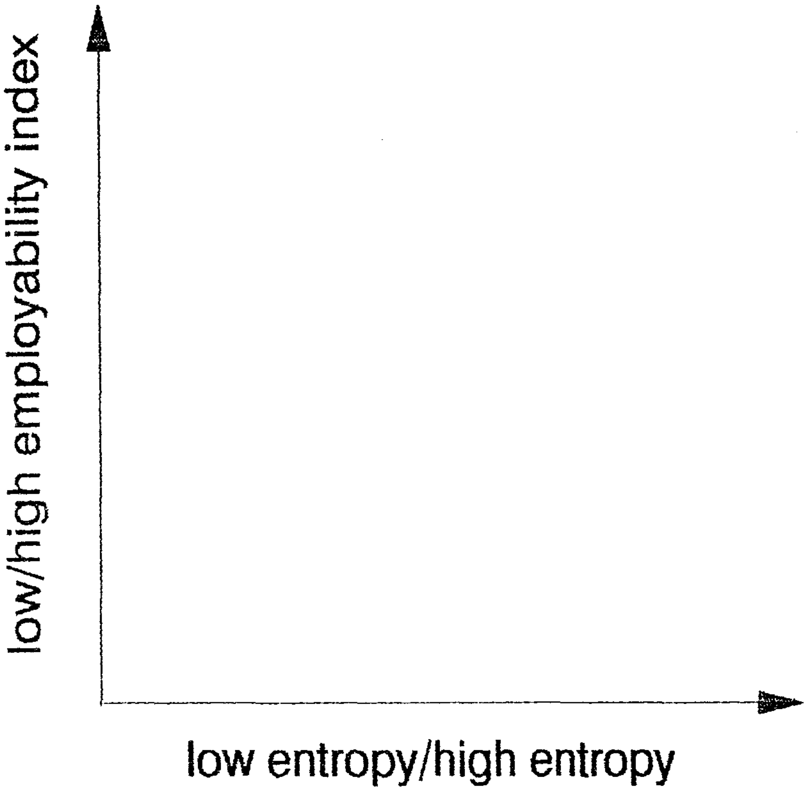
(1) Two cognitive dimensions of disciplinary cultures



(2) Two social dimensions of disciplinary cultures

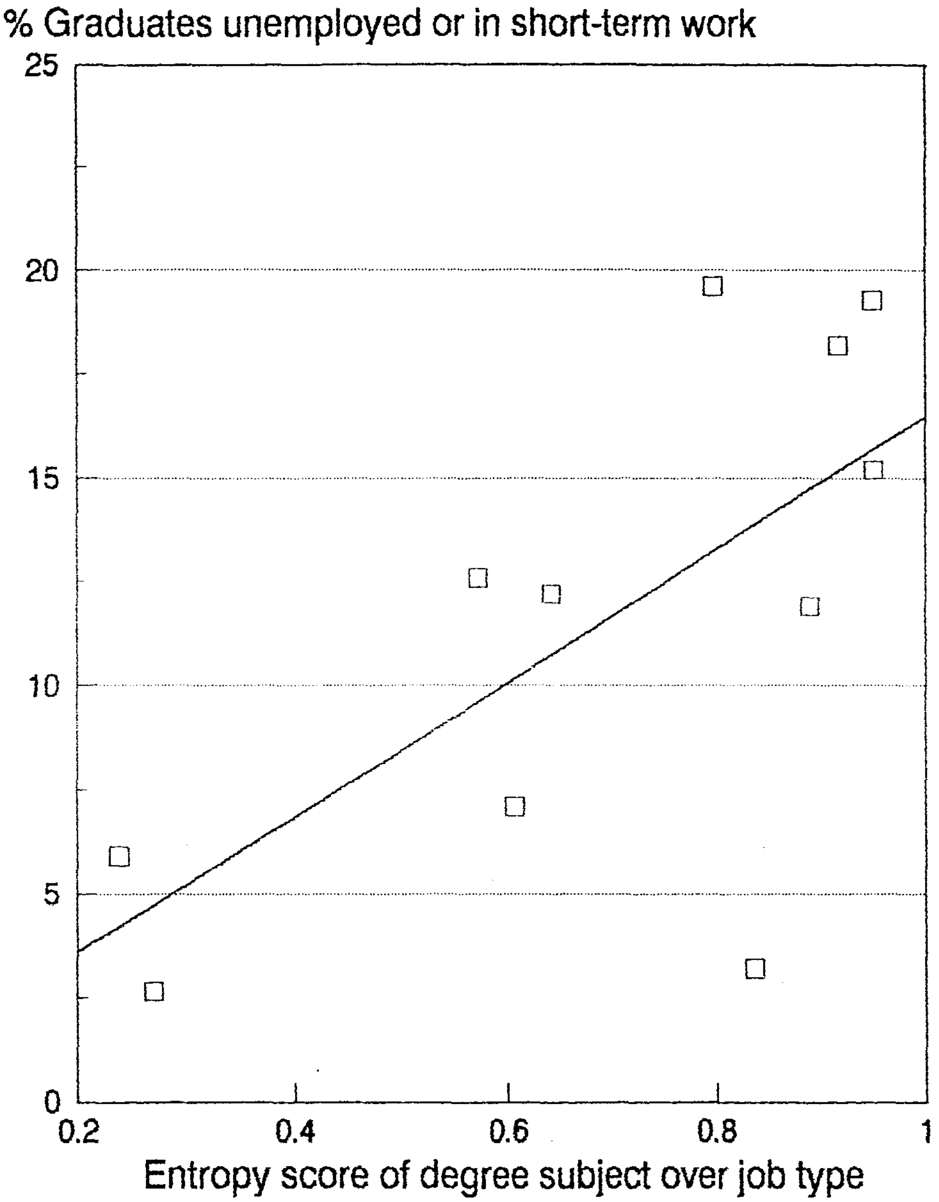
after Becher (1989)

Figure 8.5



(3) Two vocational dimensions of disciplinary cultures

Figure 8.6

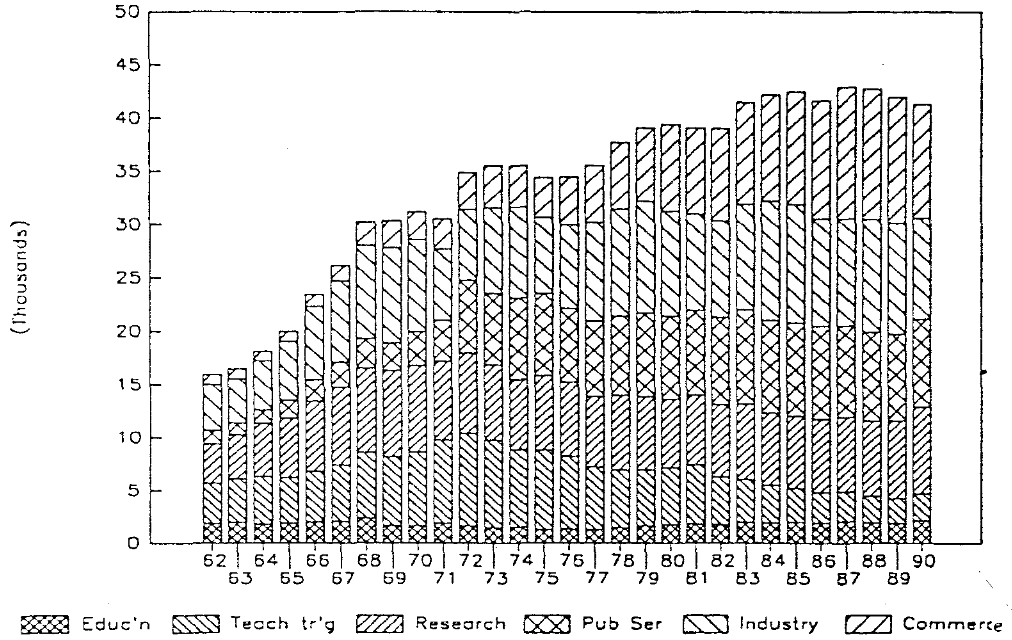


Sources: Dolton (1992), entropy figures.
CVCP (1990) unemployment figures.

Linear regression line plotted, r-squared=0.45.

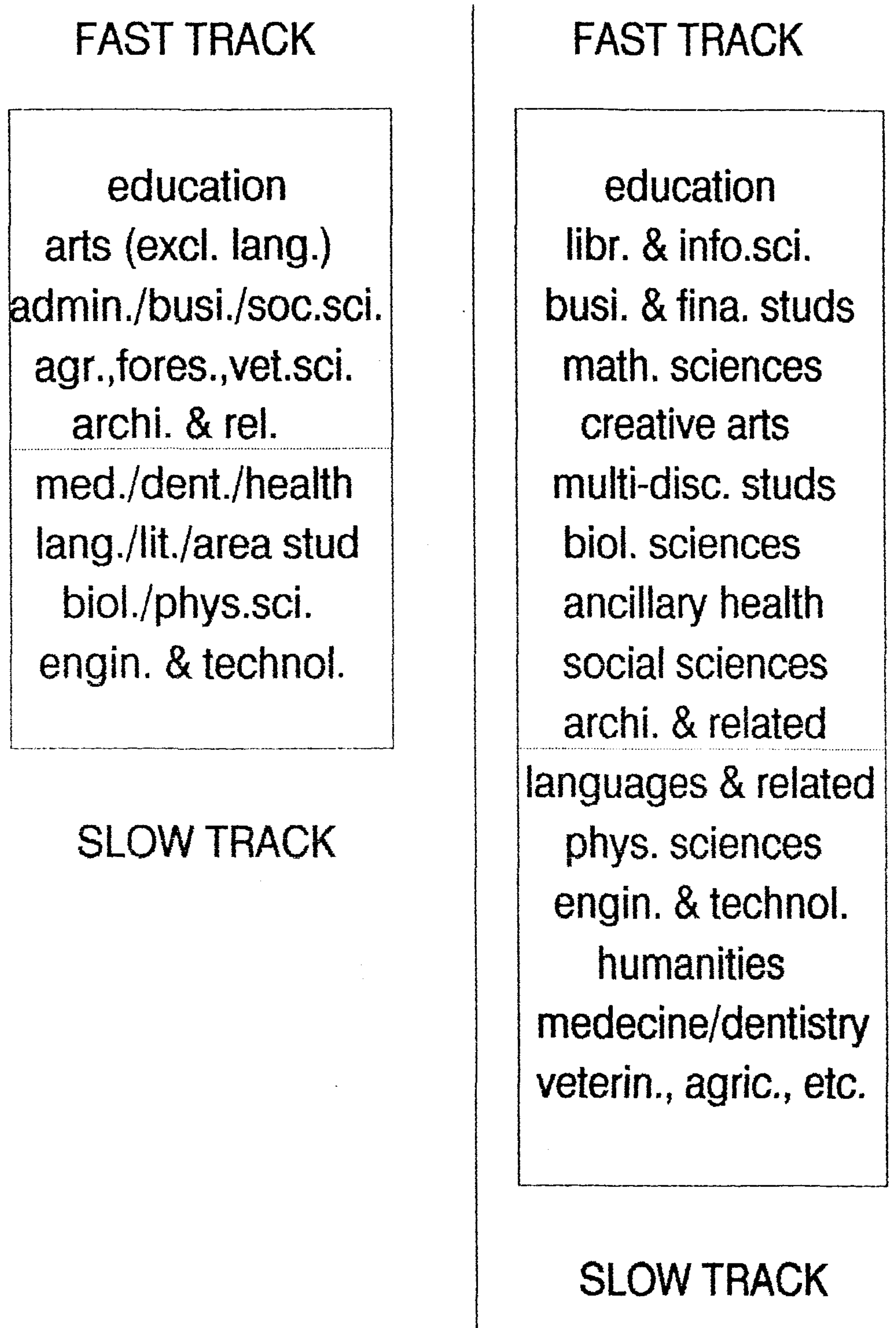
Figure 8.7

Figure 1
University Graduate First Destinations: Numbers, 1962–90



University graduate first destinations: numbers, 1962-90.
From Dolton 1992: Figure 1.

Figure 8.8

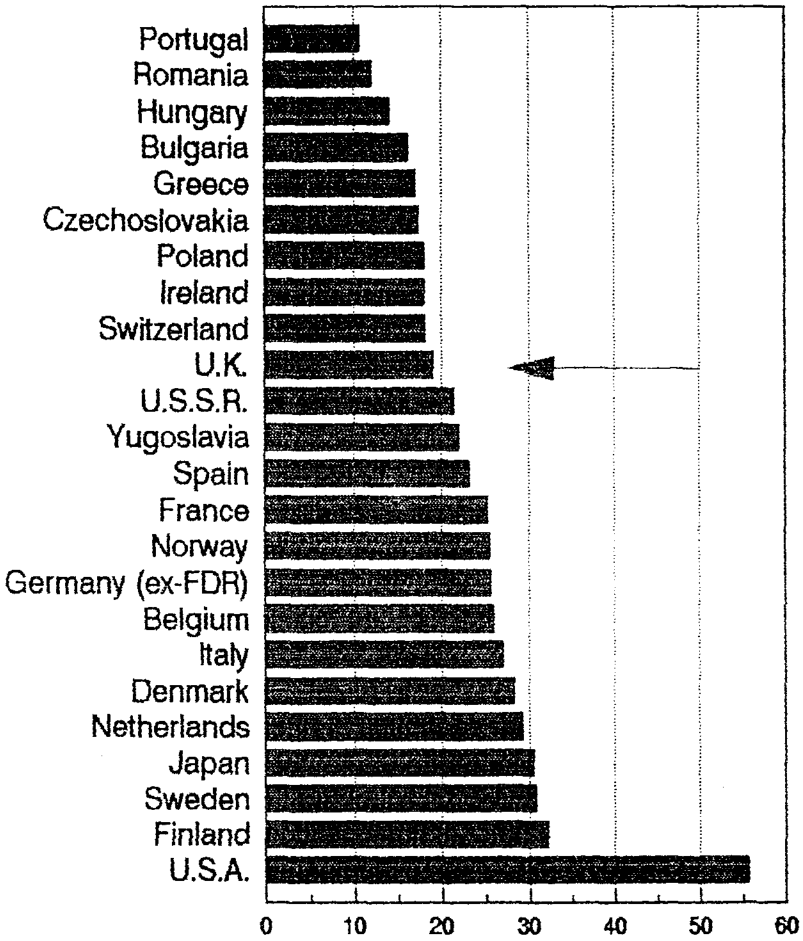


Old subject groups, 1966-1981 New subject groups, 1979-89.

Relative growth by subject group. Overall grwoth rate: dotted line.
Data from tables 0001, 0002.

Figure 8.9

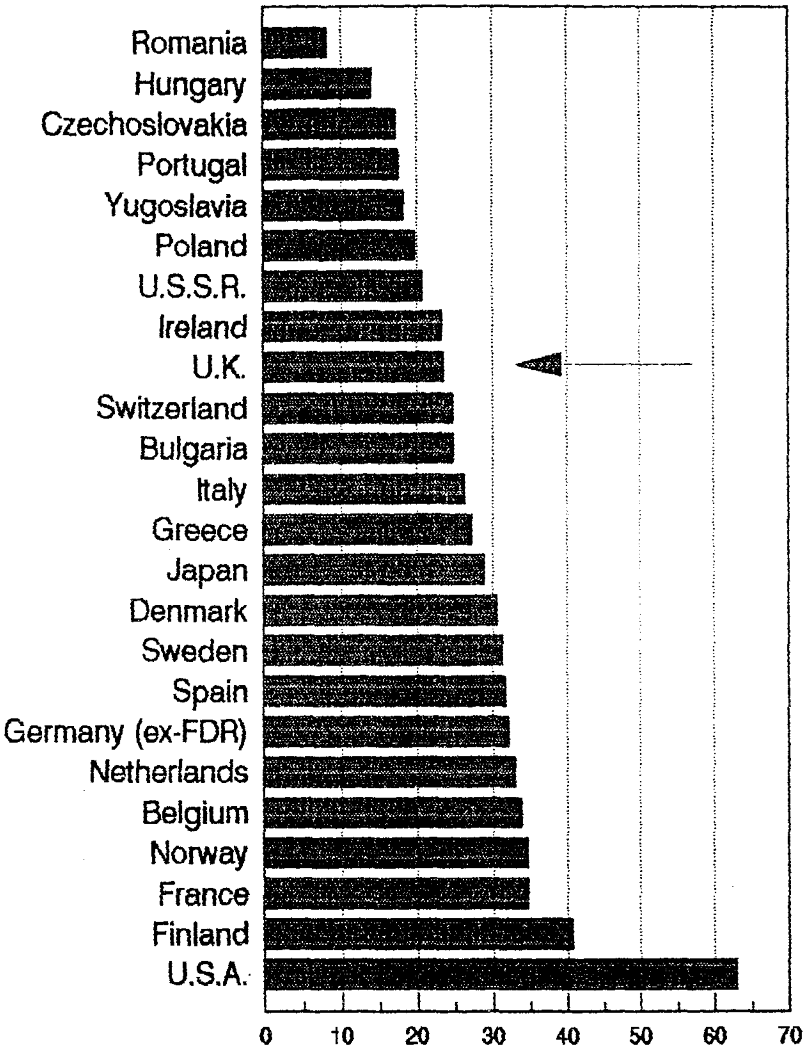
1980 enrolment as a % of population aged 19-23



Source: World Education Report 1991, UNESCO.

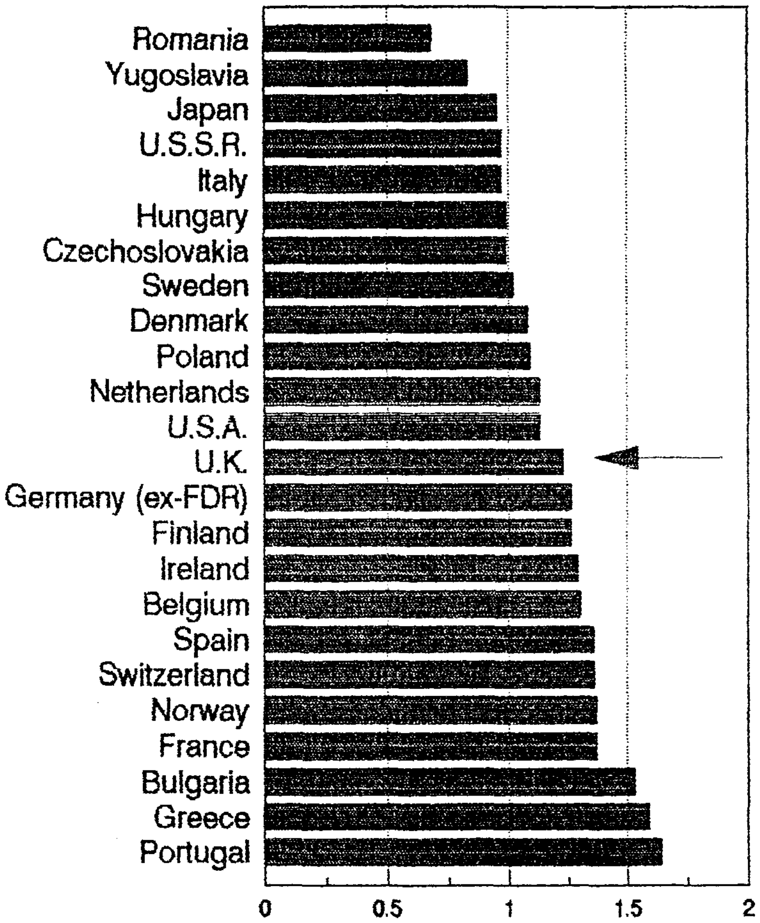
Figure 8.10

1988 enrolment as a % of population aged 19-23



Source: World Education Report 1991, UNESCO.
after Williams (1992), corrected

Figure 8.11

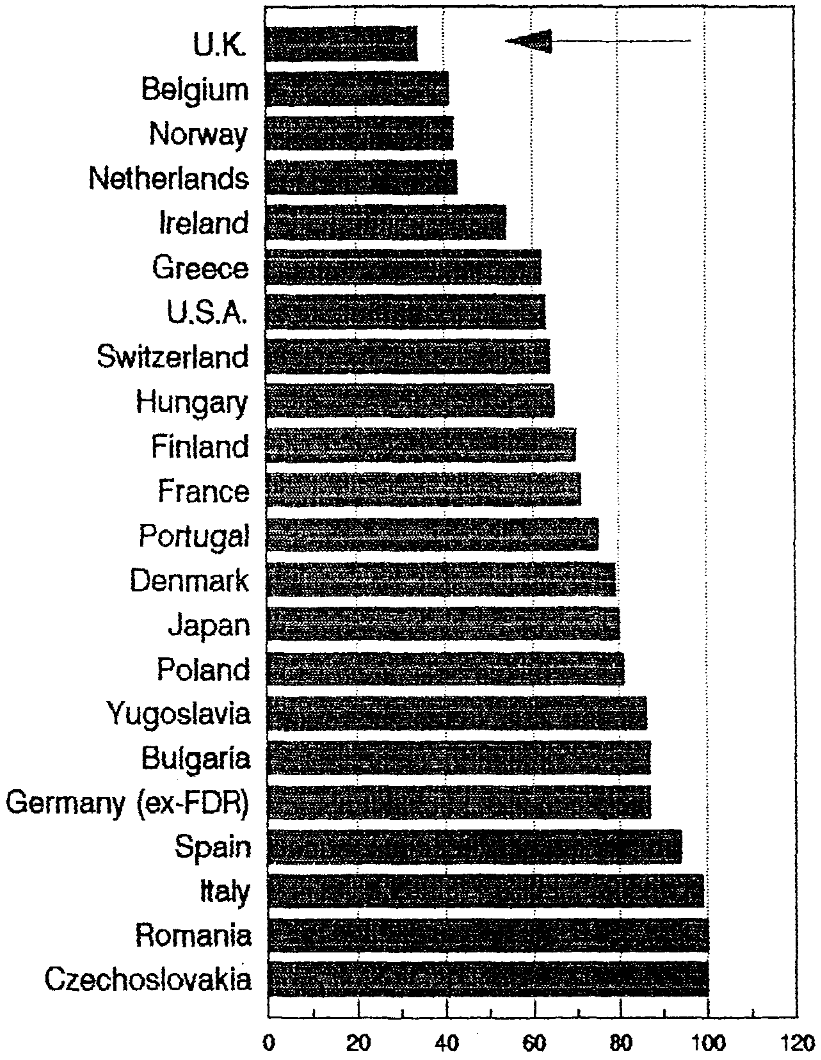


1988 enrolment rate as a multiple of 1980 rate

Source: derived from World Education Report 1991
UNESCO

Figure 8.12

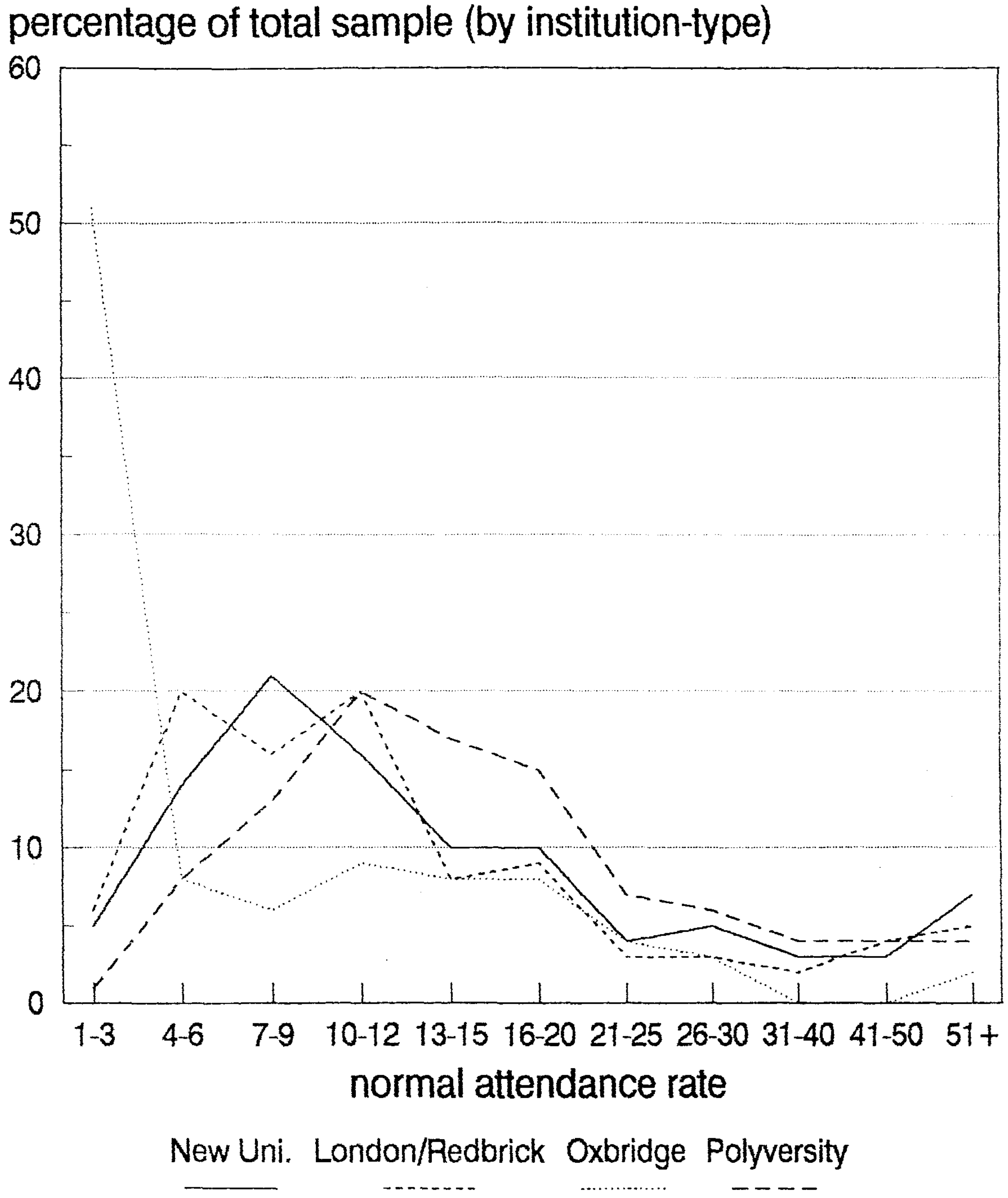
University enrolment as a % of total, 1988.



Source: World Education Report 1991, UNESCO

Figure 8.13

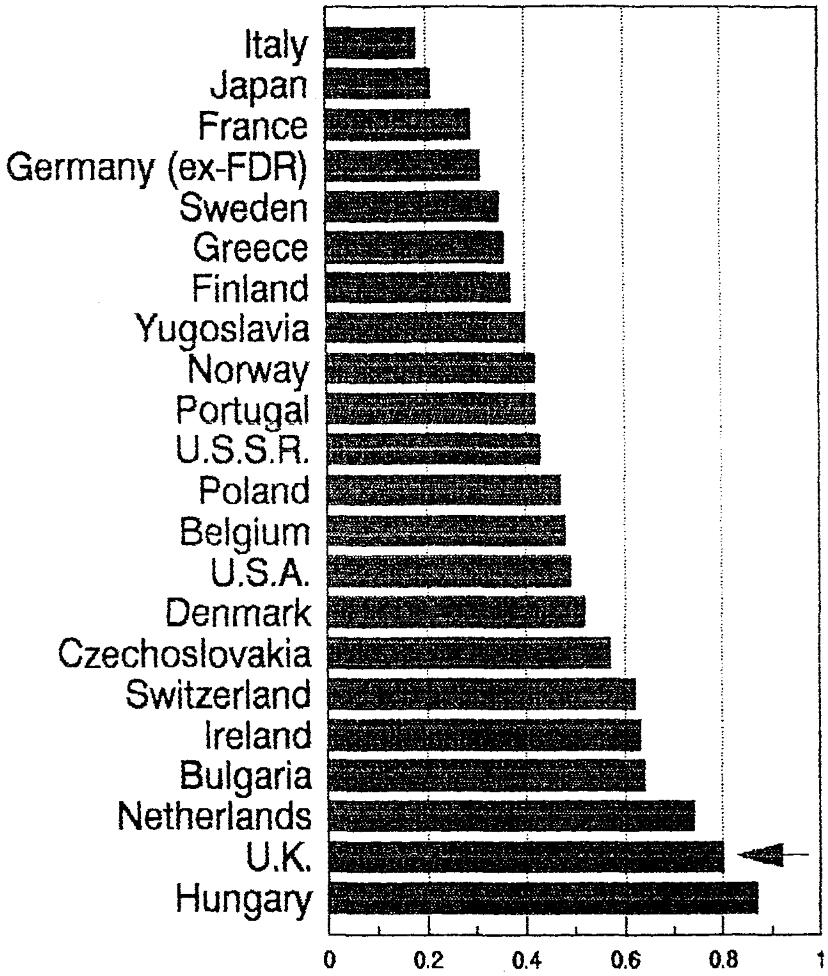
Average student attendance in normal teaching groups, by type of H.E. institution, U.K. (1992)



Source: ICM Poll, 1558 students, The Guardian, 22.9.1992.

Figure 8.14

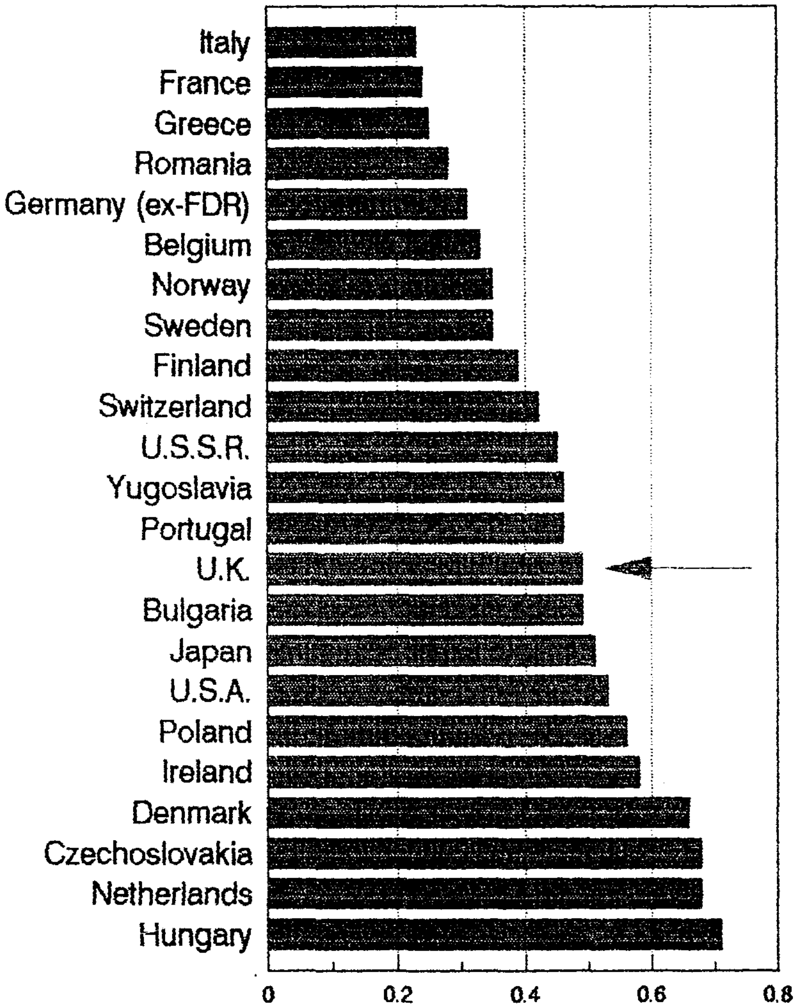
Public expenditure per student as % of per capita GNP, 1980.



Source: World Education Report 1991, UNESCO.

Figure 8.15

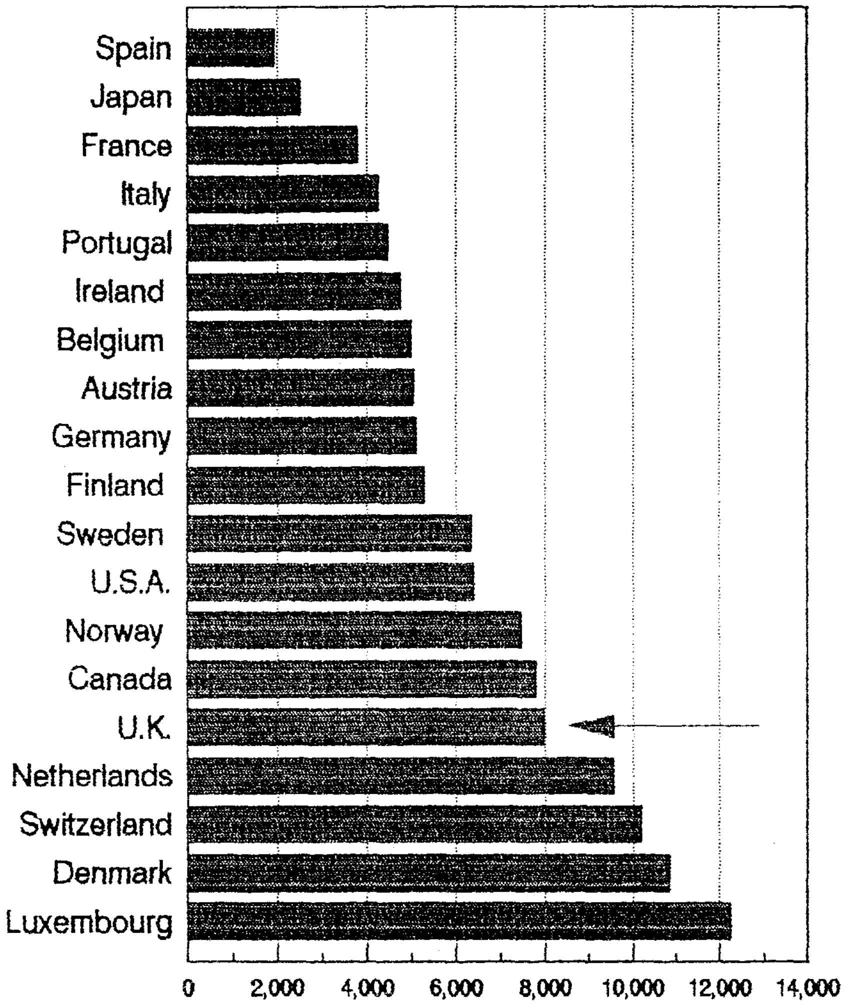
Public expenditure per student as % of per capita GNP, 1988.



Source: World Education Report 1991, UNESCO.

Figure 8.16

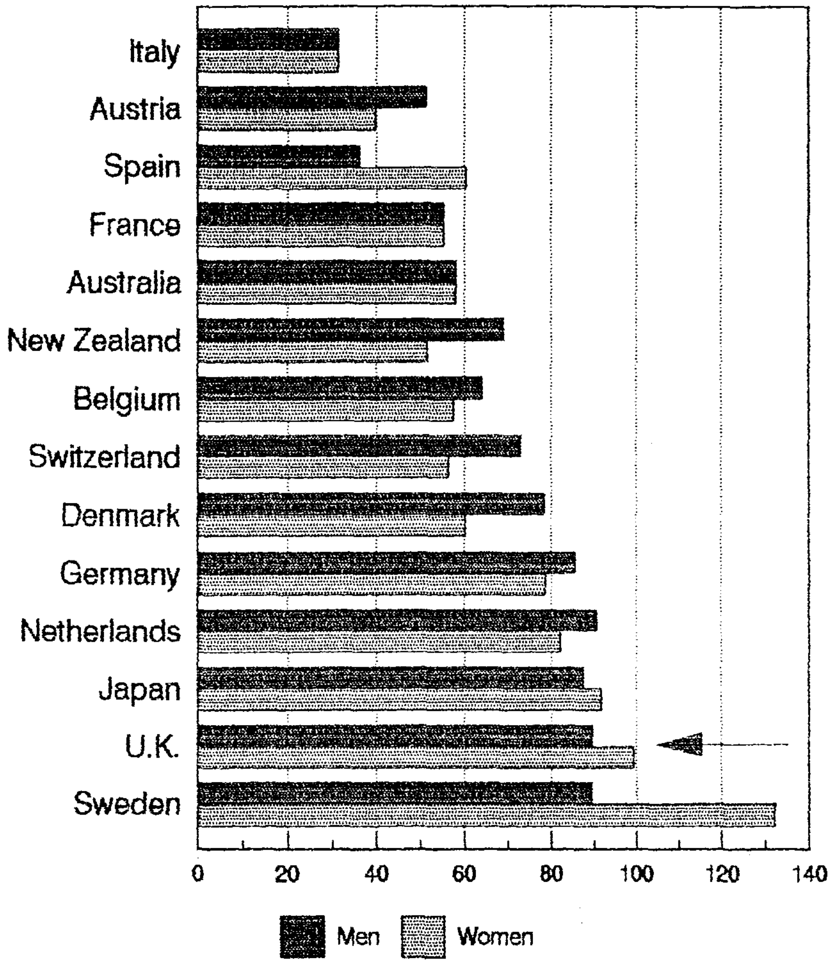
Public expenditure per student, OECD countries, U.S. Dollar equivalent, 1988.



Source: Education at A Glance: OECD Indicators (OECD, 1992).

Figure 8.17

Higher education in OECD countries: rates of student survivorship to graduation, 1988.



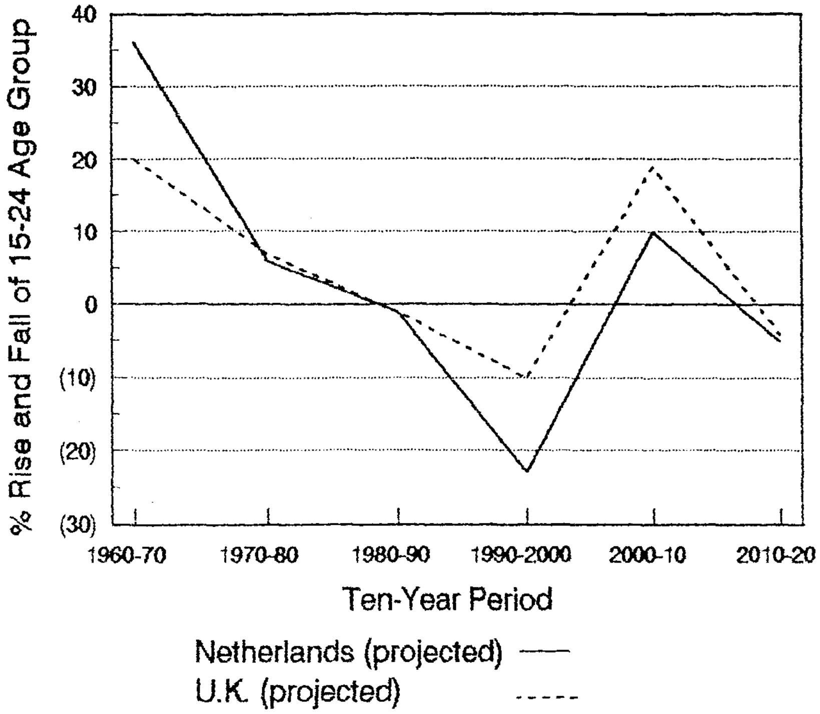
Source: Education at a Glance: OECD Indicators (OECD 1992).

Note: France, Australia: total rate, M + F comb.

Figure 8.18

CHANGING AGE STRUCTURE IN TWO EUROPEAN STATES:

THE NETHERLANDS AND THE U.K.



Projections from Amann (1985)

EFFECTS OF CHANGING AGE STRUCTURE ON PUBLIC SPENDING: THE NETHERLANDS (PROJECTED)

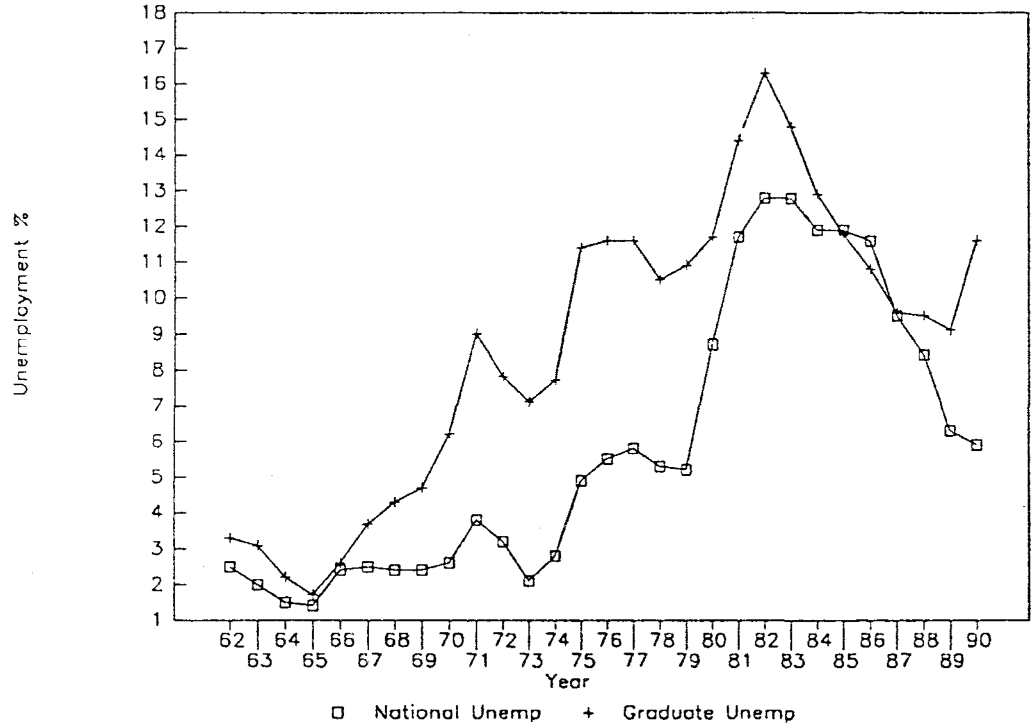
Netherlands public spending projections in 1981
as a consequence of demographic trends (low variant), 1981-2030 (1981=100)

	1981	1990	2000	2010	2020	2030
social security	100	111	121	131	139	140
education	***100***	***85***	***80***	***77***	***67***	***63***
public health	100	111	118	123	129	140
welfare services	100	104	112	120	129	140
total	100	105	112	118	122	123

source: Amann (1985), citing van den Brekel

Figure 8.19

Figure 4
Graduate and UK Unemployment:
Trends 1962–90



**Graduate and U.K. unemployment: trends, 1962-90.
From Dolton 1992: Figure 4.**

Figure 8.20

Figure 6
Graduate Unemployment Trends by Faculty:
1961/2–1989/90

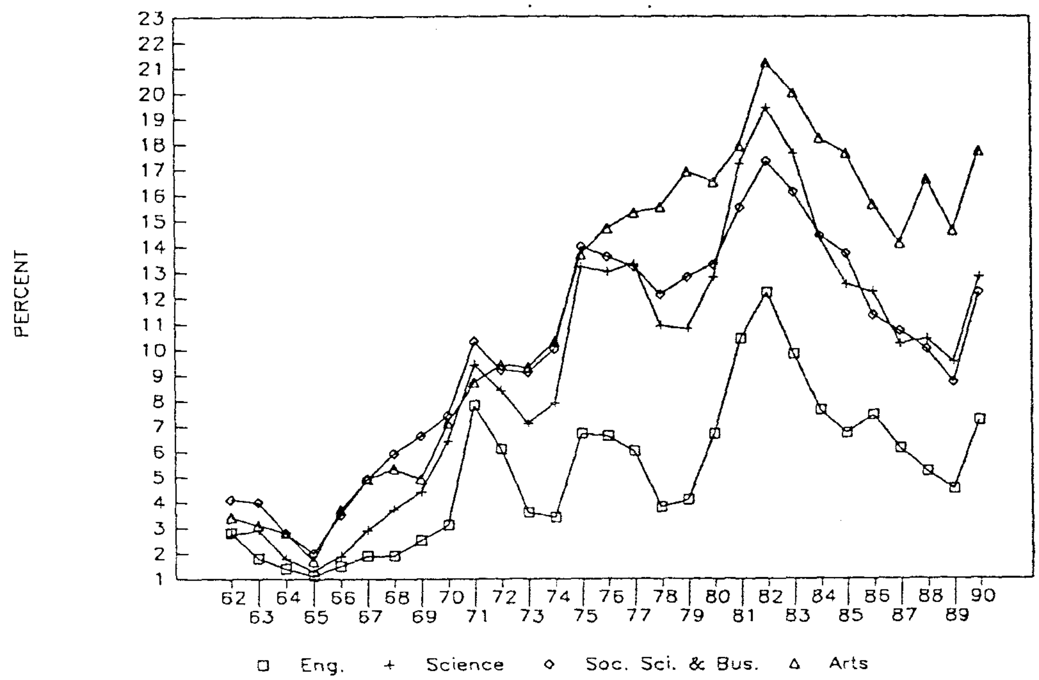
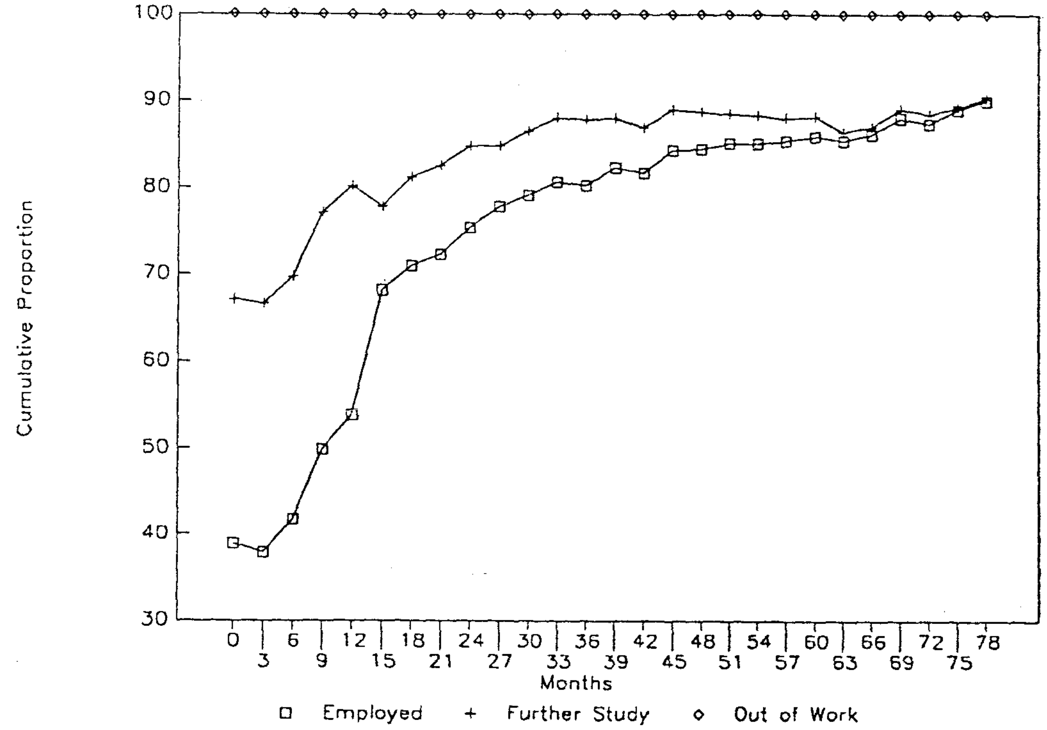
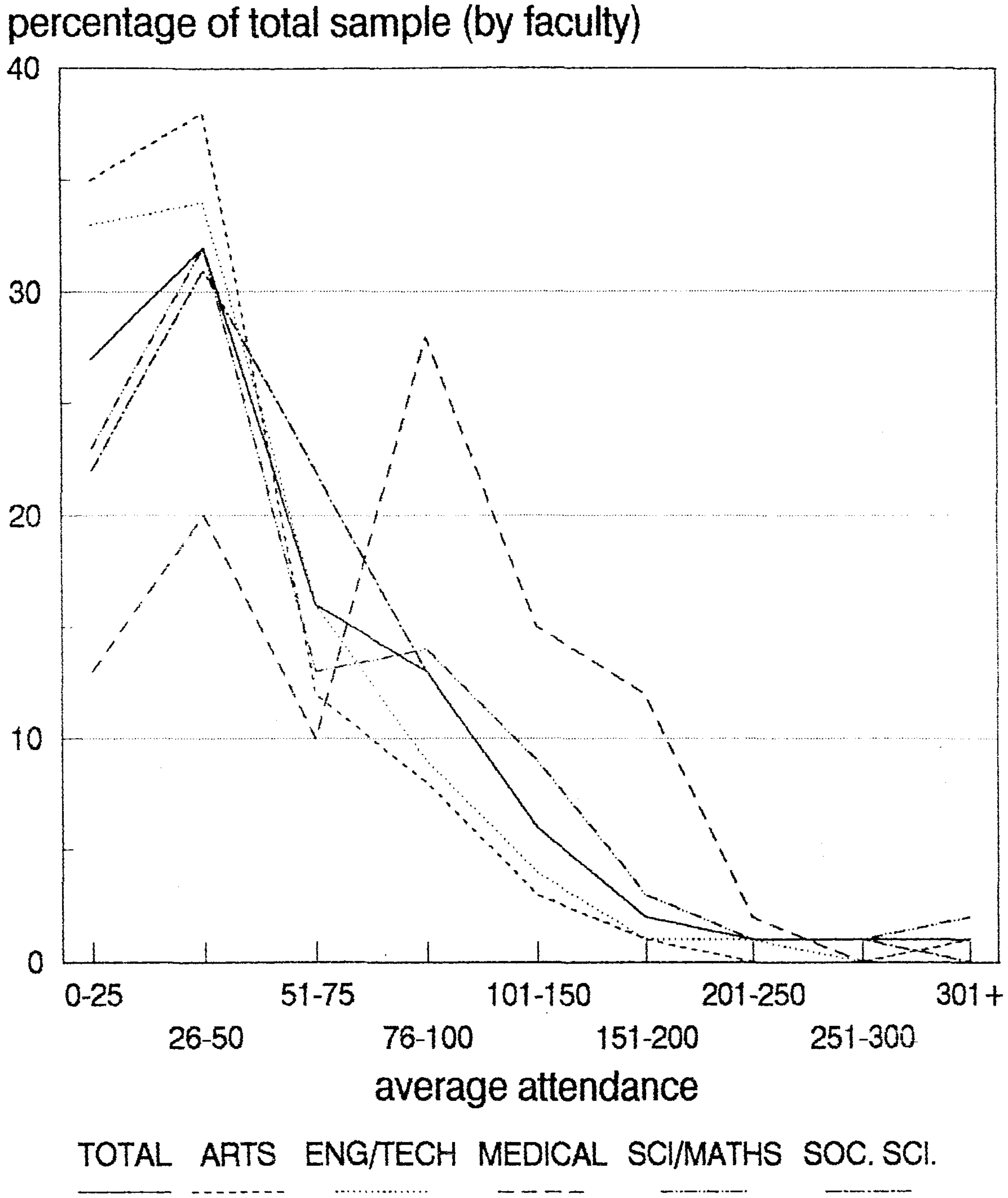


Figure 11
Arts: Proportions in States
(1980–7)



(a) Graduate Unemployment trends by faculty, 1961/2 - 1989/90
(b) Arts graduates, year Of 1980: Proportions in states over the first seven years since graduation.
From Dolton 1992: Figures 4, 11.

Figure 8.21

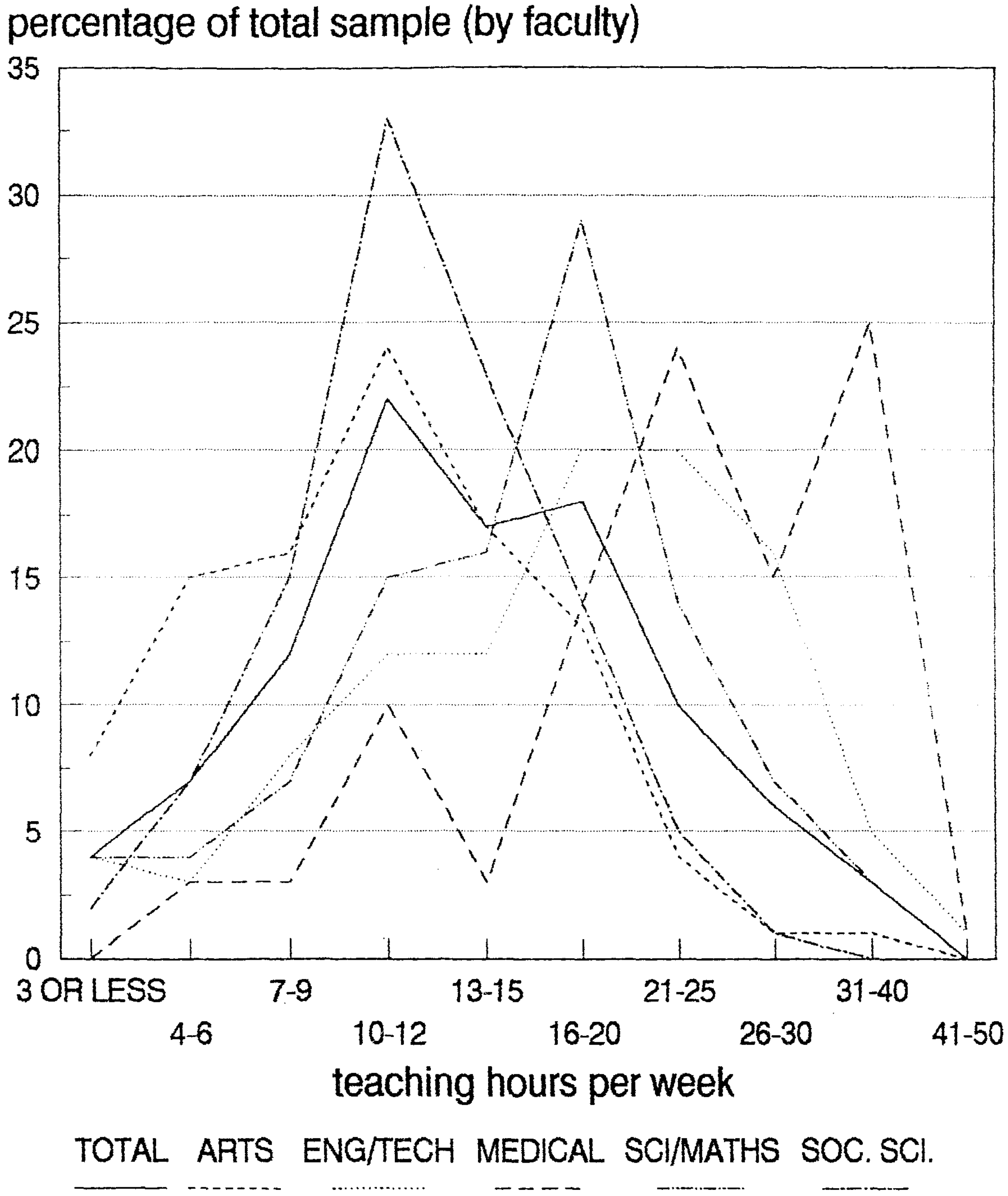


Esstimated average attendance at formal lectures (by faculty), U.K. H.E. first degrees (1992).

Source: ICM Poll, 1558 students, The Guardian
22.9.1992.

Figure 8.22

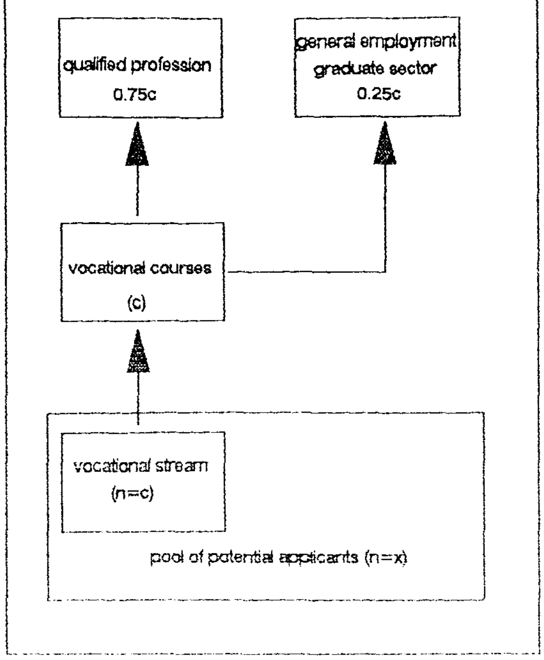
Average number of hours teaching per week, U.K. H.E. first degrees, by faculty (1992).



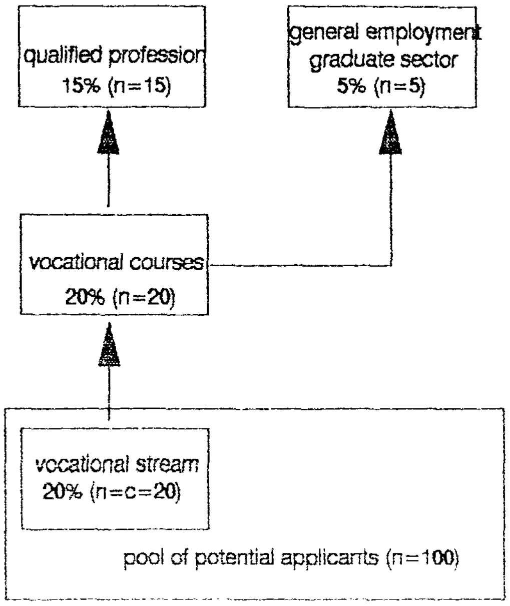
Source: ICM poll, 1500 students, The Guardian
22.9.1992.

Figure 8.23

A MODEL OF PRODUCTION FOR A VOCATIONAL COURSE
WITH CONSTANT RECRUITMENT LEVELS (c=constant)



A MODEL OF PRODUCTION FOR A VOCATIONAL COURSE
WITH CONSTANT ABSOLUTE RECRUITMENT LEVELS,
AND STABLE APPLICATIONS TO THE TOTAL COURSE SYSTEM



A MODEL OF PRODUCTION FOR A VOCATIONAL COURSE
WITH CONSTANT ABSOLUTE RECRUITMENT LEVELS,
AND EXPANDED APPLICATIONS TO THE TOTAL COURSE SYSTEM

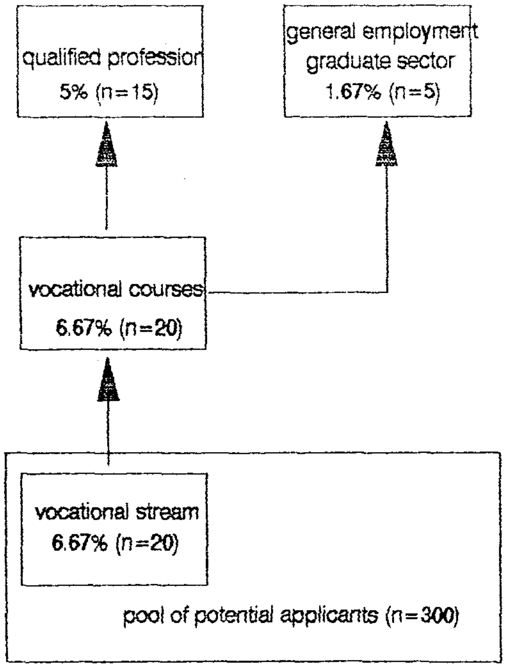
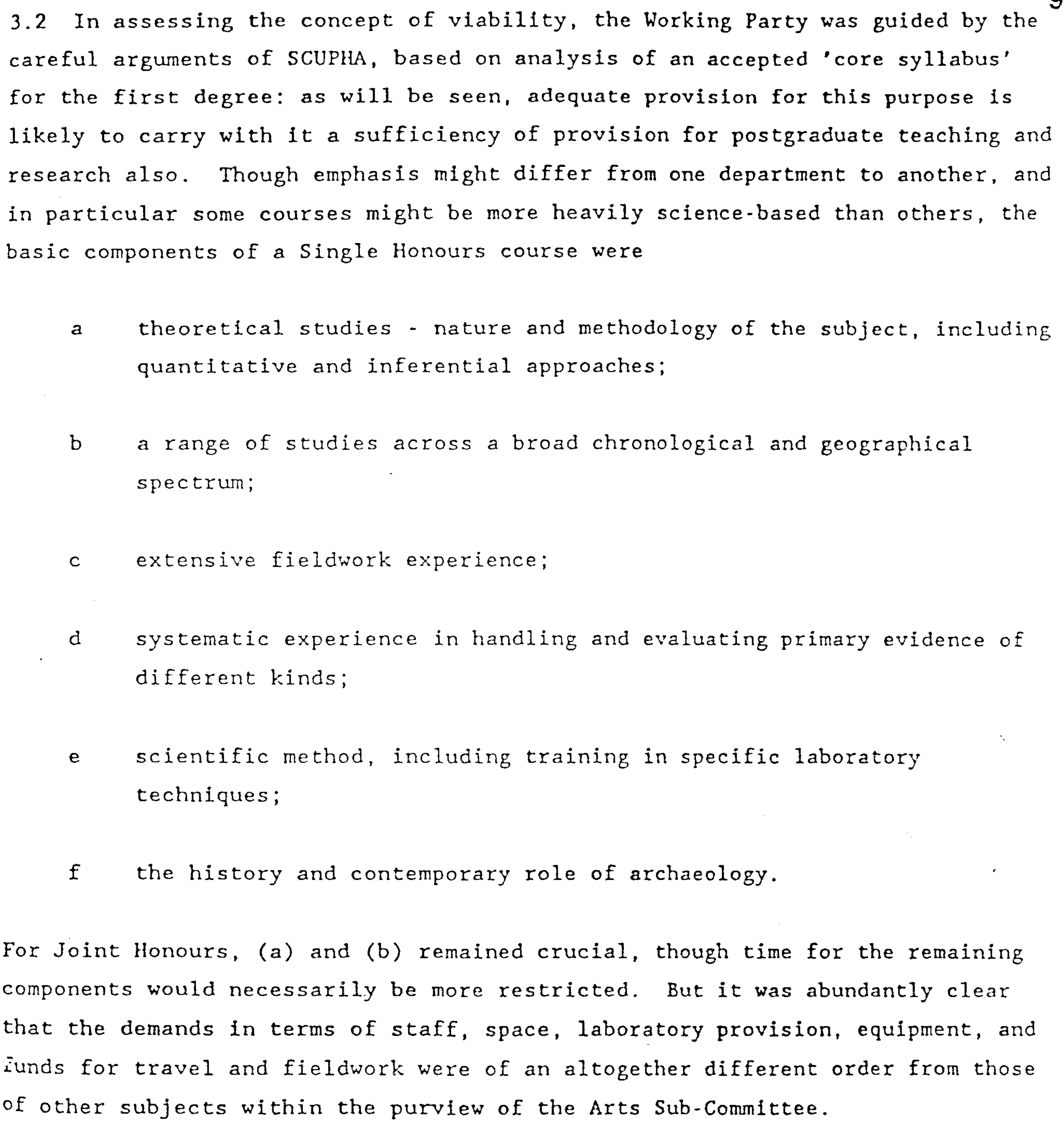


Figure 8.24



3.2 In assessing the concept of viability, the Working Party was guided by the careful arguments of SCUPHA, based on analysis of an accepted 'core syllabus' for the first degree: as will be seen, adequate provision for this purpose is likely to carry with it a sufficiency of provision for postgraduate teaching and research also. Though emphasis might differ from one department to another, and in particular some courses might be more heavily science-based than others, the basic components of a Single Honours course were

a theoretical studies - nature and methodology of the subject, including quantitative and inferential approaches;

b a range of studies across a broad chronological and geographical spectrum;

c extensive fieldwork experience;

d systematic experience in handling and evaluating primary evidence of different kinds;

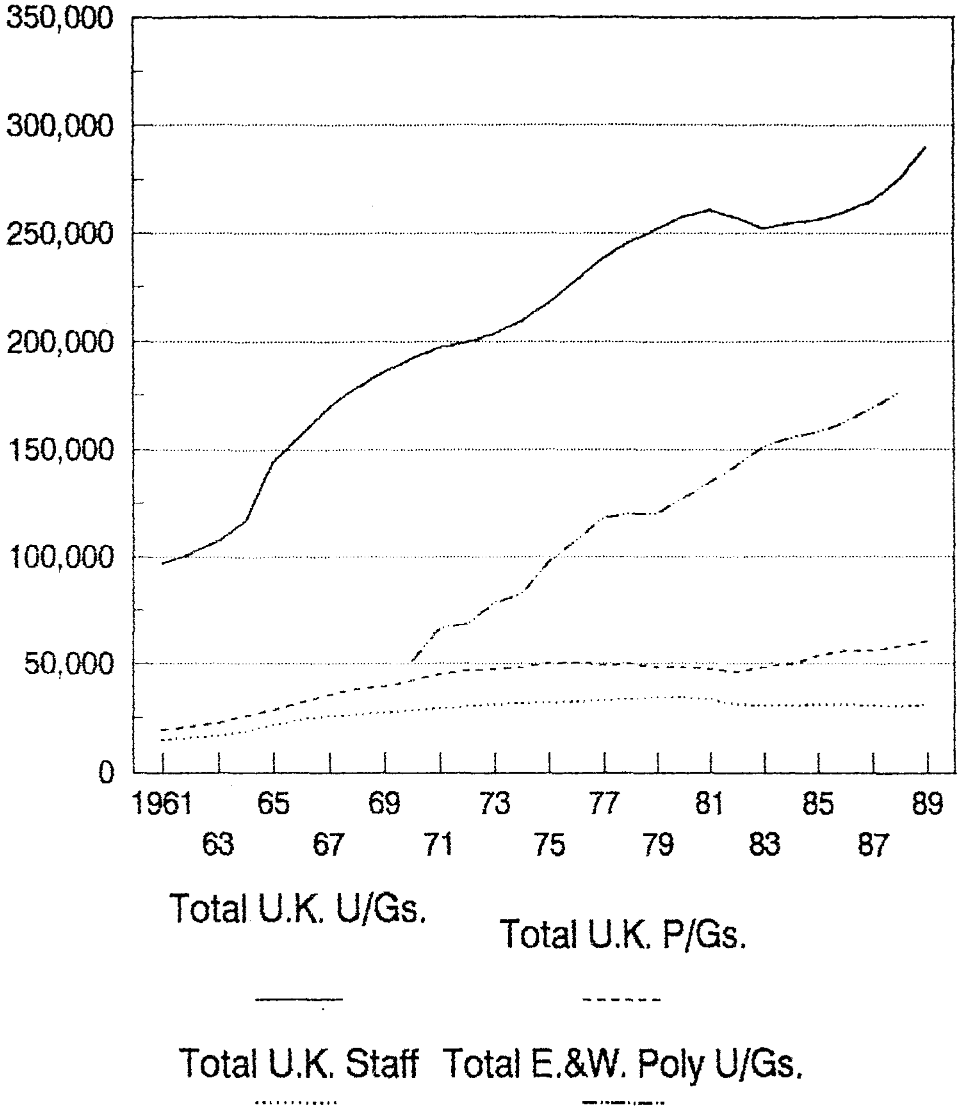
e scientific method, including training in specific laboratory techniques;

f the history and contemporary role of archaeology.

For Joint Honours, (a) and (b) remained crucial, though time for the remaining components would necessarily be more restricted. But it was abundantly clear that the demands in terms of staff, space, laboratory provision, equipment, and funds for travel and fieldwork were of an altogether different order from those of other subjects within the purview of the Arts Sub-Committee.

The core curriculum for archaeology undergraduate courses, as recommended in the UGC Working Party on archaeology's report (U.G.C. 1989).

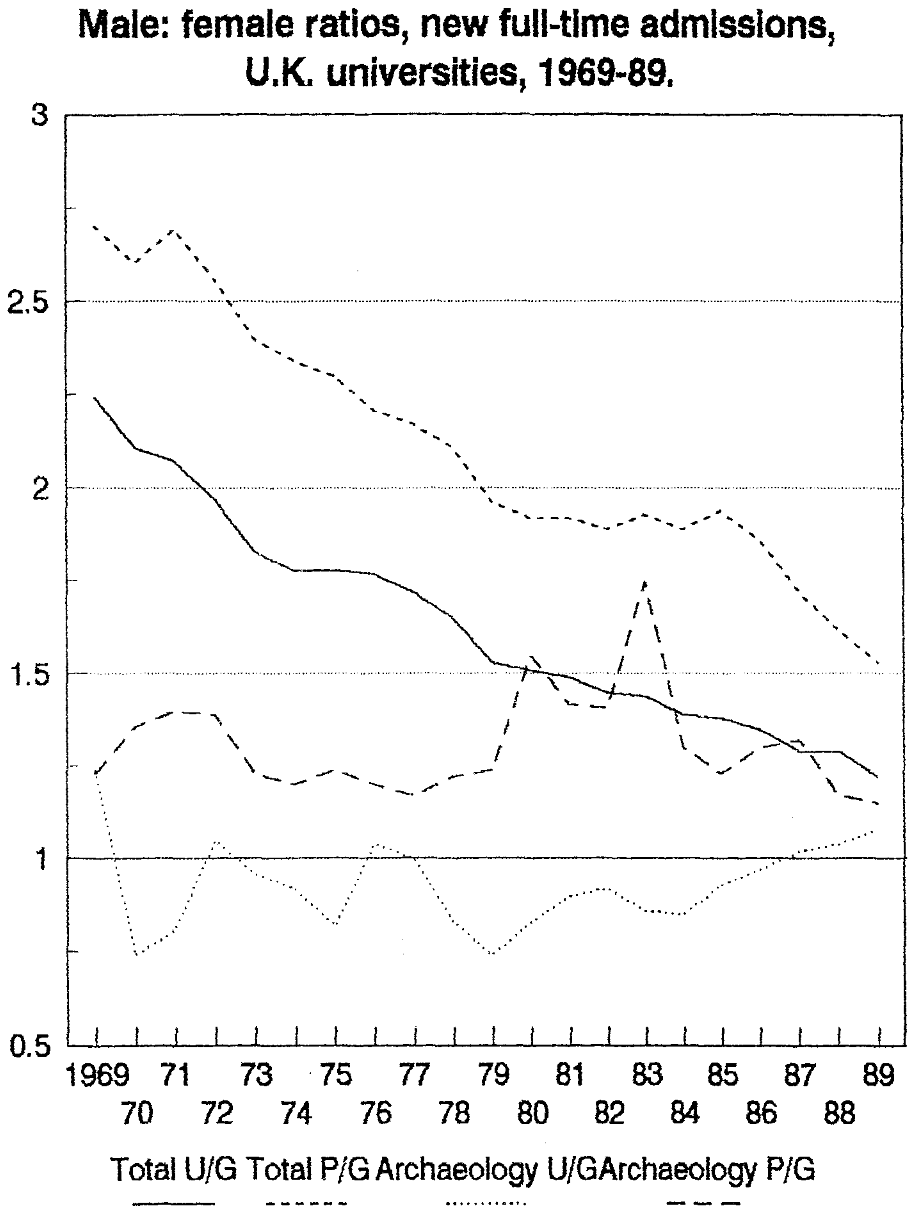
Figure 8.25



Full-time enrolment, U.K. higher education, 1961-89.

Sources: USR, DES Stats. in Education (Annuals)
Note: Poly. figures for England and Wales, full-time and sandwich (c 90% classed as advanced).
Note: Poly figures after 1979 for England only.

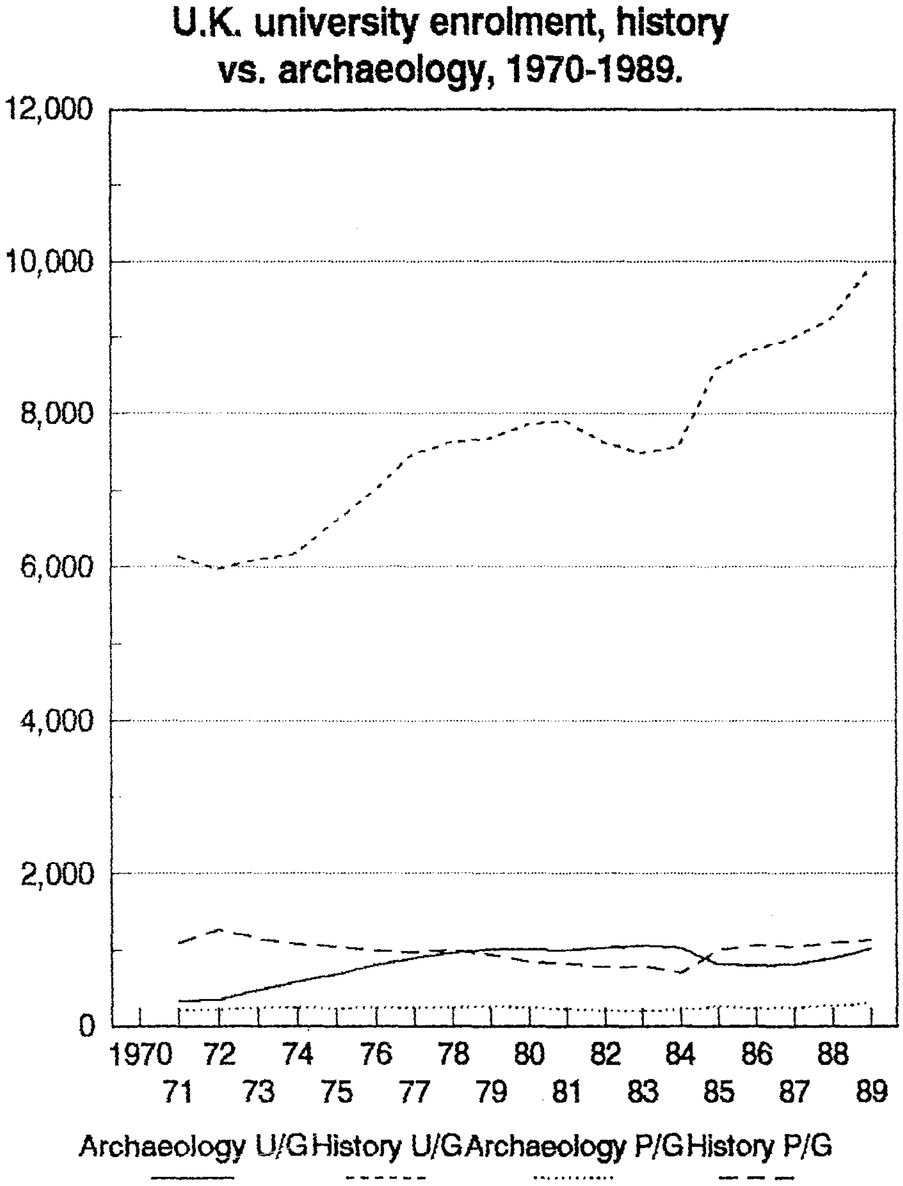
Figure 8.26



Male: female ratios, new full-time admissions, U.K. universities, 1969-89.

Source: University Statistical Record (Annual).

Figure 8.27

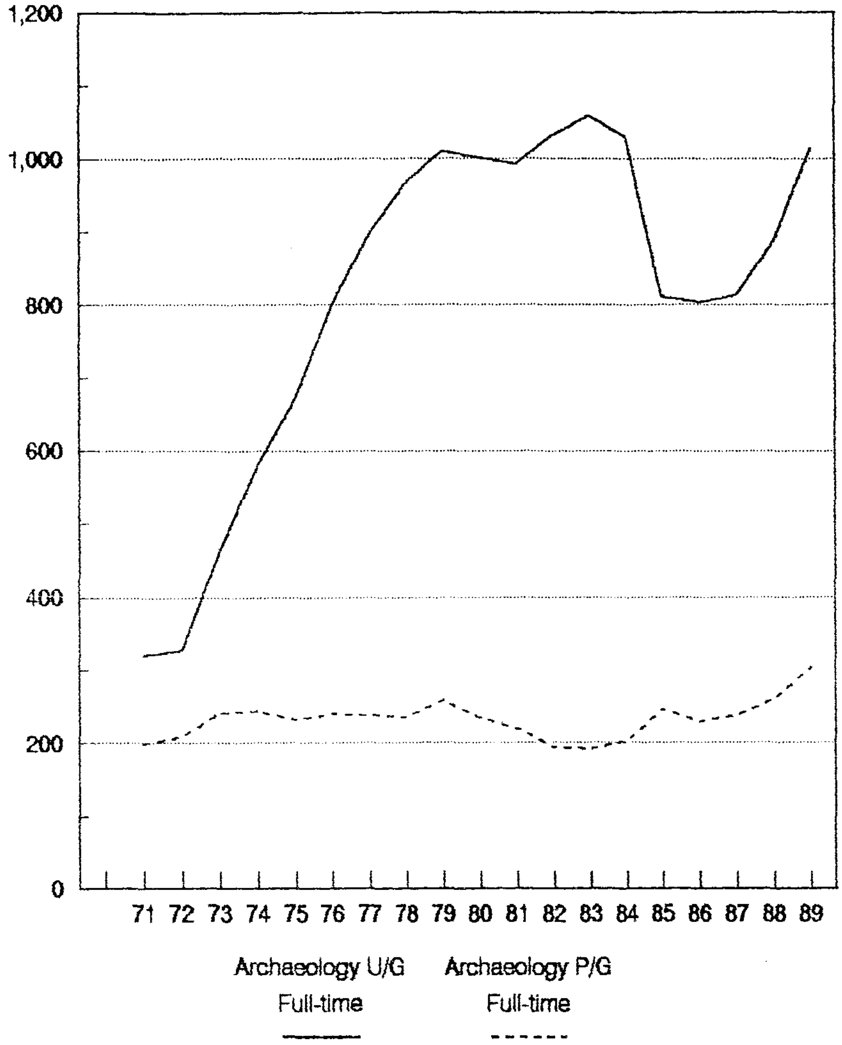


U.K. university enrolment, history vs. archaeology, 1970-1989.

Source: University Statistical Record (Annual).

Figure 8.28

U.K. university enrolment, archaeology, full time, 1971-1989



Source: University Statistical Record (Annual).

New U/G admissions, Single Hons. Archaeology, U.K. excl. Scotland, 1986-90

YEAR	ENTRY
1986	257
1987	277
1988	306
1989	340
1990	420

Source: CVCP.

Figure 8.29

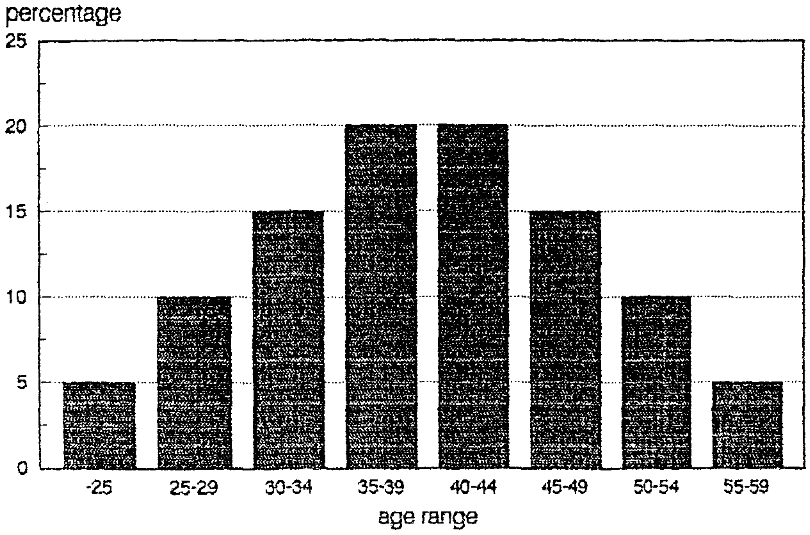
Graduates in Archaeology, Germany (F.D.R.).

1966	1988
20-25	40

Source: Sommer (1991).

Figure 8.30

Reference model of age distribution, IFA members (1990).



Replacement rates for model IFA membership pool assuming pool = 2000 and retirement at 60.

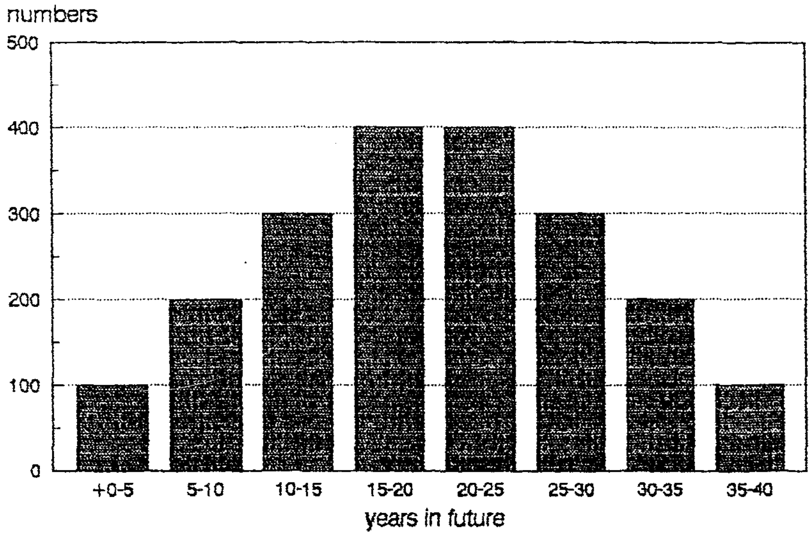
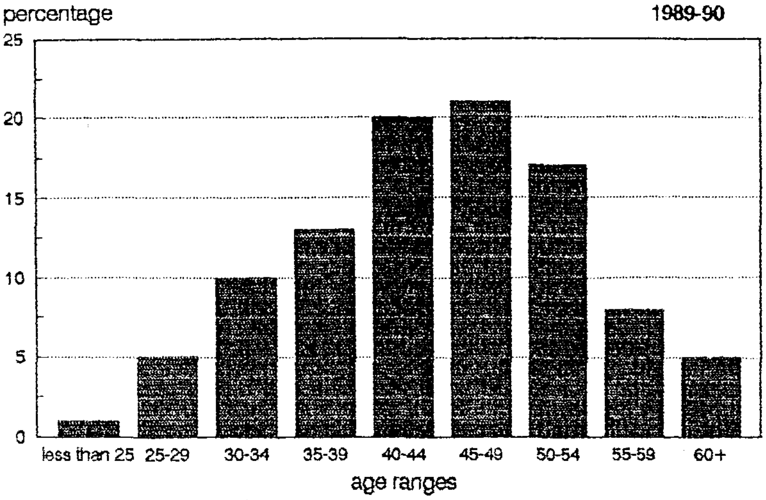
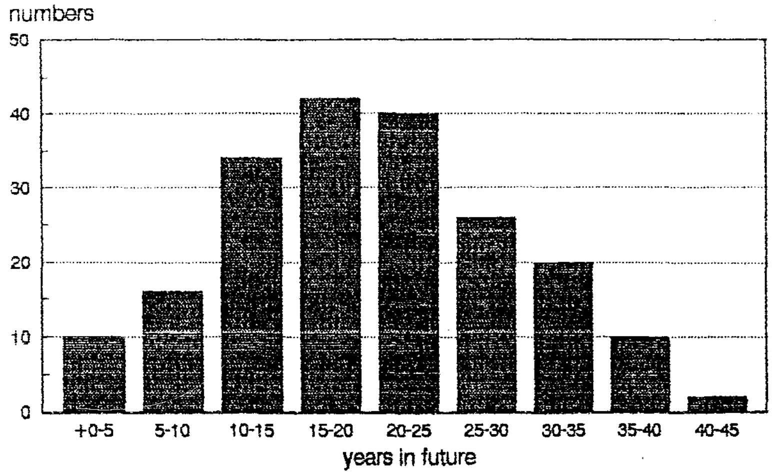


Figure 8.31



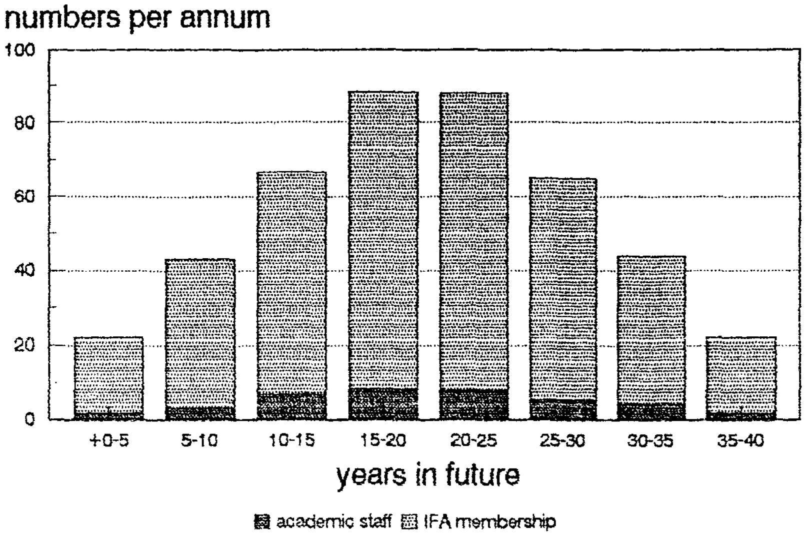
Academic staff age profile - reference model

Source: estimated from Keep & Sisson (1992)



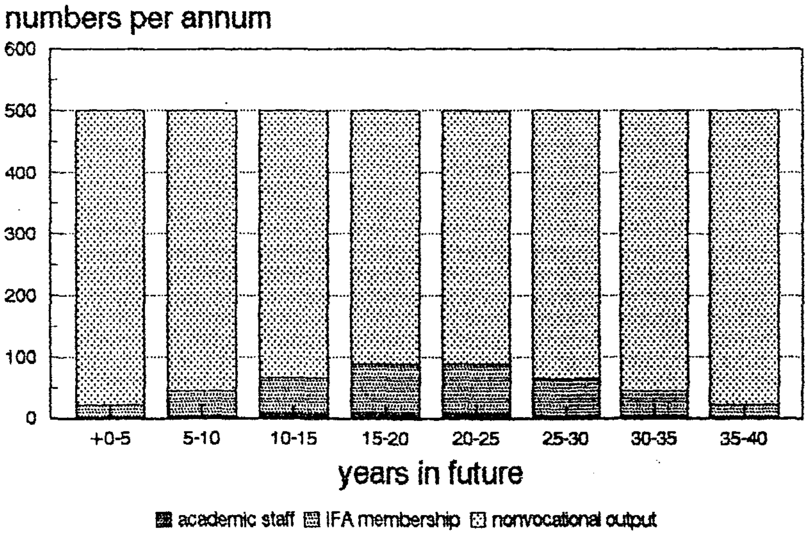
Replacement rate of existing staff pool, assuming 200 staff with reference age distrib. and retirement at 60.

Figure 8.32



Replacement projections for archaeological profession, academic and fieldwork sectors, U.K. 1990-2030.

Derived from projections in figures 000 and 000.

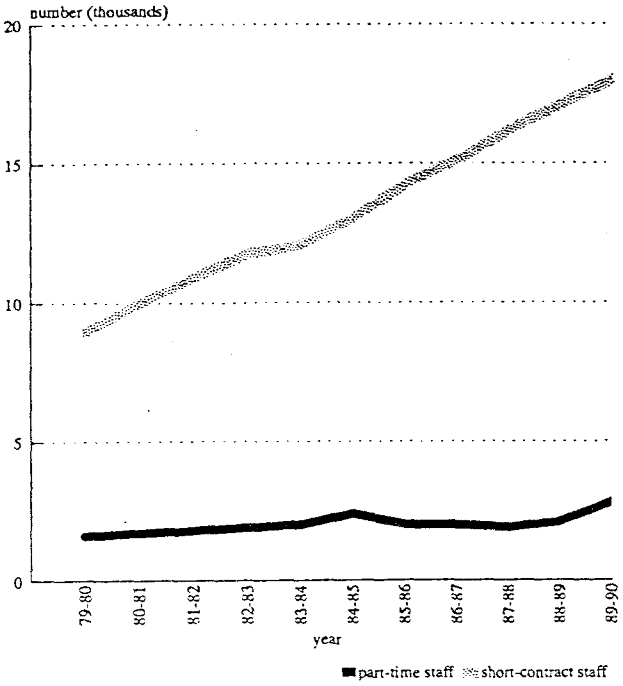


Proportions in vocational and nonvocational work assuming constant output of 500 graduates p.a. U.K. 1990-2030.

Derived from projections in figures 000 and 000.

Figure 8.33

Figure 2
Part-time and Short-contract Staff in Universities, 1979/80–1989/90



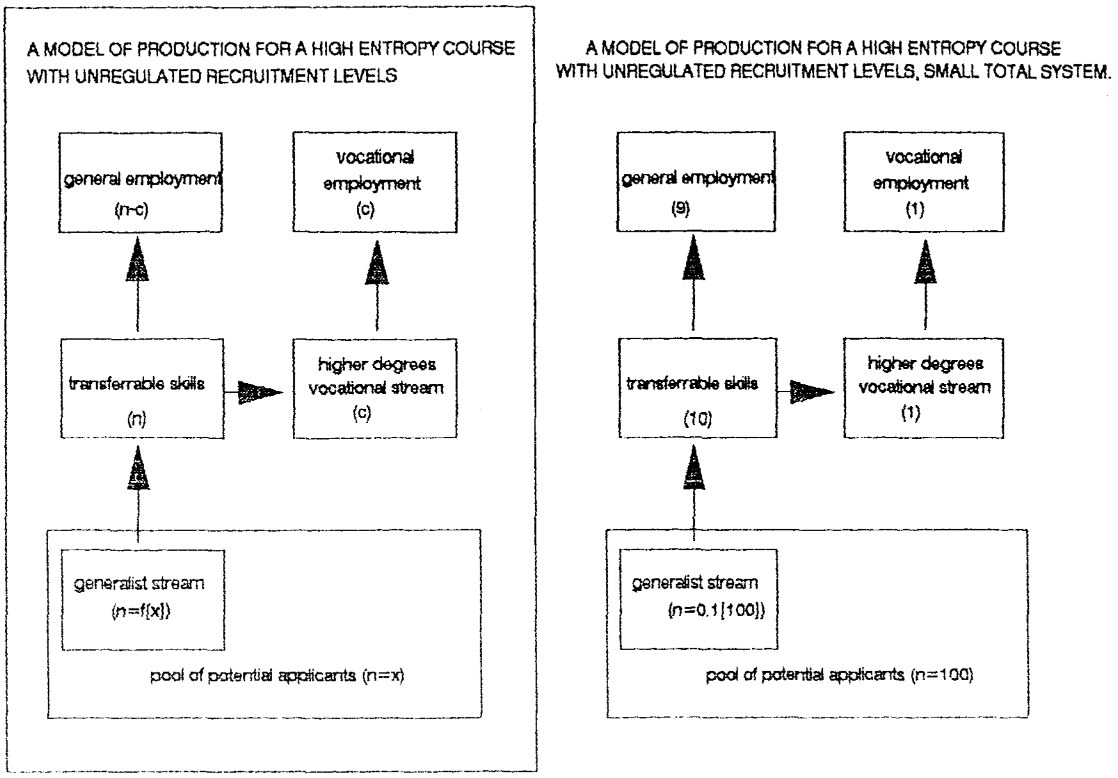
Source: CVCP (1992).

preference function:
prob. (entry to profession) f[regulatory actions, costs, and benefits of entry]
where costs include opportunity costs of not pursuing an alternative
track, and benefits include social and material yields from entry
THUS prob. (entry to profession) can vary independently as a function
- of regulatory action by professional organizations,
- of variation in the structure of opportunity outside the profession
- of variation in the structure of social and material benefits from entry;

or as a compound function of some or all of these.

(a) part-time and short-contract staff in Universities, 1979/80-1989/90. From Keep and Sisson 1992: Figure 2.
(b) A formal preference function for modelling decisionmaking in potential entrants to a profession.

Figure 8.34



A MODEL OF PRODUCTION FOR A HIGH ENTROPY COURSE WITH UNREGULATED RECRUITMENT LEVELS

A MODEL OF PRODUCTION FOR A HIGH ENTROPY COURSE WITH UNREGULATED RECRUITMENT LEVELS, SMALL TOTAL SYSTEM.

A MODEL OF PRODUCTION FOR A HIGH ENTROPY COURSE WITH UNREGULATED RECRUITMENT LEVELS, EXPANDED ACCESS TO TOTAL SYSTEM

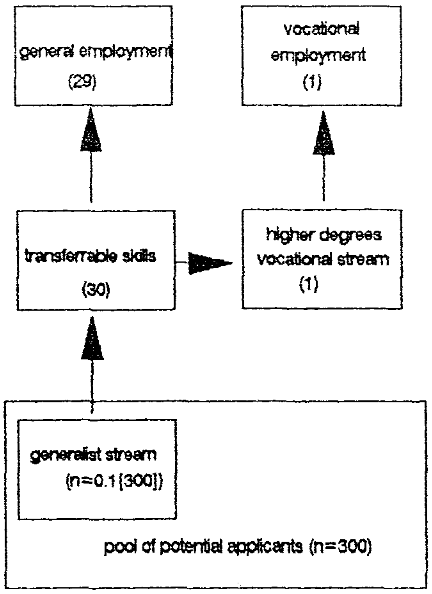


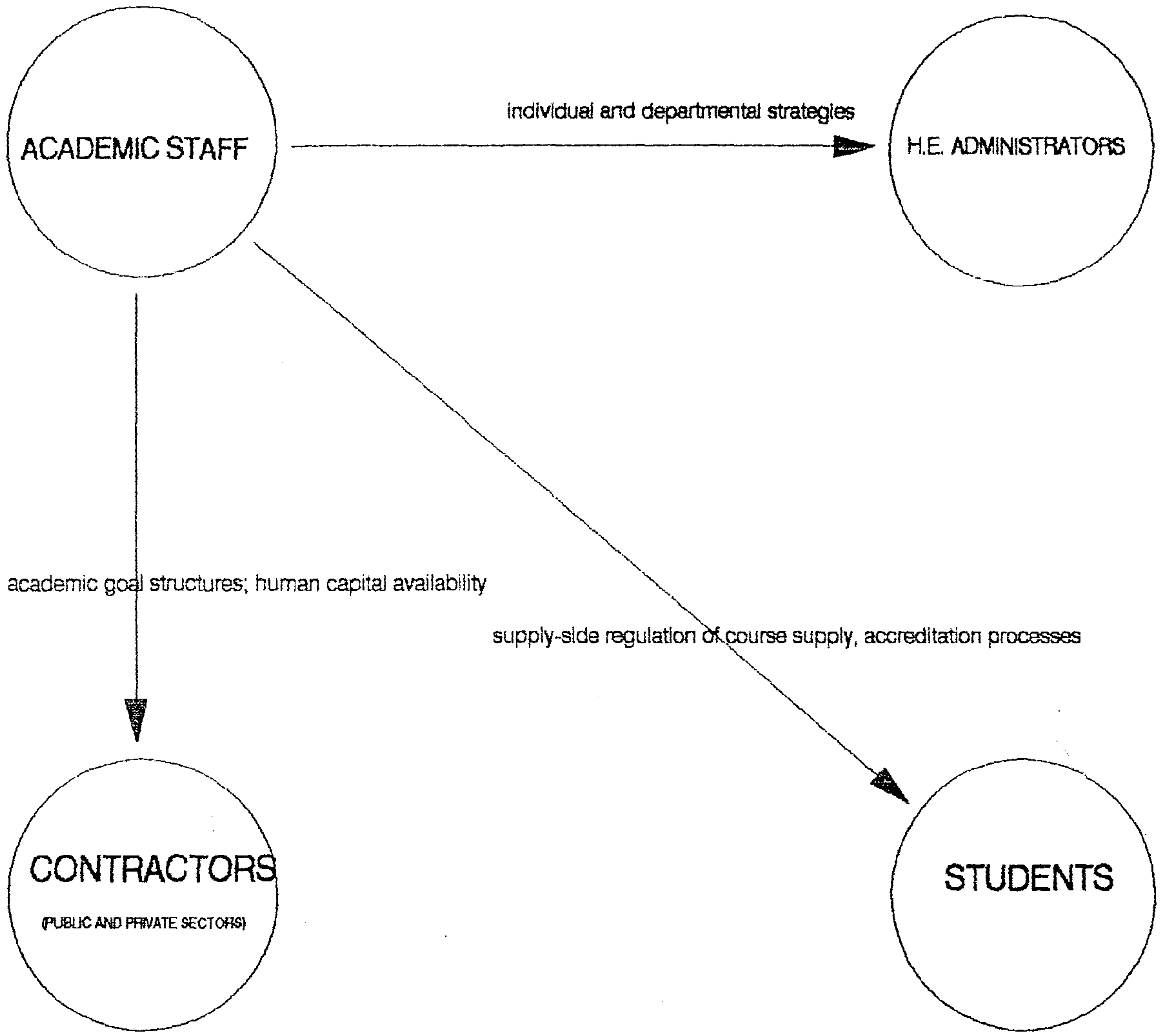
Figure 8.35

CONTRASTING SETS OF EDUCATIONAL DOGMAS

1970s →	1990s
open problem-solving	defined, delimited problem-solving
value-free approaches	values
creativity	good habits
optionality	tight objectives
child-centred work	adult-centred work
culturally permissive approaches	culturally firm approaches

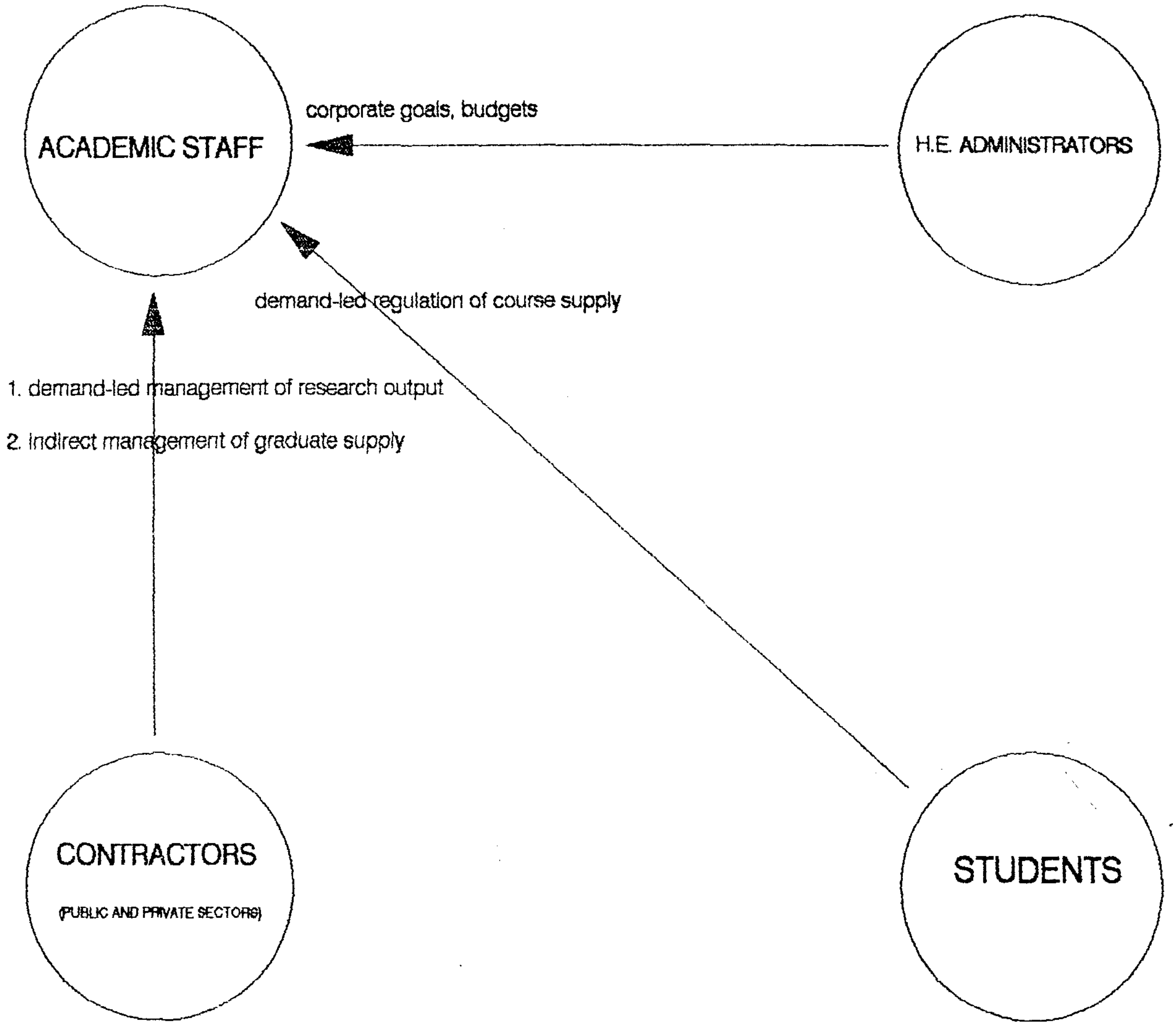
after Ormell 1992

Figure 8.36



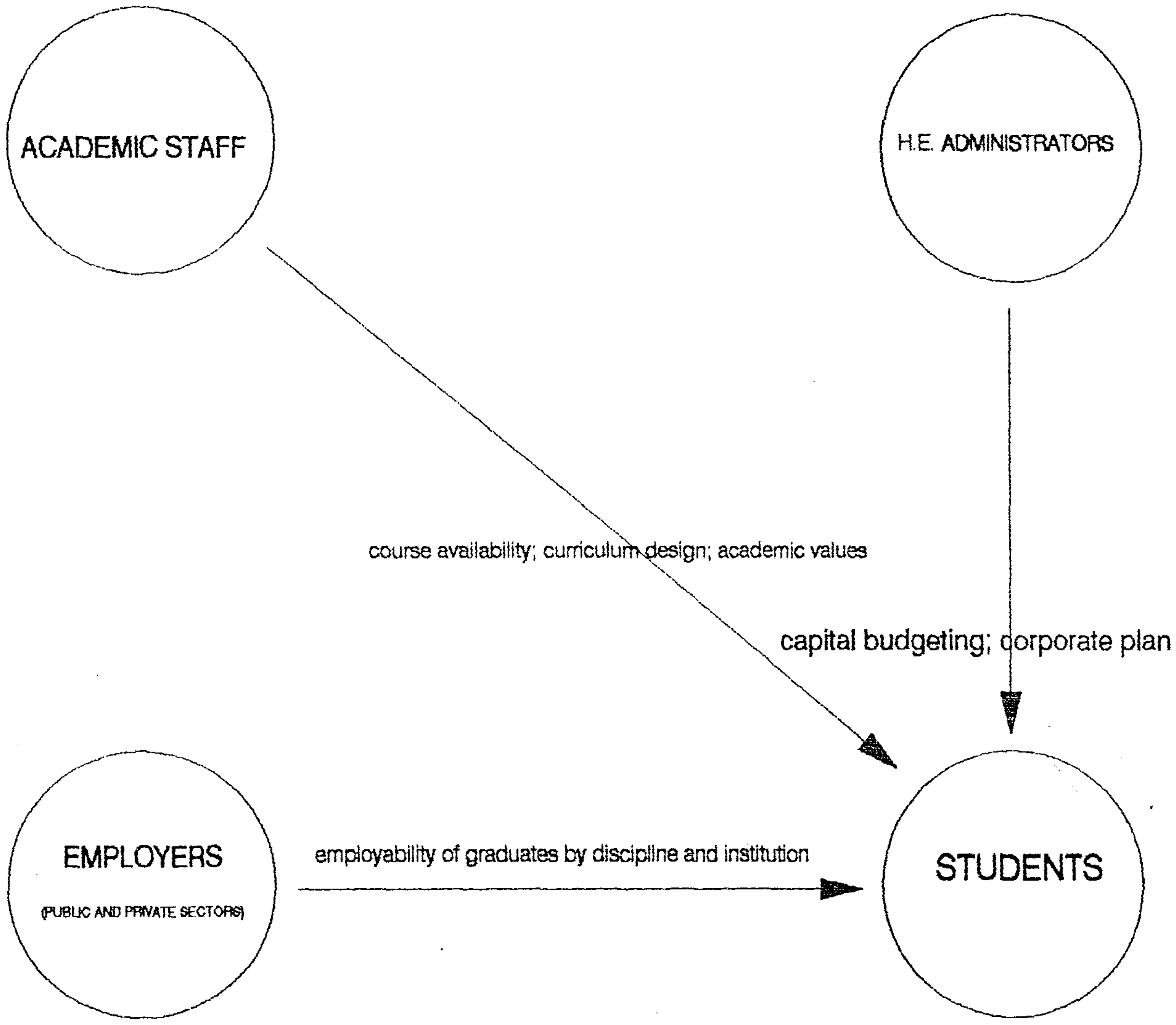
REGULATORY POWERS OF ACADEMIC STAFF

Figure 8.37



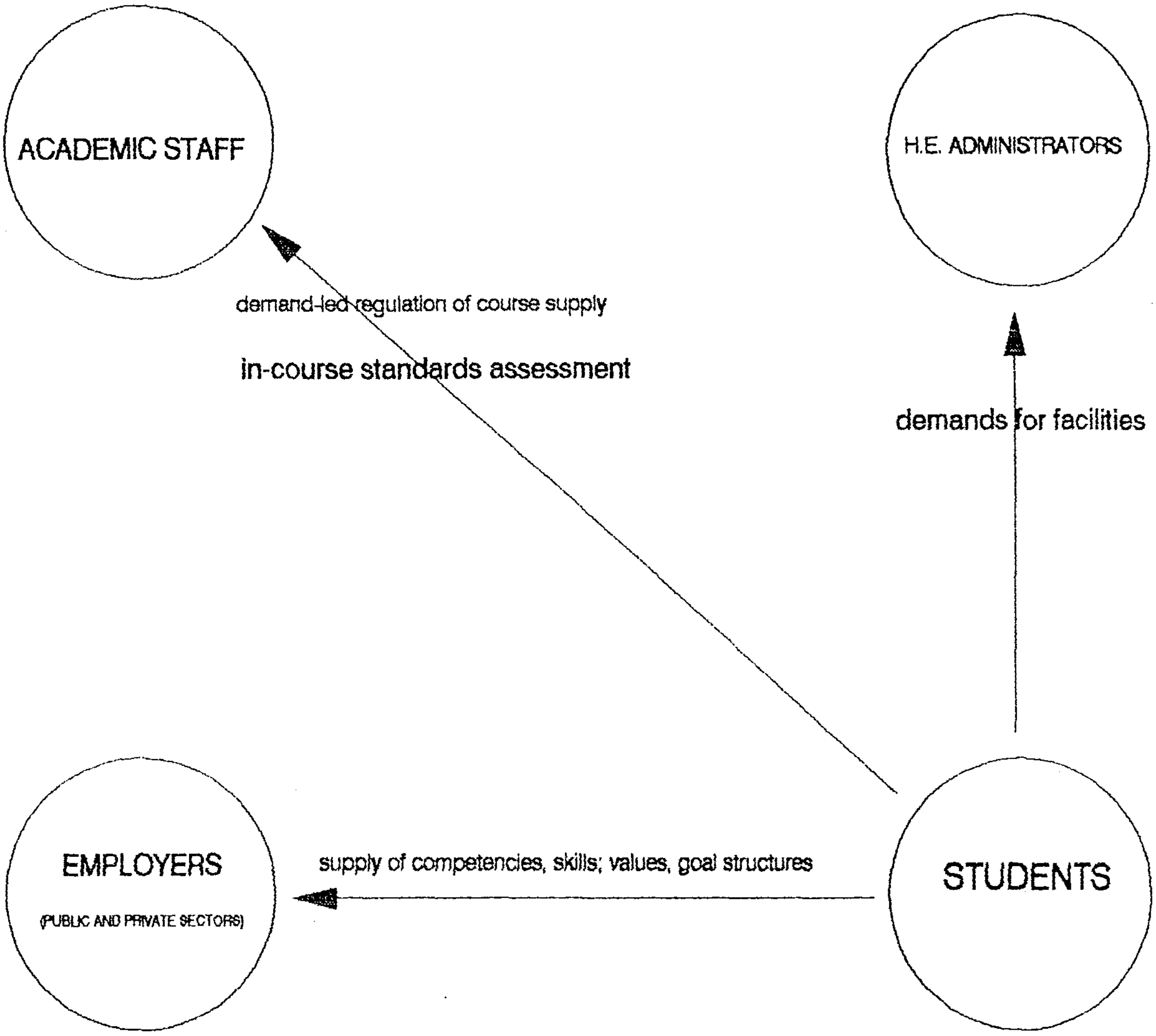
EXTERNAL FORCES IN THE ENVIRONMENT OF ACADEMIC STAFF

Figure 8.38



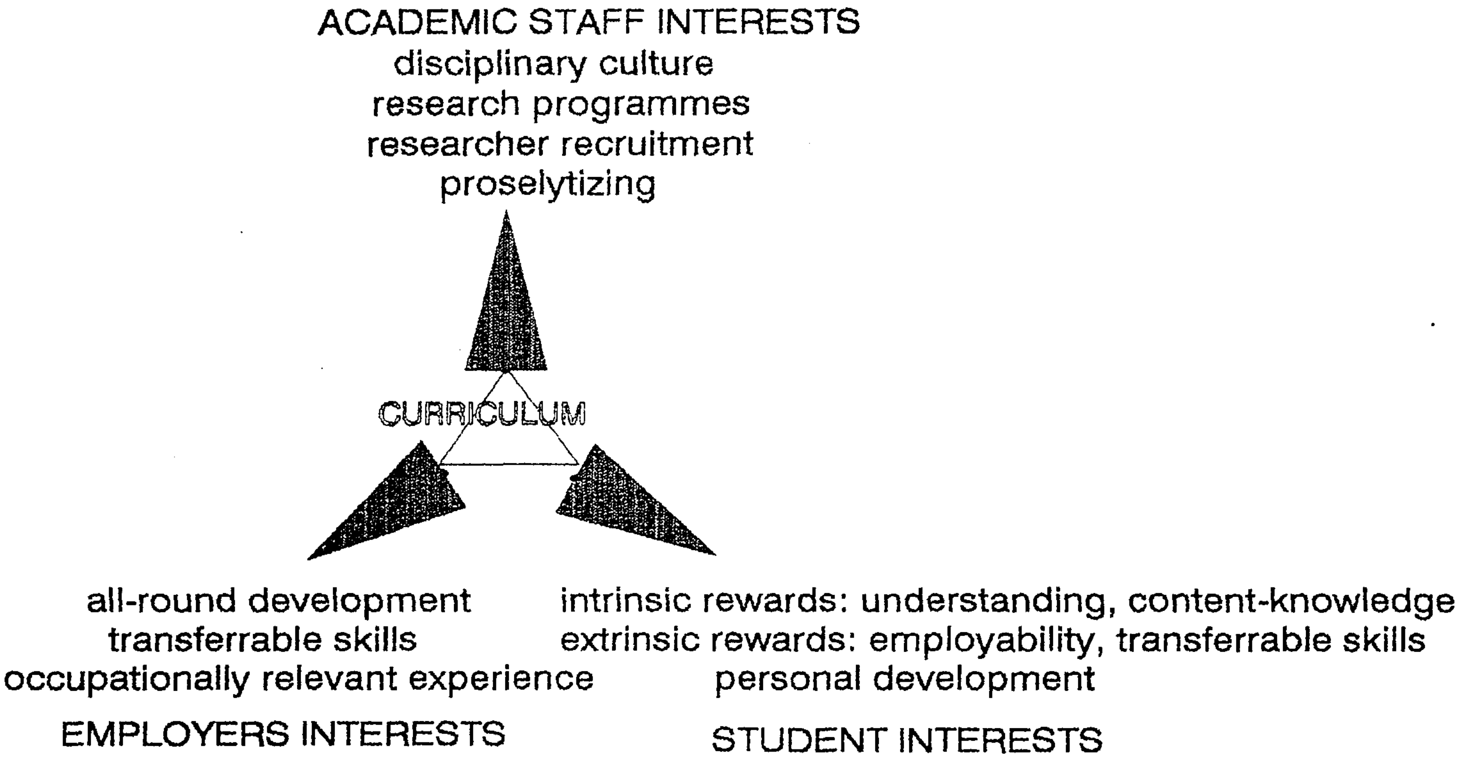
EXTERNAL FORCES IN THE ENVIRONMENT OF STUDENTS

Figure 8.39



REGULATORY POWERS OF STUDENTS

Figure 8.40



A representation of the curriculum as a tension between centripetal forces of different interest groups.

Figure 8.41

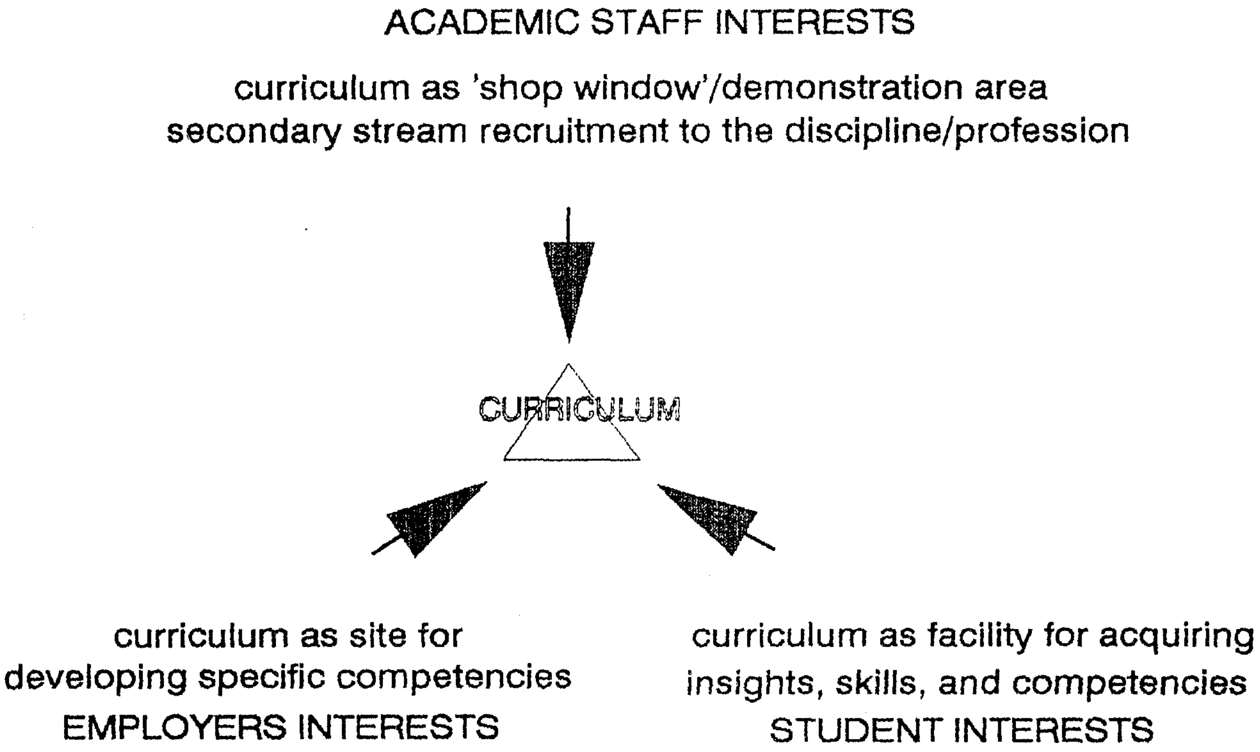


Figure 8.42

A representation of the curriculum as a focus for the negotiation of the priorities of different interest groups.

TABLES

$$\text{Log}_{0}\ (N) = 0.093 + 3.389\ \log_{0}\ (Cr)$$

Reduced major axis regression formula for the relationship between neocortex ratio (against rest of brain) (Cr) and mean group size (N). R-squared = 0.764, P<0.001. From Dunbar (1992:479).

$$\text{Log}_{0}\ (Nf) = -0.124 + 2.661\ \log_{0}\ (Cr)$$

Reduced major axis regression formula for the relationship between mean number of reproductive-age females in the group (Nf) and neocortex ratio (Cr). R-squared = 0.568. From Dunbar (1992:485).

	Correlation coefficient		
Comparison	Pairwise r	Partial r (vs body mass)	P
Cr vs Body mass	0.676	0.323	>0.05
Cr vs Group size	0.870	0.774	<0.001
Group size vs Body mass	0.636		

Partial correlations against body weight for relationship between neocortex and group size. From Dunbar (1992:482).

			Spearman r_s	
Comparison	N	Pairwise r	Partial (vs N)	Partial (vs N + W)
Cr vs % fruit	29	0.503*	0.298	
Cr vs range size	32	0.793*	0.524*	-0.345
Cr vs day journey	22	0.294	0.047	-0.599

Partial correlations between neocortex ratio and various ecological variables taking group size and body mass into account. From Dunbar (1992:486).

Table 3.1

	N	Slope	SE	p=0?	p=1?	Int.	R-squared
Cebidae	7	1.07	0.28	**	>0.05	-0.40	0.74
Cercopithecidae	22	1.23	0.11	***	*	-0.66	0.93
Pongidae	3	2.96	0.95	>0.05	>0.05	-1.86	0.91

Log mean group size-log standard deviation (between group size variability) regression fit for three primate families. N = sample size, Int. = intercept, R-squared value for each regression. Departure from 0 and 1 for each slope assessed for significance by t-test (*p=<0.05;**p=<0.01;***=p<0.001). From Beauchamp and Cabana 1990:176, Table 3).

Mann-Whitney non-parametric test for effects of ecological factors on between troop size variability in primates:

Variability f.[territoriality vs non-territoriality]?
No significant relationship (U(15,12) = 98, p>0.2, two-tailed test

Variability f.[terrestriality vs arboreality]?
No significant relationship (U(14,12) = 92, p>0.2, two-tailed test

Variability f.[frugivory vs folivory]?
Nio significant relationship (U(16,12) = 96, p>0.2, two-tailed test

From Beauchamp and Cabana (1990:177).

Table 3.2

	Mean Cortex Ratio	Rank	Mean Body Size	Rank	Group size variability rank
Pongidae	2.94[2]	1	75,500[2]	1	1[3]
Cercopithecidae	2.39[9]	2	9,228[9]	2	2[22]
Hylobatidae	2.08[1]	3	5,700[1]	3	[n/a]
Cebidae	2.00[8]	4	3,324[8]	4	3[7]
Callitrichidae	1.55[4]	5	320[4]	5	[n/a]

Mean cortex ratio and body size data from Dunbar (1992), group size variability data from Beauchamp and Cabana (1990). Sample sizes in brackets (Dunbar: *n* genera; Beauchamp and Cabana: *n* species).

Table 3.3

LEVEL 1. PARTY SIZE DATA

Mean party size (Pan troglodytes, Mt Assirik) = 5.3

MINS (Pan Troglodytes, Mt Assirik) = 11.1

LEVEL 2. COMMUNITY SIZE DATA

Mean community size (Pan Troglodytes) = 45
Mean community size (Pan paniscus) = 65

MINS (Pan troglodytes communities) = 63.2
MINS (Pan paniscus communities) = 67.5

LEVEL 3. GENERIC MEANS

Generic mean community size (Pan) = 55
Generic MINS (Pan communities) = 65.35

Mean Group Size and Mean Individual Network Size for Pan datasets.

Data from Tutin et al. (1982), Wrangham (1986:356,366).

Table 3.4

	Group size	Females	Cortex ratio
Group size	-1.00		
Females	0.85	-1.00	
Cortex ratio	0.14	0.26	-1.00

Partial correlations matrix for mean group size, mean number of females, and neocortex ratio, anthropoid primates (n=23). Data are generic means, from Dunbar (1992:474-5, Table 1).

	Group size	Females	Cortex ratio
Group size	-1.00		
Females	0.87	-1.00	
Cortex ratio	0.10	0.29	-1.00

Partial correlations matrix for the same variables and dataset, with all variables logged.

Table 3.5

	Group size	Females	Body mass	Ranging area	Day journey	% Fruit in diet
Females	0.88	-1.00				
Body mass	-0.31	0.10	-1.00			
Ranging area	0.52	-0.22	0.69	-1.00		
Day journey	-0.08	-0.02	-0.18	0.15	-1.00	
% Fruit in diet	-0.32	0.17	-0.60	0.57	-0.17	-1.00

Partial correlations matrix for various socioecological variables, anthropoid primates. Data from Dunbar (1992:475-5, Table 1).

	Group size	Females	Body mass	Ranging area	Day journey	% Fruit in diet
Females	0.95	-1.00				
Body mass	-0.42	0.40	-1.00			
Ranging area	0.53	-0.39	0.64	-1.00		
Day journey	0.05	0.01	0.15	-0.07	-1.00	
% Fruit in diet	0.05	-0.04	-0.24	-0.002	0.35	-1.00

The same matrix for the same dataset, with values for each variable logged.

Table 3.6

Body weight, brain weight, dietary quality and predation levels for selected primate species.

Species	Bo Weight (kg.)	Brain Weight (g.)	Dietary Qual.	Predation level (0/Low/High)
Lemur catta	2.70	25.6	100.0	
Lemur fulvus	2.10	25.2	129.0	
Lemur mongoz	1.80	21.8	198.0	
Lepilemur mustelinus	0.60	9.5	149.0	
Indri indri	12.50	34.5	143.0	
Propithecus verr.	3.70	27.5	159.0	
Loris tardigradus	0.20	6.7	327.5	
Arctocebus calab.	0.20	7.7	327.5	
Perodictus potto	1.15	14.3	215.0	
Galago alleni	0.26	6.1	237.5	
Galago demidovii	0.60	2.7	305.0	
Galago elegantulus	0.30	5.8	230.0	
Tarsius bancanus	1.15		335.0	
Saguinus geoffroyi	0.50	10.5	235.0	
Saguinus imperator	0.40		300.0	
Saguinus fuscicoll.	0.30	9.3	274.0	
Saguinus midas	0.49	10.4	247.0	
Pithecia pithecia	1.87	31.7	197.5	
Pithecia hirsuta	1.46		184.0	
Chiropotes satanus	2.99	53.0	200.0	
Cebus capucinus	3.25	79.2	215.0	0
Cebus nigrivitus	3.45	80.8	244.0	
Cebus apella	3.45	71.0	310.0	
Cebus albifrons	2.40	82.0	295.0	L
Alouatta villosa	6.55	55.1	146.0	L/0
Alouatta seniculus	7.25	57.9	175.5	
Aotus trivirgatus	0.96	18.2	177.5	
Callicebus moloch	0.97	19.0	175.0	
Ateles belzebuth	6.00	106.6	183.0	L
Ateles geoffroyi	7.50	110.9	181.5	L
Ateles paniscus	7.78	109.9	194.5	
Saimiri oerstedii	0.82	25.7	245.0	
Saimiri sciureus	0.86	24.4	323.0	L

Sources: Sailer et al. (1985), Clutton-Brock et al. (1987), Anderson (1986).
DQ = 1(plant stru.) + 2(plant repro) + 3.5 anim.

Table 3.7

Body weight, brain weight, dietary quality and predation levels for selected primate species. (continued)

Species	Bo Weight (kg.)	Brain Weight (g.)	Dietary Qual.	Predation level (0/Low/High)
Cercopithecus aeth.	4.05	59.8	213.5	L/H
Cercopithecus cephus	3.50	63.6	116.0	
Cercopithecus mitis	4.50	75.0	201.5	
Cercopithecus negl.	5.50	70.8	198.5	
Cercopithecus nict.	5.40	78.6	195.0	L
Cercopithecus pogon.	3.65	71.1	222.5	
Cercopithecus ascan.	7.80	66.5	156.0	
Miopithecus talap.	1.25	37.7	262.5	
Cercocebus galeritus	7.85	114.7	190.5	
Cercocebus albigena	7.60	99.1	226.5	0
Macaca fascic.	5.00	69.2	200.0	0/L
Macaca fuscata	10.10	109.1	223.0	0
Macaca nemestrina	8.50	106.0	184.0	
Macaca sinica	4.65	69.9	203.0	L/H
Papio anubis	19.50	175.1	207.0	L/H
Papio hamadryas	13.85	142.5	199.0	H
Papio ursinus	18.60	214.4	190.0	0/L/H
Theropithecus gelada	17.10	131.9	159.0	0
Colobus badius	8.75	73.8	122.0	L/H
Colobus guereza	8.85	82.3	118.0	L/H
Colobus satanas	9.50	80.2	163.0	
Presbytis entellus	12.80	135.2	153.5	0/L/H
Presbytis johnii	8.15	84.6	122.0	
Presbytis melalo.	6.10	80.0	163.0	
Presbytis obscurus	6.15	67.6	152.0	
Presbytis pileatus	11.60	57.9	139.0	
Presbytis potenz.	6.45	18.2	158.0	
Presbytis senex	8.15	64.9	140.0	0
Presbytis aygula	6.70	80.3	135.0	
Nasalis larvatus	15.20	94.2	105.0	

Sources: Sailer et al. (1985), Clutton-Brock et al. (1987), Anderson (1986).

DQ = 1(plant stru.) + 2(plant repro) + 3.5 anim.

Body weight, brain weight, dietary quality and predation levels for selected primate species. (continued)

Species	Bo Weight (kg.)	Brain Weight (g.)	Dietary Qual.	Predation level (0/Low/High)
Hylobates agilis	5.65	110.0	162.5	
Hylobates hoolock	6.50	108.5	169.5	
Hylobates lar	5.50	107.7	181.0	
Hylobates muelleri	6.10		157.0	
Symphalangus synd.	10.70	121.7	167.0	
Pongo pygmaeus	53.00	413.3	183.5	O/H
Pan troglodytes	45.00	410.3	178.0	O/L/H
Gorilla gorilla	126.50	505.9	114.0	

Sources: Sailer et al. (1985), Clutton-Brock et al. (1987), Anderson (1986).

DQ = 1(plant stru.) + 2(plant repro) + 3.5 anim.

Partial correlations matrix, primate species (n=43). data from Sailer et al. 1985, Harvey and Clutton Brock 1986.

	Log Brain weight	Log body weight
Log body weight	0.96	
Dietary quality	0.54	(0.64)

Table 3.8

GENUS/SPECIES	BoWt^{1}	TBV^{2}	CR^{2}	MAGS^{6}	MAF^{6}	DQ^{18}
PROSIMIANS						
Cheirogaleus	0.29	4667	0.967	1	1	-
C. major	0.40	6373	0.981	1	1	-
C. medius	0.18	2961	0.953	1	1	-
Microcebus	0.08	1680	0.965	1^{7}	1^{7}	-
M. murinus						
Lepilemur	0.75	7175	0.979	1	1	147^{R14}
L. ruficaudatus						
Lemur	2.78	25910	1.014	?2	?1	129
L. fulvus	2.20	22106	1.023	>2^{7}	>1^{7}	129^{S}
L. variegatus	3.35	29713	1.006	2	1	-
Avahi	1.30	9798	0.996	2	1	-
A. l. laniger						
Propithecus	3.60	25194	1.010	?>2^{7}	?>1^{7}	159^{S}
P. verreauxi						
Indri	10.50	36285	1.023	2	1	143^{S}
I. indri						
Daubentonia	2.80	42611	1.008	1	1	-
D. madagasc.						
Loris	0.28	6269	1.032	1	1	327.5^{S}
L. tadigradus						
Nycticebus	1.25	11755	1.012	1	1	225^{PS}
N. coucang						
Perodictus	1.05	13212	1.003	1	1	215^{S}
P. potto						
Galago	0.73	5794	0.992	3.7	3	255.5
G. crassicaud.	1.34	9668	0.995	4	3	183.5^{R}
G. demidovii	0.63	3203	0.994	3	3	305^{S}
G. senegalen.	0.23	4512	0.987	4	3	278^{PS}
Tarsier^{3}	0.45	3393	1.011	1	1	342.5^{S,PS}
T. sp.						
ANTHROPOIDS						
Callithrix	0.30	7241	1.053	5^{8}	2.5^{8}	-
C. jacchus						
Cebuella	0.15	4302	1.048	6	?3	250^{R}
C. pygmaea						
Saguinus	0.38	9553	1.058	4.65	1.95	235^{R,15}
S. oedipus	0.48	9537	1.059	4.65	1.95	-
S. tamarin	0.28	9569	1.057	-	-	-

Table 3.9

GENUS/SPECIES	BoWt[1]	TBV[2]	CR[2]	MAGS[6]	MAF[6]	DQ[18]
Callimico *C. goeldii*	0.59	10510	1.057	3	2	-
Aotus *A. trivirgatus*	0.96	16195	1.053	2	1	178[PS(tf)]
Callicebus *C. moloch*	1.08	17944	1.057	2	1	175[S]
Pithecia *P. monacha*	1.50*	32867	1.061	2[9]	1[9]	182[PS,tf,16]
Alouatta[4] *A. sp.*	6.67	49009	1.062	6.3	4.2	175.5[S,17]
Ateles *A. geoffroyi*	6.00	101034	1.083	13.3[10]	9.8[10]	181.5[S]
Lagothrix *L. lagotricha*	6.30	95503	1.078	16.5	7.5	-
Cebus[5] *C. sp.*	2.73	66939	1.082	8.3	5.7	266[S]
Saimiri *S. sciureus*	0.67	22572	1.090	10.6	7.9	323[S]
Macaca *M. mulatta*	4.60	87896	1.095	18.8	14.3	109[R]
Cercocebus *C. albigena*	7.70	97603	1.084	10.8	7	226.4[S]
Papio *P. anubis*	16.50	190957	1.094	18.2	11.35	207.2[S]
Cercopithecus	4.78	67035	1.090	?12.5	?10.4	197
C. mitis	6.00	70564	1.089	?14[11]	?11.1[11]	201.5[S]
C. ascanius	3.55	63505	1.092	?11[12]	9.8[12]	192.5[R]
Miopithecus *M. talapoin*	1.25	37776	1.091	40	27	262.5[S]
Erythrocebus *E. patas*	7.80	103167	1.107	12.2[13]	10.9[13]	-
Pygathrix *P. nemaeus*	7.50*	72530	1.071	-	-	-
Nasalis *N. larvatus*	15.10	92797	1.071	-	-	105[S]
Procolobus *P. badius*	8.15	73818	1.080	-	-	121.7[S]

GENUS/SPECIES	BoWt[1]	TBV[2]	CR[2]	MAGS[6]	MAF[6]	DQ[18]
Hylobates *H. lar*	5.50	97505	1.070	2	1	181[S]
Gorilla *G. gorilla*	126.50	470359	1.083	4	3	114[S]
Pan *P. troglodytes*	36.35	382103	1.103	33.8	23.1	178[S]

FOOTNOTES.

[*] Data from Stephan *et al.* 1981.

[1] Data from Harvey, Martin and Clutton-Brock 1986. Adult body weight, Kg, average of adult male and adult female. Tarsier data supplemented from Bearder 1986.

[2] Data from Stephan *et al.* 1981. Total brain volume, mm^3. Cortex ratio = Log Neocortex vol./ Log Rest of brain vol. (following Dunbar 1992, modified).

[3] Tarsier spp. unspecified in Stephan *et al.* 1981: I have used data on *T. bancanus*, *T. syrichta* and *T. spectrum*.

[4] Alouatta spp. unspecified in Stephan *et al.* 1981: I have used data on *A. palliata*, *A. caraya*, and *A. seniculus*.

[5] Cebus spp. unspecified in Stephan *et al.* 1981: I have used data on *C. albifrons*, *C. apella*, and *C. capucinus*.

[6] Mean adult group size, mean number of adult females. From Smuts *et al.* 1986 except where stated.

[7] Larger aggregations are reported suggesting neighbourhood networks of several foraging groups (Richard 1986:30).

[8] Data for *Callithrix humeralifer*.

[9] Data for *Pithecia hirsuta*.

[10] Data for *Ateles belzebuth* and *A. paniscus*.

[11] Estimated from data in Clutton-Brock and Harvey 1977.

[12] Data from Struhsaker 1988:342-3.

[13] Data from Chism and Rowell 1988.

[14] Data for *L. mustelinus*

[15] Data for *S. geoffroyi*

[16] Data for *P. hirsuta* and *P. pithecia*

[17] Data for *A. seniculus* only.

[18] Dietary Quality, following Sailer et al. (1985)'s index: 1x(plant structural matter) + 2x(plant reproductive matter) + 3.5x(animal matter).

[PS] Data from relevant chapters in Smuts et al. (1986)

[R] Data from Richard (1985)

[S] Data from Sailer *et al.* (1985), which derives from Clutton-Brock and Harvey (1977).

[tf] Quantified using the time foraging method.

```
INPUT       6/ 8/93  12:07  STATGRAPHICS Vers.5.0               Display      MREG
                     Model  fitting results for: MYDUNBA2.LOGTBV

Independent variable                       coefficient  std. error      t-value   sig.lev

CONSTANT                                     9.954103    0.078546      126.7291     0.0000
MYDUNBA2.LOGBW                               0.722452    0.039699       18.1981     0.0000

R-SQ. (ADJ.) = 0.9349  SE=           0.303713  MAE=         0.261186  DurbWat=  1.599
Previously:     0.9427               0.282802               0.209873            2.473
24 observations fitted, forecast(s) computed for 0 missing val. of dep. var.
```

```
INPUT       6/ 8/93  12:08  STATGRAPHICS Vers.5.0               Display      MREG
                     Model  fitting results for: MYDUNBA2.LOGTBV

Independent variable                       coefficient  std. error      t-value   sig.level

CONSTANT                                    20.117767    4.189481        4.8020     0.0002
MYDUNBA2.LOGDQ                              -1.761494    0.801565       -2.1976     0.0421

R-SQ. (ADJ.) = 0.1754  SE=           1.072603  MAE=         0.847564  DurbWat=  0.433
Previously:     0.9349               0.303713               0.261186            1.599
19 observations fitted, forecast(s) computed for 0 missing val. of dep. var.
```

```
INPUT       6/ 8/93  12:06  STATGRAPHICS Vers.5.0               Display      MREG
                     Model  fitting results for: MYDUNBA2.LOGTBV

Independent variable                       coefficient  std. error      t-value   sig.level

CONSTANT                                     6.501491    1.425255        4.5616     0.0003
MYDUNBA2.LOGBW                               0.775754    0.051314       15.1178     0.0000
MYDUNBA2.LOGDQ                               0.652717     0.26489        2.4641     0.0254

R-SQ. (ADJ.) = 0.9427  SE=           0.282802  MAE=         0.209873  DurbWat=  2.473
Previously:     0.7763               0.104720               0.080248            1.081
19 observations fitted, forecast(s) computed for 0 missing val. of dep. var.
```

```
INPUT       6/ 8/93  12:12  STATGRAPHICS Vers.5.0               Display      MREG
                     Model  fitting results for: MYDUNBA2.LOGTBV

Independent variable                       coefficient  std. error      t-value   sig.level

CONSTANT                                     8.418318    1.742612        4.8309     0.0003
MYDUNBA2.LOGMAF                              0.126724    0.070758        1.7910     0.0966
MYDUNBA2.LOGDQ                               0.267956    0.329469        0.8133     0.4307
MYDUNBA2.LOGBW                               0.719178    0.057556       12.4954     0.0000

R-SQ. (ADJ.) = 0.9517  SE=           0.273215  MAE=         0.189034  DurbWat=  2.445
Previously:     0.4167               0.949633               0.719682            1.278
17 observations fitted, forecast(s) computed for 0 missing val. of dep. var.
```

Key to variable labels, Tables 3.10-3.15:

logtbv = natural log of total brain volume

logbw = natural log of body weight

logdq = natural log of dietary quality

logmaf = natural log of mean number adult females

mycr = cortex ratio calculated as in Table 3.9, n.2

crtbvresid = cortex ratio residuals after regression on logtbv

logmage = natural log of mean adults in group

MYDUNBA2 = anthropoid primate dataset (generic means, excl. Homo, n=24).

Table 3.10

```
                         Model  fitting  results  for:  MYDUNBA2.MYCR
--------------------------------------------------------------------------------
Independent  variable                  coefficient  std. error     t-value   sig.level
--------------------------------------------------------------------------------
CONSTANT                                  0.960844     0.02174     44.1962      0.0000
MYDUNBA2.LOGTBV                           0.010612    0.001996      5.3176      0.0000
--------------------------------------------------------------------------------
R-SQ.  (ADJ.)  =  0.5425   SE=        0.011390  MAE=         0.008540  DurbWat=  1.001
Previously:     0.1754                1.072603              0.847564              0.433
24 observations  fitted,  forecast(s)  computed  for  0  missing  val.  of  dep.  var.
```

```
                         Model  fitting  results  for:  MYDUNBA2.MYCR
--------------------------------------------------------------------------------
Independent  variable                  coefficient  std. error     t-value   sig.level
--------------------------------------------------------------------------------
CONSTANT                                  0.835102    0.060215     13.8687      0.0000
MYDUNBA2.LOGTBV                           0.012439    0.002271      5.4777      0.0001
MYDUNBA2.LOGDQ                            0.020213    0.008505      2.3767      0.0303
--------------------------------------------------------------------------------
R-SQ.  (ADJ.)  =  0.6092   SE=        0.010043  MAE=         0.007233  DurbWat=  1.376
Previously:     0.5425                0.011390              0.008540              1.001
19 observations  fitted,  forecast(s)  computed  for  0  missing  val.  of  dep.  var.
```

```
                         Model  fitting  results  for:  MYDUNBA2.MYCR
--------------------------------------------------------------------------------
Independent  variable                  coefficient  std. error     t-value   sig.level
--------------------------------------------------------------------------------
CONSTANT                                  0.939984    0.049464     19.0033      0.0000
MYDUNBA2.LOGTBV                           0.007497    0.001736      4.3188      0.0008
MYDUNBA2.LOGDQ                            0.007843     0.00702      1.1172      0.2841
MYDUNBA2.LOGMAF                           0.008886    0.001699      5.2313      0.0002
--------------------------------------------------------------------------------
R-SQ.  (ADJ.)  =  0.8679   SE=        0.006168  MAE=         0.003927  DurbWat=  1.494
Previously:     0.6092                0.010043              0.007233              1.376
17 observations  fitted,  forecast(s)  computed  for  0  missing  val.  of  dep.  var.
```

Table 3.11

```
                 Model fitting results for: WORKAREA.CRTBVRESID
--------------------------------------------------------------------------------
Independent variable                  coefficient  std. error     t-value   sig.level
--------------------------------------------------------------------------------
CONSTANT                                -0.088977    0.038818     -2.2922      0.0349
MYDUNBA2.LOGDQ                           0.016994    0.007427      2.2881      0.0352
--------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.1905  SE=            0.009938  MAE=          0.007775  DurbWat=  1.203
Previously:    0.0000                 0.000000                0.000000            0.000
19 observations fitted, forecast(s) computed for 0 missing val. of dep. var.
```

```
                 Model fitting results for: MYDUNBA2.CRTB_RESID
--------------------------------------------------------------------------------
Independent variable                  coefficient  std. error     t-value   sig.level
--------------------------------------------------------------------------------
CONSTANT                                -0.016186    0.004603     -3.5165      0.0023
MYDUNBA2.LOGMAGS                          0.00849    0.002083      4.0756      0.0006
--------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.4384  SE=            0.008615  MAE=          0.005920  DurbWat=  1.404
Previously:    0.4902                 0.008208                0.005828            1.299
21 observations fitted, forecast(s) computed for 0 missing val. of dep. var.
```

```
                 Model fitting results for: WORKAREA.CRTBVRESID
--------------------------------------------------------------------------------
Independent variable                  coefficient  std. error     t-value   sig.level
--------------------------------------------------------------------------------
CONSTANT                                -0.011121    0.003224     -3.4493      0.0027
MYDUNBA2.LOGMAF                           0.00786    0.001747      4.4980      0.0002
--------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.4902  SE=            0.008208  MAE=          0.005828  DurbWat=  1.299
Previously:    0.1905                 0.009938                0.007775            1.203
21 observations fitted, forecast(s) computed for 0 missing val. of dep. var.
```

```
                 Model fitting results for: WORKAREA.CRTBVRESID
--------------------------------------------------------------------------------
Independent variable                  coefficient  std. error     t-value   sig.level
--------------------------------------------------------------------------------
CONSTANT                                -0.092411    0.031494     -2.9343      0.0109
MYDUNBA2.LOGMAF                          0.007134    0.001496      4.7691      0.0003
MYDUNBA2.LOGDQ                           0.015495    0.006001      2.5819      0.0217
--------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.6597  SE=            0.006639  MAE=          0.004757  DurbWat=  1.469
Previously:    0.4902                 0.008208                0.005828            1.299
17 observations fitted, forecast(s) computed for 0 missing val. of dep. var.
```

Table 3.12

```
                    Model  fitting  results  for:  MYDUNBA2.MYCR
---------------------------------------------------------------------------------
Independent  variable              coefficient  std. error     t-value   sig.level
---------------------------------------------------------------------------------
CONSTANT                             1.067821     0.00349     305.9914     0.0000
MYDUNBA2.LOGBW                       0.006558    0.001764       3.7180     0.0012
---------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.3580   SE=        0.013494  MAE=         0.011091  DurbWat=  0.936
Previously:     0.4384             0.008615               0.005920             1.404
24 observations fitted, forecast(s) computed for 0 missing val. of dep. var.
```

```
                    Model  fitting  results  for:  MYDUNBA2.MYCR
---------------------------------------------------------------------------------
Independent  variable              coefficient  std. error     t-value   sig.level
---------------------------------------------------------------------------------
CONSTANT                             0.934423    0.061651      15.1567     0.0000
MYDUNBA2.LOGBW                       0.008599     0.00222       3.8739     0.0013
MYDUNBA2.LOGDQ                       0.025061    0.011458       2.1872     0.0439
---------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.4201   SE=        0.012233  MAE=         0.009050  DurbWat=  1.396
Previously:     0.3580             0.013494               0.011091             0.936
19 observations fitted, forecast(s) computed for 0 missing val. of dep. var.
```

```
                    Model  fitting  results  for:  MYDUNBA2.MYCR
---------------------------------------------------------------------------------
Independent  variable              coefficient  std. error     t-value   sig.level
---------------------------------------------------------------------------------
CONSTANT                             1.011803    0.050556      20.0134     0.0000
MYDUNBA2.LOGBW                       0.005104    0.001641       3.1106     0.0083
MYDUNBA2.LOGDQ                       0.006808    0.009672       0.7039     0.4939
MYDUNBA2.LOGMAGS                     0.011312     0.00233       4.8553     0.0003
---------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.7781   SE=        0.007992  MAE=         0.005317  DurbWat=  1.469
Previously:     0.4201             0.012233               0.009050             1.396
17 observations fitted, forecast(s) computed for 0 missing val. of dep. var.
```

```
                    Model  fitting  results  for:  MYDUNBA2.MYCR
---------------------------------------------------------------------------------
Independent  variable              coefficient  std. error     t-value   sig.level
---------------------------------------------------------------------------------
CONSTANT                             1.020257    0.048088      21.2165     0.0000
MYDUNBA2.LOGBW                       0.004544    0.001588       2.8610     0.0134
MYDUNBA2.LOGDQ                        0.00664    0.009092       0.7303     0.4782
MYDUNBA2.LOGMAF                       0.01035    0.001953       5.3008     0.0001
---------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.8026   SE=        0.007539  MAE=         0.004748  DurbWat=  1.614
Previously:     0.7781             0.007992               0.005317             1.469
17 observations fitted, forecast(s) computed for 0 missing val. of dep. var.
```

Table 3.13

```
INPUT      6/ 8/93   11:56   STATGRAPHICS Vers.5.0              Display      MREG
                     Model fitting results for: MYDUNBA2.LOGMAGS
-------------------------------------------------------------------------------------
Independent variable                      coefficient  std. error      t-value    sig.le
-------------------------------------------------------------------------------------
CONSTANT                                     0.687475    0.065927      10.4278      0.0000
MYDUNBA2.LOGMAF                              0.866615    0.035732      24.2529      0.0000
-------------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.9671   SE=          0.167843  MAE=           0.125718  DurbWat=  2.483
Previously:     0.9691               0.162645                 0.117095            2.612
21 observations fitted, forecast(s) computed for 0 missing val. of dep. var.
```

```
INPUT      6/ 8/93   13:10   STATGRAPHICS Vers.5.0              Display      REG
Regression Analysis - Linear model: Y = a+bX
-------------------------------------------------------------------------------------
Dependent variable: MYDUNBA2.LOGMAGS          Independent variable: MYDUNBA2.LOGBW
-------------------------------------------------------------------------------------
                                   Standard              T                Prob.
Parameter           Estimate         Error             Value              Level
-------------------------------------------------------------------------------------
Intercept            1.81639       0.233721           7.77156            .00000
Slope               0.188618       0.121179           1.55652            .13608
-------------------------------------------------------------------------------------
                              Analysis of Variance
-------------------------------------------------------------------------------------
Source                  Sum of Squares     Df   Mean Square    F-Ratio   Prob. Level
Model                        1.9345270      1     1.9345270   2.422766         .13608
Residual                     15.171094     19       .798479
-------------------------------------------------------------------------------------
Total (Corr.)                17.105621     20
Correlation Coefficient = 0.336293                R-squared =  11.31 percent
Stnd. Error of Est. = 0.893576
```

```
                     Model fitting results for: MYDUNBA2.LOGMAGS
-------------------------------------------------------------------------------------
Independent variable                      coefficient  std. error      t-value   sig.level
-------------------------------------------------------------------------------------
CONSTANT                                    -1.239896    4.700319      -0.2638      0.7955
MYDUNBA2.LOGDQ                               0.617994    0.889848       0.6945      0.4980
-------------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.0000   SE=          0.992237  MAE=           0.773733  DurbWat=  1.284
Previously:     0.0000               0.000000                 0.000000            0.000
17 observations fitted, forecast(s) computed for 2 missing val. of dep. var.
```

```
                     Model fitting results for: MYDUNBA2.LOGMAGS
-------------------------------------------------------------------------------------
Independent variable                      coefficient  std. error      t-value   sig.level
-------------------------------------------------------------------------------------
CONSTANT                                    -7.450417    5.447032      -1.3678      0.1929
MYDUNBA2.LOGDQ                               1.723908    1.009332       1.7080      0.1097
MYDUNBA2.LOGBW                                0.31744    0.168034       1.8891      0.0798
-------------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.1177   SE=          0.916831  MAE=           0.663922  DurbWat=  1.923
Previously:     0.0000               0.992237                 0.773733            1.284
17 observations fitted, forecast(s) computed for 2 missing val. of dep. var.
```

Table 3.14

```
INPUT      6/ 8/93  11:57  STATGRAPHICS Vers.5.0              Display     MREG
                      Model  fitting results for: MYDUNBA2.LOGMAF
-------------------------------------------------------------------------------
Independent variable                    coefficient  std. error    t-value   sig.level
-------------------------------------------------------------------------------
CONSTANT                                  -0.720462   0.101842    -7.0743     0.0000
MYDUNBA2.LOGMAGS                           1.117808    0.04609    24.2529     0.0000
-------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.9671  SE=        0.190622  MAE=        0.149232  DurbWat=  2.404
Previously:     0.9671            0.167843              0.125218            2.483
21 observations fitted, forecast(s) computed for 0 missing val. of dep. var.
```

```
INPUT      6/ 8/93  12:03  STATGRAPHICS Vers.5.0              Display     MREG
                      Model  fitting results for: MYDUNBA2.LOGMAF
-------------------------------------------------------------------------------
Independent variable                    coefficient  std. error    t-value   sig.level
-------------------------------------------------------------------------------
CONSTANT                                   1.265524   0.258754     4.8908     0.0001
MYDUNBA2.LOGBW                             0.252572   0.134158     1.8826     0.0752
-------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.1129  SE=        0.989285  MAE=        0.775325  DurbWat=  1.023
Previously:     0.1486            1.031968              0.754929            1.820
21 observations fitted, forecast(s) computed for 3 missing val. of dep. var.
```

```
INPUT      6/ 8/93  12:04  STATGRAPHICS Vers.5.0              Display     MREG
                      Model  fitting results for: MYDUNBA2.LOGMAF
-------------------------------------------------------------------------------
Independent variable                    coefficient  std. error    t-value   sig.level
-------------------------------------------------------------------------------
CONSTANT                                   -1.11211   5.428409    -0.2051     0.8402
MYDUNBA2.LOGDQ                              0.50319   1.027688     0.4836     0.6315
-------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.0000  SE=        1.145937  MAE=        0.911152  DurbWat=  1.119
Previously:     0.1129            0.989285              0.775325            1.023
17 observations fitted, forecast(s) computed for 2 missing val. of dep. var.
```

```
INPUT      6/ 8/93  12:02  STATGRAPHICS Vers.5.0              Display     MREG
                      Model  fitting results for: MYDUNBA2.LOGMAF
-------------------------------------------------------------------------------
Independent variable                    coefficient  std. error    t-value   sig.level
-------------------------------------------------------------------------------
CONSTANT                                  -8.959276   6.131083    -1.4613     0.1660
MYDUNBA2.LOGBW                             0.401043   0.189136     2.1204     0.0523
MYDUNBA2.LOGDQ                             1.900366   1.136086     1.6727     0.1166
-------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.1486  SE=        1.031968  MAE=        0.754929  DurbWat=  1.820
Previously:     0.8738            0.080612              0.050815            1.966
17 observations fitted, forecast(s) computed for 2 missing val. of dep. var.
```

Table 3.15

CONTRASTS BETWEEN HUMANS AND OTHER PRIMATES

(1) Primary subsistence adaptations

Bipedality, habitual carrying of possessions
Spoken language: information exchange and social regulation
Active food sharing between adults, and adult-juvenile.
Home bases as focus in space for regrouping
Dietary focus on middle to large animal prey
Deferred consumption of gathered items at home base
Intensive preparation of some foodstuffs
Complex foraging tool kit

(2) Social organizational adaptations

Propensity to form long term mating bonds
Regulation of social relationships by explicit kinship
categories and rules

Summary of contrasts between humans and other primates, after Isaac (1978).

Table 4.1

Behavioral diversity between common chimpanzee populations in East Africa, after Wrangham in Gibbons (1992:287).

BEHAVIOUR	KIBALE SITE	GOMBE SITE	MAHALE SITE
insect tools	None	Termites and ants	Termites
Mother core areas	Clusters of 3-5	No clusters	Some clusters
Male coalitions	Rare	Common	Common
Drinking with tools	Stems as sponges	Leaves as sponges	Rare
Fear of red colobus monkeys	Often fearful	Sometimes fearful	Not available

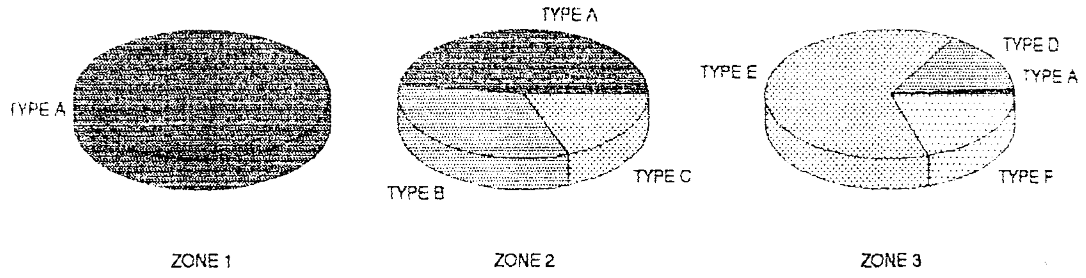
Comparison of tool making between three common chimpanzee populations, after Boesch and Boesch (1990:95, Table 5).

TYPE OF TOOL MAKING	GOMBE	MAHALE	TAI
(1) Cutting to correct length (grass, twig, stick, stone)	(I) breaking with the hands (II) cutting with the teeth	(I) breaking with the hands (II) cutting with the teeth	(I) breaking with the hands (II) cutting with the teeth (III) pulling while standing on it (IV) hitting against a hard surface
(2) Shaping (twigs, sticks)	(I) removing leaves or bark	(I) removing leaves or bark	(I) removing leaves or bark (II) sharpening ends with the teeth

Table 5.1

	ZONE	Nut cracking	Termite fishing	Termite mound perf.	Ant fishing	Ant dipping	Leaf sponging
Pan t. verus	1	+	+				
Pan t. troglodytes	2		+	+			
Pan t.schweinfurthii	3		+		+	+	+

Distribution of major types of chimpanzee tool-using activities, by sub-species/geographic zone. From Tomasello (1990:281, fig. 10.1).



Dominant vegetation types in the three zones of wild chimpanzee populations, with percentages calculated on the basis of total reported observations in field behaviour reports, and the vegetation distribution described in each such report (translated from Vea and Clemente 1988:44, Fig. 3).

KEY:

TYPE A = Dense low- or middle-altitude rainforest, with areas in cultivation and regeneration
TYPE B = Semi-humid woodland; secondary woodland, with savannah and srcrub patches
TYPE C = Drier vegetation types, including scrubland, high-elevation flatland, prairie, bamboo, and woodland.
TYPE D = Woodland-savannah mosaic.
TYPE E = Alternate sparse secondary woodland and svavannah.
TYPE F = Montane vegetation types.

Table 5.2

	Aggressivity	Group size	Food distrib.	Plasma cortisol
Peru	higher	larger	abundant, concentrated	elevated, slower recovery
Costa Rica	lower	smaller	dispersed	lower, faster recovery

Geographical variation in Saimiri spp. socioecology correlates with variation in adrenocortical axis settings in laboratory animals from the two populations, data from Boinski cited in Ketterson and Nolan (1992:S39).

	Pro	Contra	Conciliatory tendency	Adult wt F.	Adult wt M.	sexual body-size dimorphism	brain size
M. arctoides	0.182	-0.285	56.1	8.00	9.20	1.15	104.1
M. mulatta	0.281	-0.186	21.1	3.00	6.20	2.07	95.1

Behavioural and anatomical variation between two species of Macaques. Data from De Waal and Luttrell(1988), Kappeler and van Schaik (1992), Harvey et al. (1986)

	Conciliatory tendency	F-F	F-M	M-M	dimorphism cranial	dimorphism body wt	largest group	food distrib.
Pan troglodytes	32.0	10.75	18.75	38.5	more	1.29	smaller	smaller fruiting trees, less THV
Pan paniscus	48.0	19.5	30	6	less	1.36	larger	larger fruiting trees, more THV

Variation in *Pan* socioecology at the species level correlates with variation in grouping and in conciliatory social behaviours
Data from Kappeler and van Schaik (1992), Wrangham (1986), Blount (1990)

Table 5.3

OCCUPATIONAL DISTRIBUTION OF THE GAINFULLY EMPLOYED POPULATION IN GREAT BRITAIN (%).

occupational class	categories	1911	1951	1971
1	Professional			
	A.higher	1.00	1.93	1.36
	B.lower	3.05	4.70	7.78
2	Employers/managers			
	A. employers	6.71	4.97	4.22
	B. managers	3.43	5.53	8.21
3	Clerical workers	4.84	10.68	13.90
4	Foremen	1.29	2.62	3.87
5-7	Manual workers	79.67	69.58	58.23

From Routh (1980: Table 1.1), as quoted in
Hamilton & Hirszowicz (1987:154).

Table 8.1

Change in undergraduate numbers by subject group of study (old system), '000s, 1966-1981.

	1966-67	1970-71	1972-73	1974-75	1976-77	1978-79	1980-81	% increase/decrease
Education	0.76	1.55	0.66	1.50	1.95	3.36	3.7	386.8
Med./dent./health	18.87	20.62	21.93	24.18	25.85	27.10	27.9	47.9
Engin. & technol.	26.03	30.26	29.67	28.65	31.68	35.05	36.8	41.4
Agric.,fores.,vet.sc	3.17	3.64	3.43	3.71	4.34	4.90	5.1	60.9
Biol./phys. sci.	40.34	45.78	48.58	48.69	49.88	53.90	57.8	43.3
Admin./busi./soc.stu	33.86	38.62	41.91	46.10	53.30	56.93	59.9	76.9
Archi. & related	2.62	2.89	3.19	3.66	3.83	4.09	4.2	60.3
Lang.,lit.,area stud	22.41	23.53	24.93	26.14	28.59	30.91	32.7	45.9
Arts (excl. lang.)	9.06	19.01	18.95	20.07	22.07	22.96	23.0	153.9
TOTAL	156.81	185.87	193.25	202.70	221.49	239.19	251.2	60.2

Source: DES Statistics in Education Vol.6, annual.

Table 8.2

Change in undergraduate numbers by subject group of study ('000s), 1979-1989.

	1979-80 (Est.)	1984-85 (Est.)	1989-90	% increase/decrease
Medecine/dentistry	22.8	23.2	22.9	0.44
Other health studs.	6.2	6.3	7.4	19.35
Biol. sciences	15.5	15.9	18.5	19.35
Veterin., agric. etc	5.3	4.9	4.6	(13.21)
Physical sciences	19.9	20.6	21.6	8.54
Mathematical sci's	14.4	15.0	18.5	28.47
Engineering & techn.	31.9	30.8	34.0	6.58
Archit. & rel. studs	3.6	3.5	4.1	13.89
Social sciences	34.3	33.4	39.2	14.29
Business & fin.studs	9.3	9.1	12.3	32.26
Libr. & info. sci.	0.2	0.3	0.3	50.00
Languages & related	27.9	27.1	30.4	8.96
Humanities	16.2	14.8	16.7	3.09
Creative arts	3.7	3.4	4.5	21.62
Education	2.6	2.5	4.0	53.85
Multi-disc. studies	31.4	30.9	37.6	19.75
TOTAL	245.1	241.7	275.3	12.32

Source: Supplement to University Statistics, Vol 1 (1987-88); University Statistics Vol 1, 1988-91.

Table 8.3

PHASES OF GDP GROWTH, 1870-1984

(AVERAGE ANNUAL COMPOUND GROWTH RATES)

	I 1870-1913	II 1913-1950	III 1950-1973	IV 1973-1984	Acceleration from Phase II to Phase III	Slowdown from Phase III to Phase IV
France	1.7	1.1	5.1	2.2	4.0	(2.9)
Germany	2.8	1.3	5.9	1.7	4.6	(4.2)
Japan	2.5	2.2	9.4	3.8	7.2	(5.6)
Netherlands	2.1	2.4	4.7	1.6	2.3	(3.1)
U.K.	1.9	1.3	3.0	1.1	1.7	(1.9)
Five-country average	2.2	1.7	5.6	2.1	4.0	(3.5)
U.S.A.	4.2	2.8	3.7	2.3	0.9	(1.4)

Source: Maddison (1987:650), reproduced in Berger (1990).

Table 8.4

Level 6 university graduates by field of study, Britain and Germany, 1976 ('000s).

	Britain	Germany
Engineering/technol.	11.2	16.8
Medecine/health	5.9	7.4
Vocational studies	8.1	11.0
Science	17.9	5.3
Education	1.5	2.0
Social studies	14.0	17.0
Languages/arts	19.5	5.3
TOTAL NUMBER	78.1	64.8

Source: Prais, S.J., reproduced in Wagner (1986)

Vocational studies include law, accountancy, management, architecture, agriculture, etc.

Table 8.5

HUMANITIES GRADUATES AS A % OF TOTAL GRADUATES (EXCL. EDUCATION), TERTIARY LEVEL 6 (ISCED).

	1975/6/7	1979/80/81	1983/4/5/6	1987/8/9
Belgium	18.6		17.7	11.0
Bulgaria	12.2	16.4	12.8	5.9
Czechoslovakia	1.4		1.4	
Denmark	21.6	9.3	8.6	17.3
Finland	19.4	20.0	17.3	18.6
France	47.6	33.2		
Germany (ex-FDR)	4.6	6.3	5.1	14.7
Greece	14.8	17.3	18.6	21.9
Hungary	0.0	0.0		
Ireland	39.0	39.3	32.4	26.8
Italy	25.6	17.1	16.2	15.0
Japan	14.4	15.2	15.5	16.2
Netherlands			14.7	16.8
Norway	23.1		13.1	6.4
Poland	0.0	0.0	8.8	13.5
Portugal	18.0	28.1	23.2	10.5
Spain		7.4	15.7	12.5
Sweden	9.2	11.8		3.4
Switzerland	15.5	13.1	13.4	18.9
U.K.	16.0	16.7	17.0	13.0
U.S.A.	15.5	9.0	6.3	
U.S.S.R.	0.0			
Yugoslavia	14.6	12.0	12.3	10.0

HUMANITIES (ISCED) include languages, literature linguistics, comp. lit., progs for interpretors/ transl.,hist., archaeol., philos., relig., theol

ISCED (International Standard Classification of Education) Level 6 is first degree-equivalent level tertiary education

Sources: derived from UNESCO Statistical Yearbooks, 1975-1990

Table 8.6

Vocational qualifications of the labour force in Britain (1974-78) and Germany (1978)

	Employment as % of total economy	% of labour force with university level quals.	% of labour force with intermediate level quals.	% of labour force with no qualifications
All activities - B	100.0	5.5	30.0	64.4
All activities - G	100.0	7.1	59.9	33.0
All manufacturing- B	31.8	3.3	28.7	68.0
All manufacturing- G	33.8	3.5	60.8	35.7
All non-manuf. - B	68.2	6.5	30.7	62.8
All non-manuf. - G	66.2	8.9	59.4	31.6

Source: Prais, S.J., reproduced in Wagner (1986)

Table 8.7

Qualifications of manufacturing technicians and foremen, Britain, France, Germany, 1987 (%).

	Degree equivalent	Higher intermediate	None
MANUFACTURING TECHNICIANS			
Britain	12	14	31
France	3	21	n/a
Germany	7	36	8
FOREMEN			
Britain	n/a	3	n/a
France	n/a	4	n/a
Germany	n/a	64	n/a

Source: Smethurst (1992).

Table 8.8

APPENDICES

Network 1 Simulations, Conditions 1-3, 2 runs.

Simulation Number	Condition 1 Run 1 10 iteration	Condition 1 Run 2 20 iteration	Condition 2 Run 1 10 iteration	Condition 2 Run 2 20 iteration	Condition 3 Run 1 10 iteration	Condition 3 Run 2 20 iteration
1	40	42	27	27	15	0
2	48	40	9	0	6	0
3	51	54	0	0	0	0
4	51	45	36	36	36	36
5	45	46	24	0	17	0
6	61	0	0	0	0	0
7	45	47	0	0	0	0
8	44	48	0	0	0	0
9	41	49	36	36	23	27
10	46	53	2	0	1	0
11	46	52	17	0	10	0
12	44	45	12	0	1	0
13	42	46	36	36	26	27
14	45	45	45	45	38	27
15	25	50	1	0	1	0
16	47	40	9	0	6	0
17	43	40	9	0	3	0
18	46	54	36	36	36	36
19	42	52	12	0	9	0
20	36	58	2	0	1	0
21	45	45	45	45	31	36
22	45	45	45	45	32	27
23	43	36	24	0	17	0
24	45	45	45	45	32	27
25	43	42	24	0	19	0

Data are for number of nodes with trait '1' at the end of the simulation.

Appendix 4.1

Network 1 Simulations, Conditions 1-3, 2 runs (continued)

Simulation Number	Condition 1 Run 1 10 iteration	Condition 1 Run 2 20 iteration	Condition 2 Run 1 10 iteration	Condition 2 Run 2 20 iteration	Condition 3 Run 1 10 iteration	Condition 3 Run 2 20 iteration
26	38	53	0	0	0	0
27	42	41	9	0	6	0
28	64	73	1	0	1	0
29	41	47	12	0	3	0
30	46	41	18	0	11	0
31	41	42	17	0	12	0
32	43	38	36	36	24	27
33	52	48	9	0	6	0
34	48	39	0	0	0	0
35	46	49	17	0	14	0
36	45	45	45	45	41	27
37	45	51	17	0	7	0
38	43	46	9	0	6	0
39	43	52	18	0	12	0
40	47	46	36	36	36	36
41	49	44	18	0	12	0
42	40	35	12	0	7	0
43	43	90	0	0	0	0
44	46	43	12	0	9	0
45	45	40	36	36	36	36
46	43	56	18	0	12	0
47	45	39	36	36	24	18
48	45	45	27	27	21	0
49	43	51	24	0	18	0
50	44	41	0	0	0	0

Data are for number of nodes with trait '1' at the end of the simulation.

Network 2 Simulations, Conditions 1-3, 2 runs.

Simulation Number	Condition 1 Run 1 10 Iteration	Condition 1 Run 2 20 Iteration	Condition 2 Run 1 10 Iteration	Condition 2 Run 2 20 Iteration	Condition 3 Run 1 10 Iteration	Condition 3 Run 2 20 Iteration
1	52	52	39	39	39	39
2	62	47	42	42	6	42
3	47	46	23	19	0	19
4	52	46	33	33	33	33
5	69	71	35	19	34	19
6	46	44	23	19	23	19
7	48	45	36	36	36	36
8	89	90	74	75	73	72
9	42	45	19	19	19	19
10	70	71	55	55	52	52
11	0	0	0	0	0	0
12	41	39	29	29	29	19
13	43	44	19	19	19	19
14	50	53	23	19	19	19
15	49	47	26	19	26	19
16	46	47	31	31	29	19
17	54	50	42	42	42	39
18	30	45	19	19	19	19
19	88	90	68	68	68	68
20	90	60	0	0	0	0
21	32	49	19	19	19	19
22	90	90	72	72	70	69
23	49	44	23	19	19	19
24	6	50	0	0	0	0
25	40	28	19	19	19	19

Data are for number of nodes with trait '1' at the end of the simulation.

Network 2 Simulations, Conditions 1-3, 2 runs (continued)

Simulation Number	Condition 1 Run 1 10 iteration	Condition 1 Run 2 20 iteration	Condition 2 Run 1 10 iteration	Condition 2 Run 2 20 iteration	Condition 3 Run 1 10 iteration	Condition 3 Run 2 20 iteration
26	3	0	0	0	0	0
27	43	47	22	19	22	19
28	23	19	19	19	19	19
29	84	41	19	19	19	19
30	23	20	19	19	19	19
31	48	19	19	19	19	19
32	24	19	19	19	19	19
33	90	90	0	0	0	0
34	87	90	0	0	0	0
35	48	51	39	39	39	39
36	59	71	19	19	19	19
37	3	0	0	0	0	0
38	49	47	45	45	45	45
39	39	43	19	19	19	19
40	34	41	19	19	19	19
41	90	71	0	0	0	0
42	40	43	19	19	19	19
43	47	65	19	19	19	19
44	39	42	19	19	19	19
45	48	46	26	19	26	19
46	43	42	19	19	19	19
47	22	45	0	0	0	0
48	43	44	19	19	19	19
49	87	90	22	19	22	19
50	26	19	19	19	19	19

Data are for number of nodes with trait '1' at the end of the simulation.

Network 3 Simulations, Condition2 1-3, 1 run.

Simulation Number	Condition 1 Run 1 20 Iteration	Condition 2 Run 1 20 Iteration	Condition 3 Run 1 20 Iteration
1	37	36	0
2	90	34	0
3	53	0	0
4	74	38	0
5	40	0	0
6	0	0	0
7	0	0	0
8	50	0	0
9	60	0	0
10	63	0	0
11	90	0	0
12	46	0	0
13	35	33	0
14	0	0	0
15	0	0	0
16	51	26	0
17	37	0	0
18	90	0	0
19	46	0	0
20	29	0	0
21	0	0	0
22	38	30	0
23	0	0	0
24	54	0	0
25	44	0	0

Data are for number of nodes with trait '1' at the end of the simulation.

Network 3 Simulations, Conditions 1-3, 1 run (continued)

Simulation Number	Condition 1 Run 1 20 iteration	Condition 2 Run 1 20 iteration	Condition 3 Run 1 20 iteration
26	0	0	0
27	22	0	0
28	50	0	0
29	1	0	0
30	60	0	0
31	0	0	0
32	37	34	0
33	90	0	0
34	31	25	0
35	0	0	0
36	90	0	0
37	41	0	0
38	52	0	0
39	25	0	0
40	0	0	0
41	90	0	0
42	58	0	0
43	0	0	0
44	90	26	0
45	53	0	0
46	0	0	0
47	58	0	0
48	53	0	0
49	0	0	0
50	56	0	0

Data are for number of nodes with trait '1' at the end of the simulation.

Seed nodes and seed node measures, Networks 1 and 3 simulations. 50 random pairs of seeds.

Negative values in brackets.

	1	2	3	4	5	6	7
Simulation 1	24	6	5	(33)	3	2	0
2	28	52	4	(70)	2	3	(4)
3	13	81	4	(36)	3	3	(2)
4	83	81	4	90	3	3	1
5	77	45	5	(59)	3	3	1
6	47	52	1	(32)	1	1	(1)
7	3	14	2	76	2	2	1
8	47	26	2	32	2	1	3
9	80	67	4	55	3	3	0
10	47	74	5	(166)	3	3	(6)
11	52	36	2	(9)	2	2	1
12	26	82	4	(26)	4	3	(1)
13	78	70	4	(14)	3	2	1
14	2	89	5	72	3	3	2
15	42	80	6	(22)	3	2	1
16	32	60	4	16	3	2	(1)
17	23	86	4	4	4	3	1
18	60	59	2	11	2	1	1
19	27	88	4	118	3	3	3
20	70	3	5	(39)	3	2	(1)
21	36	35	3	(39)	2	1	0
22	50	51	3	(75)	2	3	(4)
23	29	81	5	(78)	3	3	3
24	70	73	5	(18)	3	3	(4)
25	72	23	5	38	3	3	0

Network centrality and distance measures calculated using UCINET IV (Borgatti, Everett & Freeman 1992).

Key:

1 = Seed Node, trait '1'

2 = Seed Node, trait '2'

3 = Network 1, distance between nodes

4 = Network 3, betweenness (s.n. 1 - s.n. 2)

5 = Network 3, distance (s.n. 1 to s.n. 2)

6 = Network 3, distance s.n. 2 - s.n. 1)

7 = Network 3, degree (s.n. 1 - s.n. 2)

Seed nodes and seed node measures, Networks 1 and 3 simulations. 50 random pairs of seeds. Negative values in brackets.

	1	2	3	4	5	6	7
Simulation 26	35	13	4	134	3	2	4
27	42	19	4	(28)	3	3	(1)
28	64	17	7	(47)	3	3	(1)
29	2	33	4	58	3	4	0
30	15	34	3	(43)	2	3	(3)
31	7	23	2	11	1	2	(1)
32	68	80	4	0	2	3	(2)
33	73	50	4	124	3	2	6
34	10	76	2	(47)	2	2	(1)
35	18	3	2	(41)	2	2	0
36	14	7	3	37	3	2	2
37	83	18	3	(53)	2	1	(1)
38	45	19	4	(16)	3	2	(5)
39	69	88	3	67	2	2	2
40	65	63	4	153	3	2	6
41	19	37	3	79	2	2	4
42	75	14	4	32	3	2	0
43	30	21	1	(71)	1	1	(2)
44	38	67	4	50	3	2	(2)
45	22	24	4	28	3	3	0
46	50	70	3	(106)	2	2	(2)
47	10	18	4	(169)	3	3	(3)
48	79	1	5	58	4	3	4
49	47	85	5	16	3	3	3
50	68	19	4	(45)	2	3	(1)

Network centrality and distance measures calculated using UCINET IV (Borgatti, Everett & Freeman 1992).

Key:

1 = Seed Node, trait '1'

2 = Seed Node, trait '2'

3 = Network 1, distance between nodes

4 = Network 3, betweenness (s.n. 1 - s.n. 2)

5 = Network 3, distance (s.n. 1 to s.n. 2)

6 = Network 3, distance s.n. 2 - s.n. 1)

7 = Network 3, degree (s.n. 1 - s.n. 2)

Seed nodes and seed node measures, Network 2.
50 random pairs of seeds.

Negative values in brackets.

	Seed Node, Trait '1'	Seed Node, Trait '2'	Network 2 Distance between nodes	Network 2 Degree (s.n. 1 - s.n. 2)	Network 2 Closeness (s.n. 1 - s.n. 2)
Simulation 1	40	22	3	15	9.14
2	77	79	4	12	2.37
3	26	80	6	0	(0.40)
4	71	64	4	14	4.65
5	83	51	5	15	3.75
6	23	75	6	0	3.42
7	49	37	2	0	3.33
8	7	32	3	0	5.53
9	4	77	5	(12)	0.14
10	9	8	2	15	3.58
11	30	19	4	(1)	(2.43)
12	89	66	4	(14)	(4.62)
13	54	34	2	(12)	0.14
14	27	74	6	0	0.00
15	38	60	4	15	3.47
16	54	13	5	0	(0.14)
17	56	68	4	14	5.11
18	6	39	5	(12)	0.14
19	1	80	3	0	5.39
20	87	62	3	2	2.74
21	57	40	4	(1)	(1.01)
22	49	26	4	0	5.79
23	4	74	2	0	5.93
24	23	5	4	0	(2.51)
25	31	81	4	(15)	(6.12)

Network centrality and distance measures calculated using UCINET IV (Borgatti, Everett & Freeman 1992).

Seed nodes and seed node measures, Network 2. (continued). 50 random pairs of seeds.

Negative values in brackets.

	Seed Node, Trait '1'	Seed Node, Trait '2'	Network 2 Distance between nodes	Network 2 Degree (s.n. 1 - s.n. 2)	Network 2 Closeness (s.n. 1 - s.n. 2)
Simulation 26	12	58	6	0	(2.16)
27	1	79	5	0	2.37
28	46	82	5	(12)	0.00
29	61	82	3	3	3.75
30	3	61	5	(15)	(3.75)
31	80	78	4	(12)	(5.39)
32	43	23	2	0	2.65
33	52	62	1	3	3.58
34	71	78	3	2	1.32
35	44	32	4	14	8.13
36	80	14	3	(14)	(8.13)
37	26	355	4	0	(5.93)
38	82	74	4	12	5.79
39	44	71	5	0	1.42
40	54	9	6	(15)	(3.44)
41	20	24	1	0	0.00
42	64	57	3	(14)	(6.07)
43	60	5	4	0	0.14
44	84	45	5	(14)	(6.07)
45	3	26	4	0	5.79
46	37	82	5	(12)	(3.33)
47	37	17	3	0	0.00
48	65	45	2	(14)	(6.07)
49	1	79	5	0	2.37
50	3	24	3	(12)	0.00

Network centrality and distance measures calculated using UCINET IV (Borgatti, Everett, & Freeman 1992).

Please do not break the seal on this booklet until you are told to do so.

Complete the six problems in order.

You must not return to a problem once you have turned over the page to the next, nor may you revise your answers to earlier problems in the light of your experience in answering later problems in the series.

Appendix 6.1

Part of your new job for the City of Southampton is to study the demographics of transportation. You read a previously done report on the habits of Southampton residents which says:

"If a person goes to Winchester, then he takes the bus."

The cards below have information about four Southampton residents. Each card represents one person. One side of a card tells where a person went and the other side of the card tells how that person got there.

Indicate only those card(s) you definitely need to turn over to see if any of these people violate this rule.

train	Winchester
bus	Southampton

You are an employee in a factory. The factory operates seven days of the week, which benefits the firm since having employees at work over the weekend means the firm keeps its machinery in use and is more flexible.
For the employees, working at the weekend means sacrificing leisure time.
In order to compensate employees for this, the following rule is said to apply:

"If an employee works on the weekend, then that person gets a day off during the week."

A colleague who has never previously worked at the weekends is now considering working on Saturdays from time to time, since the advantages of having a day off during the week would outweigh the disadvantages of working on Saturday.
But there are rumours that the rule that employees working at the weekend get a day off during the week has been violated before.
You want to check whether the rule has in fact been violated.
The cards below have information about four colleagues. Each card represents one colleague. One side of a card tells whether or not the colleague worked on the last weekend and the other side of the card tells whether or not that colleague got a day off.
Indicate only those card(s) you definitely need to turn over to see if the rule was violated.

Did get a day off	Worked on the weekend
Did not get a day off	Did not work on the weekend

You are an anthropologist studying the Namka, a hunter-gatherer culture of the deserts of southwest Africa. Over and over again, you hear various Namka repeat the following saying:

"If you eat duiker meat, then you have found an ostrich eggshell."

Duikers are small antelopes found in the eastern part of the Namka's home range. Both duiker meat and ostrich eggshells are sought by the Namka: they eat the meat and they use the eggshells as canteens because they are light and hold lots of water. Furthermore, duikers frequently feed on ostrich eggs.
As an anthropologist, you don't know if this saying is metaphorical, referring, for example, to clan territories or ritual practices, or if the saying reflects a real relationship the Namka use to guide their foraging behaviour. Do they mean that if you find the first you find the second? This is what you are trying to find out. Is it fact or folklore? Do the Namka *mean* eggshells and duiker meat, or are these things merely symbols for something else entirely? Unfortunately you don't know their language well enough to ask them. So you decide to investigate whether the rule stated in this saying has any *factual* basis.
Many species of birds populate the area, and in your wanderings you have come across several caches of eggs of various sorts. The cards below have information about four different locations with egg caches. Each card represents one location, and each location has the tracks of one mammal associated with it. One side of a card tells what kind of eggshell you found at a location, and the other side of the card tells which mammal's tracks you found there.
Perhaps the Namka's saying has no factual basis. Indicate only those card(s) you definitely need to turn over to see if your finds at any of these locations violate the rule expressed in the Namka's saying.

Ostrich eggshell	Quail eggshell	Duiker	Weasel

Part of your new clerical job at the local secondary school is to make sure that student documents have been processed correctly. Your job is to make sure the documents conform to the following alphanumeric rule:

"If a person has a 'D' rating, then his documents must be marked code '3'".

You suspect the secretary you replaced did not categorize the pupils' documents correctly. The cards below have information about the documents of four people who are enrolled at this secondary school. Each card represents one person. One side of a card tells a person's letter rating and the other side of the card tells that person's number code.

Indicate only those card(s) you definitely need to turn over to see if the documents of any of these people violate this rule.

D

F

3

7

You are a senior manager in a firm which operates a company pension scheme. You are aware that the firm benefits when employees stay for ten years or more, since training costs for new employees are kept down. However, employees are generally slightly unhappy with their job, and would prefer to leave after a shorter period. There is a rule for the company pension scheme, which states that:

"If a person has worked for the firm for at least ten years, then that person gets a company pension."

You have heard a rumour that this rule has been violated in the past.
You want to check whether the rule has in fact been violated.
The cards below have information about four previous employees. Each card represents one previous employee. One side of a card indicates whether or not that individual got a pension, and the other side tells how long that person worked for the firm. Indicate only those card(s) which you definitely need to turn over to see if the rule has been violated.

Got a pension

Did not get
a pension

Worked ten years
for the firm

Worked eight years
for the firm

You are an anthropologist studying the Kalaume, a Polynesian people who live in small, warring bands on Maku Island in the Pacific. You are interested in how Kalaume 'big men' - chieftains - wield power.

'Big Kiku' is a Kalaume big man who is known for his ruthlessness. As a sign of loyalty, he makes his own 'subjects' put a tattoo on their face. Members of other Kalaume bands never have facial tattoos. Big Kiku has made so many enemies in other Kalaume bands, that being caught in another village with a facial tattoo is, quite literally, the kiss of death.

Four men from different bands stumble into Big Kiku's village, starving and desperate. They have been kicked out of their respective villages for various misdeeds, and have come to Big Kiku because they need food badly. Big Kiku offers each of them the following deal:

"If you get a tattoo on your face, then I'll give you cassava root."

Cassava root is a very sustaining food which Big Kiku's people cultivate. The four men are very hungry, so they agree to Big Kiku's deal. Big Kiku says that the tattoos must be in place tonight, but that the cassava root will not be available until the following morning.

You learn that Big Kiku hates some of these men for betraying him to his enemies. You suspect he will cheat and betray some of them. Thus, this is a perfect opportunity for you to see first hand how Big Kiku wields his power.

The cards below have information about the fates of the four men. Each card represents one man. One side of a card tells whether or not the man went through with the facial tattoo that evening and the other side of the card tells whether or not Big Kiku gave that man cassava root the next day.

Did Big Kiku get away with cheating any of these four men? Indicate only those card(s) you definitely need to turn over to see if Big Kiku has broken his word to any of these four men.

Got the tattoo

No tattoo

Big Kiku gave him nothing

Big Kiku gave him cassava root

Please do not break the seal on this part of the booklet until you are told to do so.

The test on the next page will be timed (10 minutes).

ABSTRACTION TEST

Complete the following. Each dash (_) calls for either a number or a letter to be filled in. Every line is a separate item. Take the items in order, but don't spend too much time on any one.

Start here

(1) 1 2 3 4 5 _

(2) white black short long down _ _

(3) AB BC CD D_

(4) Z Y X W V U _

(5) 1 2 3 2 1 2 3 4 3 2 3 4 5 4 3 4 5 6 _ _

(6) NE/SW SE/NW E/W N/_

(7) escape scape cape _ _ _

(8) oh ho rat tar mood _ _ _ _

(9) A Z B Y C X D _

(10) tot tot bard drab 537 _ _ _

(11) mist is wasp as pint in tone _ _

(12) 57326 73265 32657 26573 _ _ _ _ _

(13) knit in spud up both to stay _ _

(14) Scotland landscape scapegoat _ _ _ _ ee

(15) surgeon 1234567 snore 17635 rogue _ _ _ _ _

(16) tam tan rib rid rat raw hip _ _ _

(17) tar pitch throw saloon bar rod fee tip end
plank _ _ _ _ _ meals

(18) 3124 82 73 154 46 13_

(19) lag leg pen pin big bog rob _ _ _

(20) two w four r one o three _

VOCABULARY TEST

In the test below, the first word in each line is printed in capital letters. Opposite it are four other words. *Draw a line* under the *one word* which means the *same thing,* or most nearly the same thing, as the first word. A sample has been worked out for you. If you don't know, *guess*. Be sure to underline the *one word* in each line which means the same thing as the first word.

			sample		
	LARGE	red	big	silent	wet
(1)	TALK	draw	eat	speak	sleep
(2)	PERMIT	allow	sew	cut	drive
(3)	PARDON	forgive	pound	divide	tell
(4)	COUCH	pin	eraser	sofa	glass
(5)	REMEMBER	swim	recall	number	defy
(6)	TUMBLE	drink	dress	fall	think
(7)	HIDEOUS	silvery	tilted	young	dreadful
(8)	CORDIAL	swift	muddy	leafy	hearty
(9)	EVIDENT	green	obvious	sceptical	afraid
(10)	IMPOSTOR	conductor	officer	book	pretender
(11)	MERIT	deserve	distrust	fight	separate
(12)	FASCINATE	welcome	fix	stir	enchant
(13)	INDICATE	defy	excite	signify	bicker
(14)	IGNORANT	red	sharp	uninformed	precise
(15)	FORTIFY	submerge	strengthen	vent	deaden
(16)	RENOWN	length	head	fame	loyalty
(17)	NARRATE	yield	buy	associate	tell
(18)	MASSIVE	bright	large	speedy	low
(19)	HILARITY	laughter	speed	grace	malice
(20)	SMIRCHED	stolen	pointed	remade	soiled
(21)	SQUANDER	tease	belittle	cut	waste
(22)	CAPTION	drum	ballast	heading	ape
(23)	FACILITATE	help	turn	strip	bewilder
(24)	JOCOSE	humorous	paltry	fervid	plain
(25)	APPRISE	reduce	strew	inform	delight
(26)	RUE	eat	lament	dominate	cure
(27)	DENIZEN	senator	inhabitant	fish	atom
(28)	DIVEST	dispossess	intrude	rally	pledge
(29)	AMULET	charm	orphan	dingo	pond
(30)	INEXORABLE	untidy	involatile	rigid	sparse
(31)	SERRATED	dried	notched	armed	blunt
(32)	LISSOM	moldy	loose	supple	convex
(33)	MOLLIFY	mitigate	direct	pertain	abuse
(34)	PLAGIARIZE	appropriate	intend	revoke	maintain
(35)	ORIFICE	brush	hole	building	lute
(36)	QUERULOUS	maniacal	curious	devout	complaining
(37)	PARIAH	outcast	priest	lentil	locker
(38)	ABET	waken	ensue	incite	placate
(39)	TEMERITY	rashness	timidity	desire	kindness
(40)	PRISTINE	vain	sound	first	level

PLEASE INDICATE FOR EACH STATEMENT WHETHER YOU AGREE OR DISAGREE, AND HOW MUCH. DO THIS BY SCORING YOUR RESPONSE TO EACH STATEMENT AS FOLLOWS: 1 = STRONGLY DISAGREE; 2 = MILDLY DISAGREE; 3 = MILDLY AGREE; 4 = STRONGLY AGREE.

1. It makes me sad to see a lonely stranger in a group.

2. People make too much of the feelings and sensitivity of animals.

3. I often find public displays of affection annoying.

4. I am annoyed by unhappy people who are just sorry for themselves.

5. I become nervous if others around me seem to be nervous.

6. I find it silly for people to cry out of happiness.

7. I tend to get emotionally involved with a friend's problems.

8. Sometimes the words of a love song can move me deeply.

9. I tend to lose control when I am bringing bad news to people.

10. The people around me have a great influence on my moods.

11. Most foreigners I have met seemed cool and unemotional.

12. I would rather be a social worker than work in a job training centre.

13. I don't get upset just because a friend is acting upset.

14. I like to watch people opening presents.

15. Lonely people are probably unfriendly.

16. Seeing people cry upsets me.

17. Some songs make me happy.

18. I really get involved with the feelings of the characters in a novel.

19. I get very angry when I see someone being ill-treated.

20. I am able to remain calm even though those around me worry.

21. When a friend starts to talk about his problems, I try to steer the conversation to something else.

22. Another's laughter is not catching for me.

23. Sometimes at the movies I am amused by the amount of crying and sniffling around me.

24. I am able to make decisions without being influenced by people's feelings.

25. I cannot continue to feel O.K. if people around me are depressed.

26. It is hard for me to see how some things upset people so much.

27. I am very upset when I see an animal in pain.

28. Becoming involved in books or movies is a little silly.

29. It upsets me to see helpless old people.

30. I become more irritated than sympathetic when I see someone's tears.

31. I become very involved when I watch a movie.

32. I often find that I can remain cool in spite of the excitement around me.

33. Little children sometimes cry for no apparent reason.

Please do not break the seal on this part of the booklet until you are told to do so.

The test which follows asks you to choose between three different statements of social attitudes. You must choose the one which is closest to your own beliefs, and the one which is furthest from your own beliefs. Even if none of the three options closely matches your own beliefs, you should still choose the one which is closest, and the one which is least close.

Mark the one which is closest to your own beliefs with a TICK.

Mark the one which is furthest from your beliefs with a CROSS.

Repeat this for each of the twenty sets of statements in the test.

NOTE THAT THERE ARE NO 'RIGHT' OR 'WRONG' ANSWERS IN THIS EXERCISE.

1. A. It takes more imagination to be a successful criminal than a successful business man.
   B. The phrase, "the road to hell is paved with good intentions" contains a lot of truth.
   C. Most men forget more easily the death of their father than the loss of their property.

2. A. Men are more concerned with the car they drive than with the clothes their wives wear.
   B. It is very important that imagination and creativity in children be cultivated.
   C. People suffering from incurable diseases should have the choice of being put painlessly to death.

3. A. Never tell anyone the real reason you did something unless it is useful to do so.
   B. The well-being of the individual is the goal that should be worked for before anything else.
   C. Since most people don't know what they want, it is only reasonable for ambitious people to talk them into doing things.

4. A. People are getting so lazy and self-indulgent that is is bad for our country.
   B. The best way to handle people is to tell them what they want to hear.
   C. It would be a good thing if people were kinder to others less fortunate than themselves.

5. A. Most people are basically good and kind.
   B. The best criteria for a wife or husband is compatibility — other characteristics are nice but not essential.
   C. Only after a man has gotten what he wants from life should he concern himself with the injustices in the world.

6. A. Most people who get ahead in the world lead clean, moral lives.
   B. Any man worth his salt shouldn't be blamed for putting his career above his family.
   C. People would be better off if they were concerned less with how to do things and more with what to do.

7. A. A good teacher is one who points out unanswered questions rather than gives explicit answers.
B. When you ask someone to do something, it is best to give the real reasons for wanting it rather than giving reasons which might carry more weight.
C. A person's job is the best single guide as to the sort of person he is.

8. A. The construction of such monumental works as the Egyptian pyramids was worth the enslavement of the workers who built them.
B. Once a way of handling problems has been worked out it is best to stick to it.
C. One should take action only when sure it is morally right.

9. A. The world would be a much better place to live in if people would let the future take care of itself and concern themselves only with enjoying the present.
B. It is wise to flatter important people.
C. Once a decision has been made, it is best to keep changing it as new circumstances arise.

10. A. It is a good policy to act as if you are doing the things you do because you have no other choice.
B. The biggest difference between most criminals and other people is that criminals are stupid enough to get caught.
C. Even the most hardened and vicious criminal has a spark of decency somewhere within him.

11. A. All in all, it is better to be humble and honest than to be important and dishonest.
B. A man who is able and willing to work hard has a good chance of succeeding in whatever he wants to do.
C. If a thing does not help us in our daily lives, it isn't very important.

12. A. A person shouldn't be punished for breaking a law that he thinks is unreasonable.
B. Too many criminals are not punished for their crimes.
C. There is no excuse for lying to someone else.

13. A. Generally speaking, men won't work hard unless they are forced to do so.
    B. Every person is entitled to a second chance, even after he commits a serious mistake.
    C. People who can't make up their minds are not worth bothering about.

14. A. A man's first responsibility is to his wife, not his mother.
    B. Most men are brave.
    C. It's best to pick friends that are intellectually stimulating rather than ones it is comfortable to be around.

15. A. There are very few people in the world worth concerning oneself about.
    B. It is hard to get ahead without cutting corners here and there.
    C. A capable person motivated for his own gain is more useful to society than a well-meaning but ineffective one.

16. A. It is best to give others the impression that you can change your mind easily.
    B. It is a good working policy to keep on good terms with everyone.
    C. Honesty is the best policy in all cases.

17. A. It is possible to be good in all respects.
    B. To help oneself is good; to help others even better.
    C. War and threats of war are unchangeable facts of human life.

18. A. Barnum was probably right when he said that there's at least one sucker born every minute.
    B. Life is pretty dull unless one deliberately stirs up some excitement.
    C. Most people would be better off if they control their emotions.

19. A. Sensitivity to the feelings of others is worth more than poise in social situations.
    B. The ideal society is one where everybody knows his place and accepts it.
    C. It is safest to assume that all people have a vicious streak and it will come out when they are given a chance.

20. A. People who talk about abstract problems usually don't know what they are talking about.
    B. Anyone who completely trusts anyone else is asking for trouble.
    C. It is essential for the functioning of a democracy that everyone vote.

Finally, please indicate whether you are male or female:

TICK ONE OR OTHER BOX

☐ Male

☐ Female

THANK YOU FOR YOUR TIME. THE PURPOSE OF THIS EXERCISE AND ITS RESULTS WILL BE EXPLAINED TO YOU NEXT FRIDAY WHEN WE MEET FOR THE NEXT FILM SESSION IN YOUR COURSE. 2 O'CLOCK FRIDAY 22 JANUARY, PHYSICS 'A'.

WASON TASK EXPERIMENT 1: RESULTS

Sex	Non-SC (wason)	SC (wason)	Mach V	Shipley Abstraction	Shipley Vocabulary	Shipley Total
M	0	3	103.0	18	35	71
M	1	3	100.0	17	36	70
M	1	3	106.0	19	34	72
M	0	3	104.5	19	34	72
M	0	3	100.0	19	35	73
M	0	3	97.0	16	34	66
M	0	1	85.0	18	30	66
M	0	3	112.0	17	32	66
M	0	2	100.0	17	33	67
M	1	3	103.0	19	37	75
M	0	1	94.0	18	39	75
M	0	1	100.0	20	38	78
M	0	0	130.0	18	40	76
M	0	0	125.5	18	32	68
M	1	0	115.0	19	32	70
M	0	0	118.0	18	37	73
M	1	2	88.0	18	33	69
M	1	2	82.0	17	36	70
F	0	1	94.0	17	35	69
F	1	1	123.0	15	38	68
F	0	2	82.0	19	38	76
F	0	2	94.0	18	33	69
F	0	2	118.0	18	32	68
F	0	3	100.0	15	37	67
F	0	0	97.0	17	39	73
F	1	3	100.0	17	39	73
F	1	2	85.0	14	38	66
F	0	1	91.0	18	38	74
F	1	2	109.0	18	38	74
F	0	1	85.0	19	39	77
F	0	1	110.5	13	34	60
F	0	3	115.0	17	32	66
F	1	3	88.0	16	36	68

Appendix 6.2

WASON TASK EXPERIMENT 2

Sex	Non-SC (wason)	SC (wason)	Empathy	Mach V
M	0	0	3.0	91.0
M	1	2	12.0	91.0
M	0	0	26.0	85.0
F	0	3	17.5	101.5
F	2	3	16.0	88.0
F	0	1	28.0	94.0
F	0	0	31.0	88.0

Figures are mean scores (n = 10).

SKILLS DEVELOPMENT QUESTIONNAIRES.

YOUR CO-OPERATION IS REQUESTED IN THIS RESEARCH PROJECT.

THE PURPOSE IS TO FIND OUT WHICH SKILLS ARE MOST DEVELOPED IN THE COURSE OF AN ARCHAEOLOGY DEGREE, WHICH SKILLS ARE LEAST DEVELOPED, AND WHICH MIGHT BE MOST RELEVANT TO WORK AFTER GRADUATION.

PLEASE COMPLETE THE FORM, AND HAND IT IN TO THE SECRETARY'S OFFICE.

TO PROTECT YOUR PRIVACY, ALL INFORMATION WILL BE USED ANONYMOUSLY, AND PERMANENT RECORDS WILL HAVE YOUR NAME DELETED.

IT IS IMPORTANT FOR THIS PROJECT THAT WE GET A COMPLETE SET OF RESPONSES. **FILLING OUT THE FORM MAY TAKE ABOUT FIFTEEN MINUTES OF YOUR TIME.** HOPE YOU'LL AGREE TO HELP!

THANK YOU VERY MUCH.

JAMES STEELE.

Appendix 8.1

CAREER ASPIRATIONS QUESTIONNAIRE

How important are the following considerations to you in your choice of career?

Score: 0=Unimportant; 1=Of little importance; 2=Important; 3=Very important.

High starting salary	**0.9**
High future salary	**1.7**
Social status and prestige	**1.2**
Opportunity for rapid promotion	**1.4**
Good fringe benefits	**1.8**
Chance to exercise leadership	**1.9**
Responsibility	**2.1**
Long term security of employment	**2.3**
Opportunity to help others	**1.9**
Potential for improving society	**1.8**
Working with people rather than things	**1.4**
Opportunity to work in a team	**1.6**
Involvement in technological change	**1.3**
Opportunity to be creative and original	**2.6**
Work which is continually challenging	**2.5**
Opportunity to use special skills and abilities	**2.6**
Opportunity to use skills and knowledge acquired on your degree course	**1.5**
Opportunity to work in an academic environment	**1.4**

TO WHAT EXTENT HAVE YOU IMPROVED IN ANY OF THE FOLLOWING AS A RESULT OF YOUR EXPERIENCES IN HIGHER EDUCATION EITHER INSIDE OR OUTSIDE YOUR DEGREE COURSE?

Score -1 for deterioration; 0 for stability; +1 for marginal improvement; +2 for quite an improvement; +3 for great improvement.

Skill:	Score:
Critical thinking	1.9
Objective thinking	1.8
Original thinking	1.7
Understanding concepts	1.6
Understanding social issues	1.3
Understanding ethical issues	1.5
Understanding other subjects	1.1
Absorbing information	1.4
Learning quickly	1.5
Working independently	1.8
Written communication	1.3
Oral communication	1.7
Numeracy	-0.2
Ability to work with people	1.3
Leadership	1.1
Self confidence	1.9
Drive and ambition	1.2
Reliability	0.8
Ability to work hard	1.4
Involvement and interest in work	1.9