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Genetics and Education: An Alternative to Jensenism[1]

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What is Jensenism?

Jensen himself defines jensenism as: "A biological and genetical view of human kind and of human differences — both individual and group differences . . . (and) the bringing to bear of this genetic viewpoint upon understanding the problems of education" (1973a, p. 7). Jensenism, as here defined, has strong implications for individualizing instruction: "In education, it is not group differences but individual differences in characteristics related to educability that is important" (1973b, p. 15).

There are two major implications for education. The first is that the failure of particularly pre-school programs is simply due to the fact that their targets, general intellectual ability and scholastic achievement, are genetically determined to such an extent that environmental intervention must be relatively ineffectual (Jensen, 1969). The second implication has to do with Jensen's theory of abilities, which has three aspects:

1. In the general population of educands, there are large individual differences in ability.
2. Ability is strongly related to school achievement.
3. There are two main kinds of ability; Level I (memory) and Level II (reasoning), the essential distinction between them being the amount of stimulus transformation required. It is then argued that teaching methods should match the pupil's balance of Level I and Level II abilities.

In the present paper, both these implications are examined, and an alternative genetically based model is proposed.

The Genetic Case

Jensen argues (1973a) that school learning is a cumulative and long term process; usually a minimum of ten years, during which time the performances of virtually all children change drastically. There are two aspects to this change: that reflecting the gain itself in particular specified areas (i.e. achievement), and that which is usually conceptualized at a second order level to account for the fact that the achievements tend to intercorrelate and are predictable to a certain extent across different instructional treatments. This second order aspect can be called ability or intelligence. As teachers teach, some learners learn more rapidly or effectively than others according to what Frijda (1977) calls "an autonomous transformational activity," which spontaneously spans the gap between the teacher's final activity and the student's entering activity: it internalizes and transforms the taught into the learned. This activity is beyond the control of the teacher, and is what we normally mean by intelligence. This autonomous transformational activity may be operationalized in IQ scores and has a relatively high heritability. According to the genetic theory, therefore, it accounts for much more variation in achievement scores than do environmental constraints, including quality of teaching. At this point, one can become entangled in the extremely complex issues of the efficacy of schooling, nature-nurture studies, and the amount of variance in IQ scores that is attributable to genetics.

This can rapidly turn into a fruitless argument. However, as a basic assumption, it seems reasonable that the quality of human information processing — problem solving, decision-making, reading in, storing and retrieving information — depends upon both experience and biological structure. It also seems reasonable that, along with all other structural or hardware characteristics of the human body, the genes that underly the structures (whatever they may be) that are invoked in doing the kinds of things that collectively make up academic achievement, show a range of individual differences. This is not to say that differences in school achievement are entirely accountable to genetic factors, but that some probably are to some extent; which still leaves environmental differences room to have their effect too.

Having said that, let us now turn to the more interesting *qualitative* implications of the general genetic argument. First, we may ask what it is that has its limits circumscribed by genetics. Sociobiology, as outlined below, implicates *ways* of learning, as being determined genetically, as much or more than sheer learning ability as such.

Second, it is implicitly assumed (sometimes explicitly) by many who take the genetic view, that the function of school learning should be restricted to learning abstract cognitive content. Some of these writers have made seemingly inconsistent assertions; on the one hand, minimizing the importance of environmental intervention, on the other maintaining the need for selective schools so that students of high ability can be more effectively uninfluenced by environmental intervention (e.g., Eysenck, 1977). This inconsistency disappears if schools are seen to have functions *over and above* that of cramming in cognitive content. Of course, the determination of those functions is not carried out on psychological grounds: there is nothing in psychology that tells us that schooling should be limited to gaining content rather than improvement in process, or to cognitive rather than affective targets.

Sociobiology and Preparedness of Learning

Sociobiology offers an interesting view of the genetic basis of learning which does not emphasize the quantity or power of learning, but its quality. Sociobiology represents one of Kuhn's paradigm shifts that is apparently becoming a bandwagon in the social sciences. It is an attempt to extend Darwinism to account for certain aspects of behavior (particularly social) such as altruistic acts — when, for example, the individual sacrifices himself so that his kin may survive. This is difficult to explain in traditional Darwinian terms, but is relatively easy to explain if the gene becomes the unit, rather than the individual (Dawkins, 1977). It is hypothesized that through the process of evolution, certain biograms, which directly govern particular behavior patterns in a species, become clarified. Members of the species become wired up to behave in certain adaptive ways; and it is these adaptive behavior patterns, not individuals, that are preserved and enhanced through evolution.

Sociobiology has two possible implications for the present discussion: First, certain behavior patterns are controlled by biograms which are transmitted genetically; and second, those behavior patterns that emerge at any particular point are ones that have survival value for the genes concerned. It does not follow that those behavior patterns that are wired up to their biograms are not modifiable: the examples of social behavior patterns used by the sociobiologists show tremendous cultural variation, which of course does not invalidate the possibility of a genotypic constancy underlying the phenotypic variation.

These ideas, which are admittedly conjectural, add considerably to Seligman's (1970) views on biological preparedness for certain tasks. Seligman recounts how he was violently sick several hours after eating some sauce béarnaise. He was unable to eat sauce béarnaise for a considerable time afterwards, although cognitively he knew that he was not allergic to any of the ingredients, that another sauce béarnaise would almost certainly not have the same effect, and that he could explain the nausea on the grounds of stomach flu; i.e., it had nothing to do with the sauce itself.

This quite common example presents problems to the learning theorist. It would seem to be an example of classical conditioning, but clearly it is not: it is established in one, arguably less than one, trial; it is highly discriminatory and shows no generalization; it is extremely resistant to extinction, sometimes taking years. Equally, such behavior is clearly not instinctual.

Another set of observations refers to instrumental conditioning, specifically the puzzle box experiments of Thorndike at the turn of the century. Thorndike's thesis was that any response would be learned if it led to a satisfying outcome: When cats were placed in a puzzle box they learned the correct connection, string pulling or level flicking, because only these responses resulted in escape. The *coup de grâce* was to show that the cats in Box X would also learn to escape when the door was opened immediately after the cat scratched his left ear. However, what Thorndike didn't emphasize (although he was disturbed by and noted the fact) and what didn't get reported in the textbooks, was that the learning in Box X took *considerably longer* than learning to pull strings or flick catches.

From these and similar observations, Seligman concluded that certain behavioral patterns are much easier to learn than others. Further, those patterns that are established rapidly, and are hard to extinguish, are ones that have high survival value. It needs little imagination to see that string-pulling/escape as a sequence has more survival value, over the long haul, that ear-scratch/escape. It is as if the animal is biologically *prepared* to learn behavior patterns in contexts which give those patterns particular survival value, more easily than when those behavior patterns appear in contexts in which they are relatively irrelevant to survival. The argument is very close to the sociobiological one, and suggests, similarly, that biograms governing such adaptive behaviors may be inherited. Seligman, in fact, postulates that there is a continuum of preparedness for learning, which is biologically determined, and along which it is possible to place particular learning behavior patterns, and the conditions for learning these vary according to the place on the preparedness continuum.

This seems a fruitful idea for putting human learning, and educational learning in particular, into context. At the prepared end of the continuum would be such things as the learning of food aversions, learning to walk, learning to talk, etc. Continuing from the prepared to the unprepared side of the continuum, learning to read emotions, learning by example, or modeling (as opposed to learning from verbal instruction), and learning mechanical skills. Moving more toward the unprepared end, learning to read and write, and learning to solve complex and abstract problems by use of symbolic representation, with the most unprepared acts involving logico-mathematical and formal operational understandings. Jensen's Level I learnings would be placed around the middle, Level II learnings at the extreme right.

Language illustrates the point clearly. Oral language learning is obviously well toward the prepared end of the continuum; the mother tongue is acquired with astonishing rapidity by all but the severely handicapped. *Reading and writing,* as opposed to *speaking* the mother tongue, appear to be further toward the unprepared end. In evolutionary terms, this makes sense: Man has been speaking, as far as we can tell, for probably one million years, but has been writing for less than one percent of that time. Other examples of unprepared learning would include learning something from someone else when they explain it by word of mouth rather than by demonstration, or following an argument expressed in mathematical or scientific symbols, etc. Much unprepared learning is learning the sort of things that constitute our cultural heritage; what other people have discovered and preserved in symbolic form for transmission to the next generation.

The cultural transmission of the written word is, biologically speaking, very recent, hence we are not well adapted for learning it. Consequently, such learning needs a catalyst — which is precisely the role of the school. There is no point in setting up schools to help people learn those things that they are going to learn anyway. Children simply do not need to go to school to learn how to speak, but they do need help in learning how to read: At the very outside, a very small minority have only had a few thousand years of natural selection to prepare them biologically for reading (assuming poor readers are poor breeders), whereas there has been a million years for selecting out people who do not learn how to speak. School in this view is a cultural invention, the purpose of which is to help children learn those important things about our culture which they would not otherwise pick up, and the learning of which has had little chance at being facilitated or prepared in our biological wiring.

This view is much kinder to educators than is that held by many psychologists. Ginsburg and Opper say:

> In the first two years of life, for example, the infant acquires a primitive concept of causality, of the nature of objects, of relations of language, and of many other things, largely without the benefit of formal instruction or adult "teaching." One needs only to watch an infant for a short period of time to know that he is curious, interested in the world around him, and eager to learn. It is quite evident that there are characteristics of older children as well. If left to himself the normal child does not remain immobile; he is eager to learn. Consequently, it is quite safe to permit the child to structure his own learning. The danger arises precisely when the school attempts to perform the task for him. To understand this point, consider the absurd situation that would result if traditional schools were entrusted with teaching the infant what he spontaneously learns during the first years. The schools would develop organized curricula in secondary circular reactions; they would develop lesson plans for object permanence; they would construct audio-visual aids on causality; they would reinforce "correct" speech; and they would set "goals" for the child to reach each week. One can speculate as to the outcome of such a program for early training! (1969, pp. 224–5)

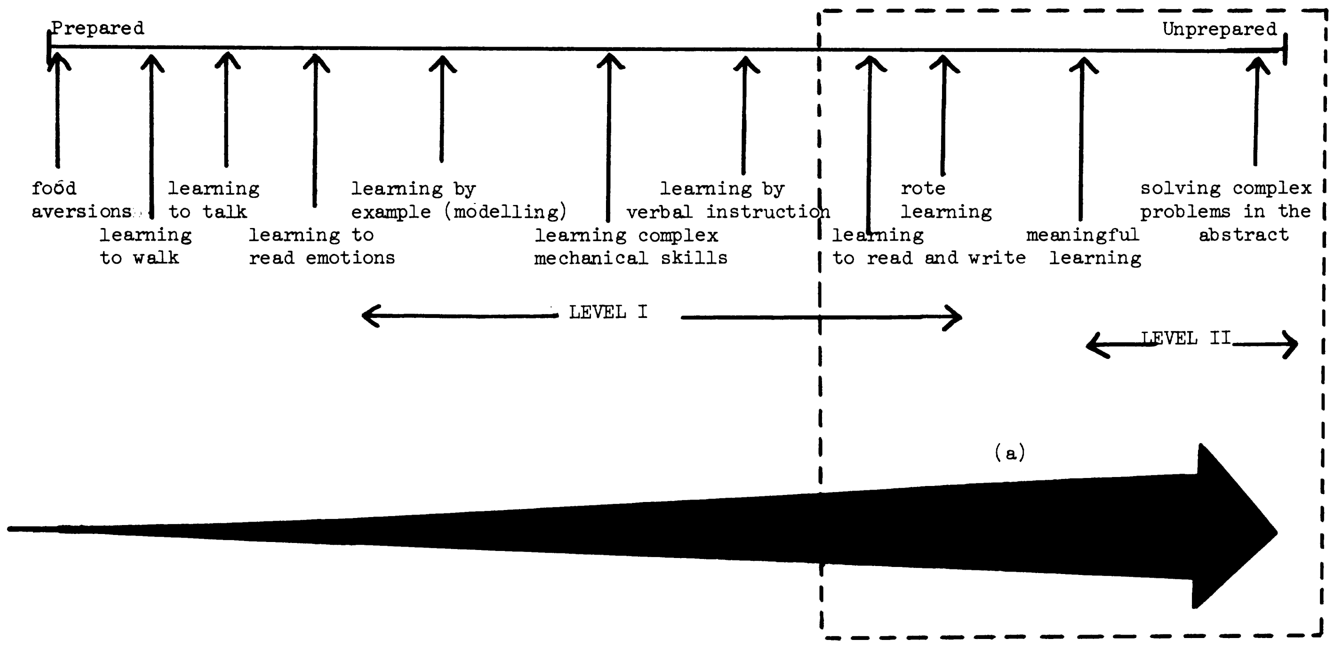
Their last speculation can be easily resolved; there would clearly be no difference in outcome. Children will rapidly learn biologically prepared behavior patterns relatively independently of environmental conditions.

The relationship between teaching and preparedness is shown in Figure 1. In general, educators are concerned with a relatively narrow segment of human learning; with those tasks for which the individual is only moderately prepared by nature, and the learning of which will require the application of specialized skills and a technology of instruction. Their learning needs to be catalyzed by a different process — teaching. Teaching may be defined as an intervention that changes environmental conditions in order to compensate for organismic unpreparedness, so that learning may proceed. Such learning aids would include a situational structure providing the space for learning, the conditions of non-interruption and the social support of other learners, the reasons for learning in the form of motivational aids and curriculum materials, and a concentration of information and its mode of presentation. Above all, there needs to be a teacher to orchestrate these various elements of the total learning situation.

School learning from this sociobiological viewpoint might be seen to lean to a rather traditional, indeed reactionary, conception of the process of schooling; that in order to compensate for low preparedness, schools should function solely to facilitate cognitive learning by providing conditions of high structure. While it follows that a great deal of catalytic support is needed for abstract learning, there is nothing in this view that says that schools must *restrict* their activities to the area labeled (a) in Figure 1.

There are other skills, in the *affective* domain, for which we are equally ill-prepared by our present environment. Specifically, schools were founded at a time when there was a fair degree of common agreement as to right and wrong, and to the type of role, both vocational and social, that one would fulfill in society as an adult. Today we cannot assume the role requirements today's children will need as adults; or that children will learn right from wrong through the family, community and organized religion (indeed today many do not believe that it is possible to give a universal answer to questions of

FIGURE I: PREPAREDNESS-UNPREPAREDNESS AND EDUCATIVE LEARNING



INCREASING NEED FOR STRUCTURING, SPECIFIC TEACHING AND SITUATIONAL AND MOTIVATIONAL AIDS FOR LEARNING.

right and wrong). Instead, it would appear that children would need to know how to form their own values. Unfortunately, schools haven't really changed from the traditional organizations, with the teacher as the source of wisdom and the children as uncritical receptors of that wisdom, and that is a highly inappropriate model for deriving relativistic values. In brief, it is necessary here only to point out that the sociobiological view of learning in no way implies that the *sole* function of schools is to facilitate reception learning of prescribed content.

The second implication of the model might appear to be that high structure is given. Again this is unduly restrictive. What the model does is point to some of the *processes* or *vehicles* of learning for which we may indeed be biologically well prepared. It would seem more sensible, therefore, for schools to press these processes into service, rather than to deliberately ignore them. For example, learning by the written or spoken word is a process for which we are much less prepared than learning by example, as Bandura's work on modeling has made quite clear. As has been long established, and recognized by teachers, the relationship of the learner to the teacher-model is crucial to the amount of learning that takes place. Similarly, learning by activity, and the related process of learning by discovery, would appear to be more easily activated in our biogrammar, than learning by verbal precept.

It seems likely that ontogeny recapitulates phylogeny; that a similar sequence unfolds in individual development. Clearly, the more unprepared learnings develop later in individual development, which is another way of saying that through the normal process of cognitive development, the individual becomes more prepared to acquire certain kinds of learning. Referring to Figure 1, it is evident that sensory-motor and concrete learnings are more toward the prepared end of the contiuum, while abstract tasks, including formal operations, are more toward the unprepared end, and this again has implications for the structure of education from elementary through high school. The fairly common pattern of low structure in kindergarten, through medium structure in elementary, to high structure in high school, could even have some sociobiological validity.

The discussion thus far has indicated that the first implication of jensenism, that schools should concentrate their efforts on achievement gains and be content with modest increments of content learning that are relatively predictable from IQ, does not follow from "a biological and genetical view of human kind." If *processes* are genetically determined, and are the concern of schools, then the whole ballgame changes. Similarly, it is arbitrary simply to assert that the role of schools is one of content learning alone.

The Structure of Abilities

The second implications of jensenism concerns the structure of abilities and educational treatment. Treatment is based on Jensen's theory of Level I and Level II abilities. Level I ability refers to the ability to receive, store, and recall material with a high degree of fidelity. Its basis is associative memory, involving the serial organization of material in short term memory. Level II ability is involved with reasoning, and the essence of this is characterized by transformation and manipulation of the stimulus prior to making the response. Level I ability is involved with learning what goes with what, and Level II ability with more complex processes, such as those underlying IQ scores and school achievement. Nevertheless, the differences between them is not due to difficulty of the item as such, but to the complexity of the mental transformation required in successfully completing the task. Both abilities are regarded as primarily genetic in origin, and developmentally, Level I ability appears earlier and more quickly than Level II ability. Level II ability moreover is said to be hierarchially dependent on Level I ability, which, incidentally, would follow if Level I learning was biologically more prepared than Level II learning (see Figure 1).

The next and possibly most contentious claim of the theory is that the distribution of Level I and Level II abilities is different in different subpopulation and racial groups. Success in western society is said to be mediated by school achievement, hence ultimately by Level II ability. Schooling, therefore, becomes the pipeline which drains from the low SES group those who were well endowed genetically with Level II ability, since the latter, through schooling, become middle class, marry within the middle class, and pass on their own high Level II ability to their own, now middle SES, children. Over several generations of such assortive mating, it is predicted that the low SES and middle SES gene pools have become qualitatively different, being equal in Level I ability, but with the low SES groups deficient in Level II ability. Jensen claims evidence for an interaction that is directly deducible from this, which means essentially that the correlation between associative learning (Level I) and IQ (Level II) is much higher in the middle SES than in the low SES groups. He claims that IQ tends to be associated with high Level I ability only in the middle SES groups. Low IQ is symptomatic of low Level I ability in middle, but not low, SES groups. Thus, while many low SES children of low IQ are capable of learning the rules of the games in the playground and of names, and appear in these contexts as bright, or brighter than a high IQ, high SES child, they are grossly deficient in school achievement. This interaction is the basis for Jensen's theory of secondary retardation (1970).

Jensen's complaint is that traditional schooling has been unsuccessful in teaching the secondary retardate, that is, the child with a low IQ but normal Level I ability. He suggests that teaching emphasizes Level II competence (broad transfer, the ability to elaborate and "tell it back in your own words"), while Level I ability is not encouraged or rewarded. He compares the frustration of the secondary retardate at having to solve $2 + ? = 4$, instead of $2 + 2 = ?$, to Pavlov's induction of experimental neurosis in dogs; in both, similar incapacitating emotional reactions result from impossible discriminations. He therefore suggests that the approach to the target population of secondary retardates, who would mostly be drawn from low SES, be in terms of rote learning, drill, repetition, etc. Those of high Level I, low Level II ability would be taught by rote, and those of Level II ability by transformational or meaningful methods. While this seems to fit the aptitude-treatment interaction model (Cronbach, 1967), it will be argued below that it does not do so, for seveal reasons.

Simultaneous and Successive Processing: An Alternative

The first issue to be considered is that of the structure and organization of cognitive processes: this is central to Jensen's theory. In factor analyzing various cognitive tests, Jensen has come up with a model which fits into the traditional factor structure models of Burt, Vernon and others. However, Das, Kirby and Jarman (1975) point out that recently there has been a shift from the study of abilities to that of processes. They quote Messick (1973) as suggesting that it is easier and more meaningful to conceptualize the interaction between genetic endowments, individual experience and the nature of the task, in terms of the *processes* the individual uses, rather than his abilities. This general notion is also in keeping with Cronbach's (1967) and Bracht's (1970) discussion of aptitude treatment interaction, and also with Hunt and Sullivan (1974), who conceptualize individual performance in terms of the particular person environment interaction. For one thing, the notion of abilities does not adequately prescribe treatment in the way that processes do; and secondly, there is some logical difficulty, which is inherent in the notion of ability, in moving from measures of *current performance* to assertions about intellectual *capacity*.

What this might mean, in terms of the nature of cognitive processes, can best be seen by reference to Das, et al.'s own work. They used as their starting point the physiological work of Luria, whose work with brain-damaged patients led him to postulate two major types of processing activity in the cortex; simultaneous processing, located in the occipital-parietal area; and successive processing, located in the fronto-temporal area. Das and his colleagues have used this model to interpret several factor-analytic studies of cognitive performance in different cultural groups. They repeatedly found that their tests defined factors which seemed at first to replicate Level I and Level II abilities, but on close examination, and particularly comparing results over different groups, concluded that the factors defined by the traditional Level I marker of serial recall, and the Level II marker of Raven's Progressive Matrices, could not refer to Level I and Level II abilities respectively.

The factor marked by Raven's Progressive Matrices also had a high loading from figure copying and memory for designs; they called this the simultaneous factor and the factor defined by serial and free recall, a successive factor. Contrary to the Level I/II hypothesis, then, the so-called reasoning factor was defined by a memory test; the memory tests which should be marker tests for Level I turn out to load on either simultaneous or successive factors, depending on the processes involved, not upon the apparent ability tapped. For example, it is possible for a perfect Level II encoding to produce output of 100% fidelity. Further, the distinction between Level I and Level II ability on the basis of stimulus transformation is not compatible with the most recent research on memory; even free recall and digit span involve subject-initiated strategies of transformation (Lawson & Jarman, 1977).

Das, et. al., also found that the Raven's Progressive Matrices loaded on a successive factor in a group of Canadian Indians before training; on a simultaneous factor as expected after training. This is difficult to square with the notion that the matrices test an ability, but it is very compatible with a process interpretation. Likewise, Hunt (1974) draws attention to the fact that the RPM can be solved by either a "gestalt" or an "analytic" process, a finding which clearly presents problems in interpreting what the "ability" marked by the RPM might mean. In the next section, this question of abilities vs. processes will be elaborated.

Processes, Abilities, and Aptitude Treatment Interaction (API)

In several respects, then, Das's reinterpretation of Luria's model of simultaneous and successive processing is preferable to Jensen's for explaining much of the data we now have. Most importantly, from the point of view of educational implications, it leads to rather different recommendations for educational practice. It is not based on abilities, but on processes, and these are processes that speak directly to methods of structuring input, hence to teaching method. Abilities may set the upper and lower boundaries for the operation of a process, but it is the latter that interacts with treatment within these boundaries.

Another way of looking at this is in terms of test "bandwidth" (Jarman, in press). Tests with a high bandwidth are those involving tasks that allow for heterogeneous processes or strategies for successful solution. Such tests would shift markedly in factor loadings across different training and cultural groups and would make it very difficult to create a theory that tied tests directly to various cognitive abilities. Tests with a narrow bandwidth are those that call out a limited, or homogeneous, range of processing strategies; in such tests, abilities tend to become synonymous with process. Forward digit span has a narrow bandwidth, while cross-modal coding has a broad bandwidth. Narrow bandwidth tests are useful as marker tests to provide information on how a broad bandwidth task is attacked. This notion has important implications for ATI.

School achievement is probably a high bandwidth task in that there are several process options that can be called out for success. Jensen's tests tend to be narrow bandwidth (with the exception of the Raven's), which makes the abilities marked by such tests unlikely to be useful as aptitudes in an ATI situation. Cronbach himself said that ability was a poor aptitude in ATI, precisely because high ability students do well whatever the treatments. This point seems particularly applicable to Jensen's proposition that Level I and Level II should form such aptitudes. Level II is argued to relate strongly to achievement, and indeed, no one has yet designed a Level I program that results in academic competence to match the outcomes of a Level II-type program (Kirby & Das, 1977).

Kirby & Das correlated simultaneous and successive factor scores with some aspects of school achievement, and found that reading, vocabulary, comprehension and verbal and nonverbal IQ all correlated significantly with both types of strategy for success. This order of correlation is significantly lower than that for Level II ability, and of course much higher than that for Level I, which is a pattern that is much more desirable for obtaining useful ATI.

Further, if we are looking for treatments that maximize achievement across various types of students, the search is unlikely to be successful if those student types have been defined in terms of performances that remain stable across different populations and different learning conditions. Cronbach defined aptitude as "whatever permits the pupils' survival in a particular educational environment." Thus, it is likely (see Biggs, 1976) that effective survival in a given environment might require a fairly unique mix of characteristics that are relevant to that particular environment, rather than a unidimensional characteristic that remains stable across several environments. Similarly, Snow (1977a; 1977b) suggests further that fairly basic processing styles that are particularly relevant to the task under consideration, such as speed of reaction and eye movement, might produce more effective ATI than has been managed so far. This approach to ATI suggests a specific and fine-grained person-task analysis, rather than the use of a very broad ability/capacity parameter.

There is some relevant evidence on the use of process-type aptitudes. Biggs and Das (1973) showed that high performing students in an educational psychology course could obtain their grades by using either one of two basic types of study strategy; one relying on a successive kind of rote-learning, the other on an internalizing transformational strategy. Even more to the point is the work of Pask and Scott (1972) who classified students into serialists or holists, depending upon how they approached a classification task, and then taught them new material with serialist or holist kinds of treatments. When serialists were taught serially and holists taught holistically, both achieved near perfect scores. However, mismatched groups in which serialists were taught holistically and holists taught serially, averaged less than half the maximum score. The Pask & Scott study is a beautiful example of how psychological process and instructional treatment can be integrated to maximize high performance without the tautology and question-begging that lurks beneath the application of an abilities–based theory.

The heritability issue likewise takes on quite a different complexion in the process interpretation. The physiological locus of the simultaneous and successive processes has been mentioned; as such, it appears highly likely that the undoubted individual differences that exist are, to some significant extent, genetically determined. Now what does this mean? In the case of abilities, it is all too clear what we mean: that there are strong limits to the effectiveness of learning, particularly academic, content. In the case of process, it means that there are constraints on the *way* of learning the material, not on the *power* of learning.

Perhaps a useful analogy here is that of handedness. There is much evidence that handedness is physiologically based and that preferences are inherited. Now left-handed people survive perfectly happily in a right-handed culture in one of two ways; either by training themselves to use the right hand when required, or by adapting their environment to suit a left-handed approach.

Even more relevant is the work of certain cultural anthropologists. Paredes and Hepburn (1976), for example, explore the paradox that while the brain is basically structured in the same way all over the world, the fundamental operations of the brain differ radically with cultural background. The operations they refer to are generally agreed to be organized laterally, analytic in the left-hand hemisphere, and relational in the right, rather than the simultaneous and successive operations which are organized longitudinally. Our culture is a left-brain one: our skills tend to be organized analytically. Other cultures are, however, right-brain cultures, emphasizing relational thinking. The skill of navigation offers an excellent example of how entirely different, yet equally effective, modes of thinking can be brought to bear: While Westerners read maps, the Trukese navigate using relational thinking in a way that simply defies analysis in Western terms. Yet a post-mortem on American and Trukese skulls would be most unlikely to yield the slightest clue as to the quite enormous functional difference in operation. Paredes and Hepburn hypothesize that both modes of operation are present, and the culture selects and trains just one, but *either* one.

If we rotate the locus of discussion 90° in the skull, we would be talking about simultaneous and successive processing. Indeed, Das, Kirby and Jarman (1975) note that the pattern of simultaneous and successive factor loadings changes with different cultural groups, and, even more interestingly, with intervention training programs. Such research as we have so far (and admittedly it is meager) suggests that intervention and training may fairly readily call out different processing options for the individual, in a way that the evidence shows fairly clearly cannot be done for abilities. For example, Krywaniuk (1974) showed that Canadian Indian children could be trained to improve poor successive processing.

In this conception, then, perhaps two things might be noticed. The first is that the genetic argument loses its emotional steam. As in the sociobiological argument on preparedness (the conclusions of which are not dissimilar to the above argument on the process question), all that a physiological locus of learning, involving genetic determination, does is to define the options with which a teacher may operate.

The second point elaborates the first: The process interpretation has quite direct implications for the educator that have hardly been explored. The task of the educator becomes rather like that of the human engineer, in that the solution of a particular task is subjected to a human engineering kind of analysis, so that the optimal strategies for its solution can be worked out and then taught. It will be noted in this approach too, the goal of education extends to incorporate not only the traditional one of mastering content, but of modifying and optimizing the strategies the individual has potentially at his disposal.

Summary and Conclusions

The nature-nurture controversy has generated more heat than light, both in psychological theory and when theory has been applied to education. The traditional genetic position with regard to educational implications, has been that (a) intelligence (as operationalized in IQ scores) is to some significant extent genetically determined; and (b) school achievement is, again to a significant extent, predictable from IQ independently of the common range of environmental and educational conditions. The combination of these two assertions has led to a certain stance or policy towards education that has been recently referred to, and accepted by its chief spokesmen, as jensenism.

It is possible to question the grounds upon which both assertions have been made (e.g. Kamin, 1974). The point of the present paper is not, however, to deny the genetic case. Rather, there is a great deal of both intuitive and hard evidence which suggests that the *quality* of human learning has been shaped by evolution, biology and genetics. However, consideration of the genetic argument when applied to the *processes* by means of which humans acquire, store and deploy information, leads to models of educating that are quite different from, and more optimistic about, the role of schooling than models derived from a genetic abilities-based theory.

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Notes

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