THE TECHNOLOGICAL OBSOLESCENCE OF MEDIOCRITY

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ABSTRACT

Will artificially intelligent expert systems necessarily serve to amplify human intelligence? Or will they simply create another wave of technological displacement? What types of occupations will be affected? What effects will these technologies have on developing human expertise?

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mediocrity ...the quality of being mediocre; spec. a moderate or average degree of mental ability, talents, skill, or the like; middling capacity, endowment, or accomplishment" — O.E.D

In an earlier issue, Joseph (1982) wrote of the possibilities of (human) intelligence amplification through the use of artificially intelligent machines. His article examined a variety of technological developments which make this a possibility. However the question remains open as to how these developments will combine with human abilities to attain higher capacities of cognition.

Artificial Intelligence research has always emphasized the similarities between the observable evidence of human cognition and the behavior of computer programs. The comparison has been used in two ways: one, as a psychological methodology, using computer programs as a possible model of human cognition; the other as an engineering orientation, using human cognition as a model for building smarter computer systems.

However, by accepting these similarities as the basis for combining computers and humans in a single category of 'cognitive entities,' we are likewise led to focus on their *differences* as well.

On one hand, there is a fairly well developed literature (e.g., Miller 1956, Tversky and Kahneman 1974, Simon 1981) which emphasizes the limitations of human cognition with respect to machines. These deal mainly with the limitations of short term memory, coupled with relatively slow sequential processing capability which lead us (humans) to simplify problems by abstracting their components into larger 'chunks,' and using short-cut heuristics to trim down the problem's complexity.

On the other hand, another literature is emerging (e.g., Weizenbaum 1976, H. Dreyfus 1979, S. Dreyfus 1981). which emphasizes the limitations of computational cognition as compared to that of humans. The general criticism is that computational techniques rely on atomistic representations of data and the sequential application of separate and exact inference rules whereas human (organic) cognition appears to store wholistic impressions and images and is capable of fuzzy* pattern matching between them which allows for great flexibility of association.

This suggests a theory of cognitive complementarity between human and machines.

Humans for instance require a great deal of discipline and training to perform the types of iterative calculations most easily programmed in machines.

Contrariwise, the types of cognition which are basic even to human infants — e.g., recognizing faces and voices, acquisition of language — present deep, unsolved problems for computational theories.

The middle area where humans and machines appear to be on comparable footing is in so-called 'rule-based' system which form the general architecture of expert systems applications (see Davis and King (1975) or Nilson (1980) for background).

Rather than procedural programs where the computer executes instruction after instruction in a pre-determined order, these are non-procedural programs of un-ordered rules where the machine searches repeatedly through the rule set for the appropriate rules pertaining to a given situation. The non-determinism of this approach sacrifices much of the efficiency where the computer normally has advantage over the human. On the other hand, it provides considerably more flexibility and adaptability which are the human's normal advantage.

Stuart Dreyfus (1981) makes some interesting observations regarding rule-based cognition in the formation of human expertise. His claim is that the use of a small set of discrete rules is characteristic of the novice stage in the development of a particular skill. As the individual becomes more experienced, these rules are gradually refined to incorporate numerous exceptions. Additional experience adds a context dependent organization to the rules as well as additional refinement so that the rules take on a much broader, parametric character. In the case of more advanced expertise, the individual rules give way to more wholistic patterns which are no longer processed in sequence but rather in a simultaneous pattern oriented manner. He suggests mundane examples such as learning to drive a car or playing chess. The novice driver learns to shift at specified velocities, has certain fixed procedures for parallel parking, etc. Experienced drivers, on the other hand, no longer rely on these elementary measures but rather incorporate a wide variety of factors such as the sound of the engine, road incline and surface condition, weather, anticipated traffic situations, etc. A key point is that at

* Fuzzy reasoning, once a pejorative term, has in recent years gained academic respectibility. See Zadeh (1975).

this level, most experienced drivers can no longer specify the individual factors and rules they use.

Likewise most novice chess players begin with a simple point valuation scheme for each of the players and evaluate the value of an exchange through this numeric comparison. Subsequent development adds consideration of the relative position of pieces and their projected positions through scenarios of play and counter-play. Evidence of master level chess play however suggests a much more holistic orientation depending on comparative 'field of force' in actual and potential configurations of the pieces.

Along these lines, a dimly recalled anecdote tells of well-known and widely recognized designer of electric motors. His fame grew to the point where he decided to write a book explaining how he did his designing. After the book was published, the quality of his subsequent designs declined. The conjecture is that he felt obligated to follow the rules and methods of his book which somehow failed to capture the full capacity of his former expertise.

The general hypothesis here is that the major impact of rule-based, expert systems will be at these types of cognition characteristics of the early to middle level stages of human expertise development.

These types of considerations from the basic design philosophy of so-called "decision support systems" e.g., Keen & Scott-Morton (1978),, Sprague & Fick (1980), Bonczek et al. (1981). As opposed to expert systems, which attempt to replicate the abilities of a human expert in a specific problem domain, the aim behind decision support systems is to arrive at a symbiotic combination between person and machine. These have been of especial interest in management applications where decisions are at best only partially formalizable and continue to rely on experienced judgment. It is in these types of decision support applications that the notation of intelligence amplification holds the most promise.

On the other hand, while these developments have a certain exotic fascination, they also suggest a new wave of technological displacement. Rather than the typical victims such as clerks or factory workers, this wave threatens to shake occupations of the middle level professional, e.g., in banking, law, medicine, public administration.

A great deal of this intellectual activity is the application of established professional principles. While it often takes extensive specialized training to acquire these abilities, the very process of specialization tends to make these disciplines amenable to rule-based, automatable representations. As observed in Lee (1980), the Weberian concept of rationalization of organization has already become closely linked with automation.

Supposing these developments do occur, what would be the potential impact on expertise formation in these fields?

We would like to think that by removing the more mechanical types of cognition, human abilities will be freed to address problems requiring higher levels of creativity and innovation. A social question is whether their are enough such challenging problems to go around. The corresponding psychological question is whether the displaced professionals will have the creative aptitude to address these challenges.

There is a pedagogic issue here as well. If rule based cognition is an important initial stage in expertise acquisition, what will be the effect if this stage loses its rewards? Will this tend to block the development of further experts?

The example of chess may provide us the first experimental evidence. The more sophisticated compute chess programs now approach "expert" (in chess terminology) levels of play. The most advanced "masters" level chess players continue relatively unchallenged by these machines. Nonetheless it now takes a minimum of several years concentrated chess study to beat a machine. Even the inexpensive commercially marketed chess machines are a match for intermediate level players. What effect will this have for potential chess students? Will they be challenged or merely discouraged?

What would be the effect if the problem domain were law or engineering and the only jobs available are beyond the machine's capability? Will short term intelligence amplification become long term intelligence stagnation?

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