Definition of Intelligence

SIR,--As a user but non-worshipper of computers, I must take exception to the definition of intelligence, and to the logic employed in the letter entitled "A Defini-tion of Intelligence" (*Nature*, **228**, 97; 1970). As to the suitability of definitions, that is a matter of opinion, but I find Webster's "the capacity to apprehend facts and propositions and their relations and to reason about them" quite satisfactory if not completely explicit. (What dictionary definition is ?)

Furthermore, you will find the authors' definition in the dictionary, under "induction". To quote Webster again, "the act, process, or result, of reasoning from a part to a whole, from particulars to generals, or from the individual to the universal". To give the letter its due, I prefer their definition of "induction" to that of Webster, but it is clear that induction is only one of several skills associated with intelligence.

What is more serious is the failure of logic, "Thus machines . . . cannot be intelligent because the machine's instruction set is a proper subset of man's instruction set".

First, even simple, admittedly non-intelligent computer programs contain instructions which man's brain does not. Second, recent computer program research has produced programming which is able to expand itself. Given rules for induction, deduction, and other "intelligent" processes, these programs expand themselves, generating further instructions on the basis of experience and observation. Third, even granting every statement in the letter, we already know from experience that one man's having a "smaller" instruction set (less intelligence) than another does not mean that such a man is incapable of innovation and intelligent behaviour. Why, then, do the authors assume that a computer has to have a larger set than man in order to innovate, improvise, discover or induce ?

While human beings are obviously more than mere biological computers, I find nothing in their argument, nor in any other I have encountered, which rules out the possibility that, some day, a computer-machine will be constructed which is able to accept a sophisticated, maninvented program, which permits this new life-form to evolve mentally through experience and learning in a manner similar to man, and do this in such a way as to satisfy any reasonable definition of intelligence. Perhaps Norbert Wiener's test of such a machine could be employed. He suggests that any computer candidate plus several men for controls be equipped with typewriters for input and output. Those who would doubt the candidate are required to interview any and all of the unlabelled teletype units by typing in questions to be answered. If the doubters do not do much better than the statistical random probability in pointing out which teletype is connected to the computer, we must conclude that the computer simulates man and displays intelligence.

Yours faithfully,

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SIR,-Fatmi and Young¹ suggest that "Intelligence is that faculty, of mind, by which order is perceived in a situation previously considered disordered". This is an attractive definition because it opens the way to measures of intelligence that are not based upon comparison with population norms.

Consider a very simple test. To create some disorder, suppose we toss a penny and represent the result as a binary number 0 or 1. Show a subject a sample of these

disordered digits, then tell him that you may, or may not, change the method of selecting the digits, and ask him to tell you as soon as he knows whether you have changed it. Because the initial sample was completely disordered, the only change possible is the introduction of order, and if the subject perceives it, he has displayed intelligence by Fatmi and Young's definition.

The amount of order can be measured by the change in information or entropy of the new sample of digits compared with the old. The minimum amount that can be detected would be expected to be inversely related to the strength of the faculty that detects it. Suppose we show only 0s; the maximum amount of order (one bit's worth) has been introduced, and this should be quickly perceived by any subject. If, on the other hand, we slightly bias the penny, this would be more difficult to detect. There may be more to intelligence than the ability to perform such a task; but if it is required for it, one can set out to measure its "threshold" in the same way that one measures the threshold of an eye or ear, namely by measuring the least amount of light or sound that can be detected.

The detection of bias in a coin is a statistical problem. and one can say how many tosses are required to detect a given bias at any confidence level. Thus one could compare a subject's performance with the theoretical ideal, and if he required S tosses to achieve a performance ideally requiring I tosses, then it would be reasonable to say that his efficiency at this task was I/S. This is closely similar to the measure of quantum efficiency that is used to compare photodetectors and human vision, and it provides an absolute scale applicable in a wide variety of situations2,3.

It is easy to see what is missing from this model; for coin tossing there is really only a single null hypothesis that we can ask a statistician to test, namely "The bias in the second sequence is the same as in the first". With many coins, the number of possible forms of order that can be introduced increases very rapidly indeed, and if the possibility of ordered sequences is introduced the number of possible null hypotheses becomes virtually unlimited.

Fatmi and Young apparently framed their definition in order to distinguish more clearly between machine and human intelligence. However, its real merit may be that it enables one aspect of the intelligence of either mind or machine to be compared with, and measured in terms of, the performance of an ideal detector of order in disorder.

Yours faithfully,

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¹ Fatmi, H. A., and Young, R. W., Nature, 228, 97 (1970).

² Rose, A., J. Opt. Soc. Amer., 38, 196 (1948).
³ Barlow, H. B., J. Physiol., 160, 155, 169 (1962).

SIR,-G. Hyde (Nature, 228, 589; 1970) gives a definition of intelligence which is good but not complete, as it cannot be quantified as expressed, nor lead to such quantification.

A simpler yet more complete definition is "intelligence is the capacity to understand".

It may be possible at some time to quantify this capacity, which does not need linguistic behaviour for its definition.

Yours faithfully,

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