# CSC: Classic Paper Review/Analysis #1

## Title and Author

Title: Computing Machinery and Intelligence

Author: A. M. Turing

## Summary/Hook

This paper considers a long-standing question within the field of cognitive science and artificial intelligence. Turing explores the consideration and possibility that computing machines/digital computers will one day hold intelligence and he begins his analysis by posing the question: "Can machines think?" Turing goes on to replace that long-standing question with what he calls the Imitation Game. The Imitation Game is a scenario in which an interrogator has typewritten communication with a man and a woman. Both the man and the women are in separate rooms from one another and the interrogator. Then through the information obtained through the exchanges of typewritten communication, the interrogator must decide which room the man is in and which the woman is in. After explaining the game, Turing poses a series of questions exploring the possibilities of a machine performing the position of any of the three players, and if that machine could yield better results than any human. Turing goes on to give numerous objections to the possibility of computing machines being capable of having intelligence while also giving his responses to those long-standing objections. After a detailed analysis of each objection, Turing goes in-depth about his argument for why he believes machines may one day be able to compete with humans intellectually in all areas of study.

## Knowledge Relating to the Cognitive Science Program Learning Outcomes

## 1. Formal Systems and Theories of Computation

The idea behind digital computers may be explained by saying that these machines are intended to carry out any operations which could be done by a human computer. The human computer is supposed to be following fixed rules; he has no authority to deviate from them in any detail. We may suppose that these rules are supplied in a book, which is altered whenever he is put on to a new job. He has also an unlimited supply of paper on which he does his calculations. He may also do his multiplications and additions on a "desk machine," but this is not important.

## 2. Algorithms and Automata

"It will seem that given the initial state of the machine and the input signals it is always possible to predict all future states, This is reminiscent of Laplace's view that from the complete state of the universe at one moment of time, as described by the positions and velocities of all particles, it should be possible to predict all future states. The prediction which we are considering is, however, rather nearer to practicability than that considered by Laplace. The system of the "universe as a whole" is such that quite small errors in the initial conditions can have an overwhelming effect at a later time."

#### 3. Formal Systems and Theories of Computation

There are a number of results of mathematical logic which can be used to show that there are limitations to the powers of discrete-state machines. The best known of these results is known as Godel's theorem (1931) and shows that in any sufficiently powerful logical system statements can be formulated which can neither be proved nor disproved within the system, unless possibly the system itself is inconsistent. There are other, in some respects similar, results due to Church (1936), Kleene (1935), Rosser, and Turing (1937). The latter result is the most convenient to consider, since it refers directly to machines, whereas the others can only be used in a comparatively indirect argument: for instance if Godel's theorem is to be used we need in addition to have some means of describing logical systems in terms of machines, and machines in terms of logical systems. The result in question refers to a type of machine which is essentially a digital computer with an infinite capacity. It states that there are certain things that such a machine cannot do. If it is rigged up to give answers to questions as in the imitation game, there will be some questions to which it will either give a wrong answer, or fail to give an answer at all however much time is allowed for a reply. There may, of course, be many such questions, and questions which cannot be answered by one machine may be satisfactorily answered by another.

#### 4. Consciousness and Controversies

This argument is very, well expressed in Professor Jefferson's Lister Oration for 1949, from which I quote. "Not until a machine can write a sonnet or compose a concerto because of thoughts and emotions felt, and not by the chance fall of symbols, could we agree that machine equals brain-that is, not only write it but know that it had written it. No mechanism could feel (and not merely artificially signal, an easy contrivance) pleasure at its successes, grief when its valves fuse, be warmed by flattery, be made miserable by its mistakes, be charmed by sex, be angry or depressed when it cannot get what it wants."

This argument appears to be a denial of the validity of our test. According to the most extreme form of this view the only way by which one could be sure that machine thinks is to be the machine and to feel oneself thinking. One could then describe these feelings to the world, but of course no one would be justified in taking any notice. Likewise according to this view the only way to know that a man thinks is to be that particular man. It is in fact the solipsist point of view. It may be the most logical view to hold but it makes communication of ideas difficult. A is liable to believe "A thinks but B does not" whilst B believes "B thinks but A does not." instead of arguing continually over this point it is usual to have the polite convention that everyone thinks.

#### 5. Language and Culture

The use of punishments and rewards can at best be a part of the teaching process. Roughly speaking, if the teacher has no other means of communicating to the pupil, the amount of information which can reach him does not exceed the total number of rewards and punishments applied. By the time a child has learnt to repeat "Casabianca" he would probably feel very sore indeed, if the text could only be discovered by a "Twenty Questions" technique, every "NO" taking the form of a blow. It is necessary therefore to have some other "unemotional" channels of communication. If these are available it is possible to teach a machine by punishments and

rewards to obey orders given in some language, e.g., a symbolic language. These orders are to be transmitted through the "unemotional" channels. The use of this language will diminish greatly the number of punishments and rewards required.