INDUCTIVIST FOUNDATION FOR THE TURING TEST: A PEIRCEAN-HEMPELIAN PERSPECTIVE

BY

ASODUN, FATAI ORIYOMI

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APPROVAL

This research has been approved for the Department of Philosophy, Faculty of Arts, and the School of Postgraduate Studies, University of Lagos.

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CERTIFICATION

This is to certify that the Thesis

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By

ASODUN, FATAI ORIYOMI

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DEDICATION

This work is dedicated to Almighty God for giving me the strength and power to complete this programme.

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ABSTRACT

There is ample evidence in Artificial Intelligence (AI) research indicating that appropriately programmed machines are capable of performing functions that require intelligence when performed by humans. However, there is no available correlative record that any such machine has been able to pass the Turing Test; an intelligence test purposefully designed by Alan Turing to actualise his objective of justifying machine intelligence. This work attempts to resolve this paradox. Consequently, employing the critical method of conceptual analysis native to philosophical inquiry, the work subjects the Turing Test to rigorous philosophical investigation. Findings show that inappropriate criterion resulting from the misinterpretation of the test by some scholars has all along been used to misjudge machine's performance in the test. The criterion stipulates that machines need to possess the human properties of brain, mind and consciousness in order to pass the test. Since the criterion could not be met, machines could not pass it. However, further findings show that the appropriate criterion is actually anchored on machine's "imitative" ability. Turing believes that if in the course of imitating human functions machines exhibit appropriate intelligent behaviours that make them indistinguishable from humans, that could serve as sufficient evidence to infer that they are also intelligent irrespective of the availability of evidence that they possess brain, mind and consciousness or not. This work interprets Turing's conclusion to be based on inductive reasoning, and argues that machines, if appropriately programmed, might pass the test on inductive grounds. Consequently, in a bid to put the Turing Test in its appropriate theoretical perspective so as to attain Turing's objective, our research presents a model of induction that will serve as an inductivist foundation for the test. The model, referred to as Peircean-Hempelian inductive reasoning, offers the logical template both for inductive generation of hypotheses on human intelligent behaviour and inductive confirmation of machine's imitative ability of such behaviour as a proof of intelligence in the Turing Test. The template also offers an appropriate interpretation of the Turing Test. Incidentally, in actualising Turing's objective, the work aspires to raise awareness on the importance of exploiting the idea of machine intelligence for human benefit. Pursuant to that, our research shows that exploiting the potentiality of ICT - an AI paradigm for processing, maintenance and transmission of information - in the area of educational development, shall have positive impact on the field of education, philosophy of education and the educational system of Nigeria generally.

1.0 GENERAL INTRODUCTION

On May 11, 1997 a fabricated IBM computer programme named Deep Blue defeated the then reigning world human chess champion, Garry Kasparov in a six-game chess match. In a defeatist remark, Kasparov claimed he sensed playing a new kind of intelligent agent. Kasparov's reaction seems to vindicate the position held by some Artificial Intelligence (Al) researchers that someday, computers will equal and perhaps surpass human intelligence.

Ascribing intelligence to the functions of machines has been a source of intense debate among cognitive scientists, philosophers, psychologists, linguists and Al researchers themselves. This situation is not surprising considering the fact that defining human functions in terms of intelligence is also not yet a settled matter among these practitioners. Incidentally, researchers are still grappling with the problem of understanding the nature of intelligence itself. However, the practice among some psychologists and researchers is to aver notions of intelligence and then cleverly design empirical tests that would help in establishing these notions in humans. Now, the question is whether it is possible to establish intelligence in machine through this method in order to resolve the machine intelligence debate once and for all?

In 1950, after giving much thought to this puzzle, Alan Turing proposed a decisive test as a solution. The Turing test (TT), as it is fondly called, shall help in establishing that appropriately programmed machine can instantiate intelligence through its behaviour. Turing went ahead to boldly claim that fifty years from the time he proposed the test, machines will be recording success in it. But more than sixty years after, Turing's claim still remained visionary.

Could this mean that machines are not intelligent afterall? The level of achievement in the field of Al research, however, indicates otherwise. Apart from Deep Blue, the field can boast of other numerous machines that effortlessly instantiate intelligence through their functions. There is Stanley, the car robot that can effortless engage in auto-driving on difficult terrain; there is Watson, an IBM programme that defeated human champion in quiz game; there is MYCIN and GIDEON programmes that can diagnose human ailments and also suggest appropriate treatments, and many other computer programmes and machines.

The consideration of the various evidence of machine intelligence listed above informs the interest of this research to take another critical look at the Turing test and identify possible factors that could account for machines poor showing in it. The outcome of the inquiry indicates that the test has all along been misinterpreted. The misinterpretation led to the assumption that machine must possess brain and mind in order to pass the test. The research, however, discovers that Turing's fundamental criterion is behavioural disposition. Machine, for him, shall be deemed intelligent if it exhibit behaviour that suggests intelligence.

Consequent to this insight, a step is taken further in this research to develop a logical paradigm called Peircean-Hempelian induction for interpreting the Turing test appropriately. The paradigm also offers an inductivist proof for justifying machine's behavioural disposition as sufficient evidence of intelligence. The logic of induction of Charles Sanders Peirce and Carl Gustav Hempel are combined to form the paradigm.

This dissertation has a general introduction, five chapters, a conclusion, and a list of references. Chapter one discusses the nature of intelligence from the perspectives of definitions and theories. The chapter also examines AI research (being the architectonic of machine intelligence) and its historical background. The different areas of the application of the knowledge of AI research are to be examined with the view to demonstrating its various benefits to man. Chapter two introduces the nature of the Turing test as articulated by Turing himself alongside its standard interpretation. Chapter three examines the nature of Peircean-Hempelian inductivist paradigm, with a detailed background of the ideas that gave rise to it.

Chapter four critically scrutinise the standard interpretation of the Turing test. The chapter introduces the Peircean-Hempelian inductivist paradigm as a theoretical framework for assessing the TT as it relates to the problem of machine intelligence. The attention of chapter five is on the application/relevance of this research to the development of education in Nigeria. In this regard, Information and Communication Technology (ICT) is positioned as the offspring of Al research. ICT shall be shown as an instantiation of machine intelligence with the capacity to propel educational development. Finally, findings of the research, its recommendations and contributions to knowledge are presented to close the chapter.

1.0.1 Background to the Study

Taking a cue from the tradition of measuring human intelligence with cleverly devised intelligence test, Alan Mathison Turing (1912-1954), a British mathematician and one of the progenitors of the idea of programmable machine, also considers it appropriate to design similarly applicable test to establish machine intelligence. His effort yielded the popular Turing Test (named after him, and hereafter referred to as the TT). Going by the standard interpretation of the test as adopted by some scholars who wrote on the subject, an appropriately programmed machine shall be deemed intelligent if a human interrogator converses with it through an exchange of typed messages and he fails to determine whether he was talking to a human being or a machine (Traiger, 2000).

When Turing proposed the TT in 1950, he had in mind two fundamental agenda. First, he aimed at initiating a paradigm shift in the art of designing intelligent machines. Second, he intended to put in place a test for justifying his conviction that machines like humans are capable of functioning intelligently.

Before Turing, machines were usually mechanically designed or rigged to instantiate intelligent behaviours. As far back as 8th century B.C, Homer, the Greek poet wrote of mechanical "tripods" that wait on gods at dinner. The practical efforts of Ramon Lull, the Spanish logician, brought about the emergence of a machine for discovering non-mathematical truths in the 13th century. Four centuries later, Blaise Pascal and, later Gottfried Wilhelm Leibniz, laid the groundwork for the Abacus, a calculating machine that mechanized arithmetic. Von Kempelen's effort in the 18th century led to the design of the "Turk", a mechanical chess player. A machine regarded as the mechanical precursor of the modern computer, Analytic Engine, was designed by Charles Babbage in the 19th century. In 1945, John Von Neumann made a remarkable feat of developing a problem solving electronic computer called EDVAC (Electronic Discrete Variable Automatic Computer). However, the TT with the various ideas anchored on it, as advanced in Turing's famous article "Computing Machinery and Intelligence" (1950), introduces a new tradition in the history of machine intelligence. In what could be considered as a paradigm shift, Turing proposed the replacement of mechanical devices with digital or programmable machines to compete in an intelligence test. The Universal Machine, as he called it, was expected to instantiate intelligent behaviour.

Shortly after the publication of Turing's paper, his first agenda materialised as researchers' attention shifted to developing programmable machines. This effort eventually climaxed in the emergence of a branch of Computer Science known as "Artificial Intelligence" (hereafter referred to as AI) in 1956. AI focuses on developing hardware and software systems that solve problems and accomplish tasks that, if accomplished by humans, would be considered a display of intelligence (Moursund, 2006:n.pag). Consequently, the TT has bolstered research interest in the field of AI (French, 2000; Norvig and Russell, 2003; Saygin et al, 2000). The authors of one of the most popular text books on AI, P. Norvig and S. Russell, are credited with the statement that "It was Alan Turing who first articulated a complete vision of AI in his 1950 article" (Norvig and Russell, 2003:17). Consider the following ground-breaking AI research achievements that were driven by Turing's vision.

1974: An Expert System, MYCIN (generic name of anti-bacterial drug), which consists of an AI programme that diagnoses bacterial infections of the blood and suggests treatments, was produced.

1997: An IBM-designed AI game programme, Deep Blue, defeated the then reigning world human chess champion, Garry Kasparov, in a widely followed chess match.

2005: Stanley, the car robot, won the 2005 Defence Advanced Research Projects Agency, DARPA, Grand Challenge. The robot was developed for high-speed desert driving without manual intervention.

2011: Watson, an IBM AI Question and Answer programme, defeated Brad Rutter, the biggest all time human prize winner, and Ken Jennings, another human record holder for the longest championship streak (75 days), in a quiz show "Jeopardy!"

In spite of these achievements, the move by AI researchers to accord intelligence to machines has been met with scepticism from scholars like J. Searle, N. Block, P. Miller, and a host of others mainly on two grounds. First, they argue that since 1950, the field is yet to accomplish the primary goal set for it by Turing, its progenitor (Dreyfus, 1992; Miller, 1973; Purtill 1971). Turing's goal is that by the year 2000, appropriately programmed machines would be competing favourably with humans in the TT. It is already more than a decade beyond that date, these scholars re-iterate, and no machine has attained this goal. Turing is therefore considered to be mistaken in his second agenda of using the TT to establish machine intelligence. Secondly, they argue that machines lack the natural properties – mind, brain and consciousness – upon which intelligence is believed to be grounded (Block, 1981; Gunderson, 1973; Searle, 1980).

This study employs the critical method of philosophy as an instrument for theoretical reassessment of these standard objections with a view to making a case for success in passing the TT. On the basis of this reassessment, the study takes the view that if the TT is supported with an appropriate theory of induction, it will be feasible for appropriately programmed machines to pass it and then the question of whether they can properly be described as intelligent will be easier to settle. As a mode of inference, induction legitimises inferring a claim from probable evidence. The logic behind the reasoning process is that where conclusive evidence for a claim is unavailable, a reasonable degree of warranted evidence can suffice if a relation between such evidence and the claim can be established. A theory of induction considered appropriate for the attainment of the aim of this research is intended to be a robust interpretive paradigm for the TT and thus help in clarifying the set of broad theoretical presuppositions on which Turing based the test. Incidentally such a theory of induction provides legitimate justification for machine intelligence (as conceived by Turing) without being constrained by considerations pertaining to brain, mind and consciousness.

Our reassessment of the TT reveals that some scholars misunderstand what Turing intends the test to actually accomplish. John Searle (1980), for instance, believes that subjecting machines to an intelligence test like the TT implies testing whether they possess mind, consciousness and brain in human context. There is no way a machine would pass the TT on this count since no dissection of its parts would reveal that its intelligence is a product of such human qualities. From another perspective, Robert French (1990) argues that the TT is crafted to test or reveal a form of intelligence that can only originate from humans. Consequently, machines would have to be human or sub-specie of Homo Sapiens to pass it. Since this is impossible, it is anticipated that no machine shall record any success in it.

Contrary to the interpretations expressed above, the TT is not focused on demonstrating that machines could be transformed into humans. But it is on the basis of such interpretations that the organizers of the popular Loebner Award for the TT, designed questions that are targeted at revealing what is considered human intelligence quotient (IQ) or general intelligence ("g" factor) rather than machine intelligence as outlined and conceived by Turing. The British mathematician conceives machine intelligence in term of machine's capacity to achieve the goal of successfully imitating human intelligent behaviours in manners not distinguishable from humans themselves. Most critics, however, fail to understand that at the heart of the TT is "imitation" and as such questions designed for the test should primarily be tailored towards proving the capacity of machines to imitate human intelligent functions. In this test, Turing meticulously crafted out means of showing how humans exhibit intelligence through their overt behaviour and how appropriately programmed machines could be shown to be capable of exhibiting similar behaviour. Consequently, in what this study considers as the TT's appropriate rendition, the test is executed in two phases. In the first phase, a male player, who is pitted against a female player in an imitation game, is assigned the function of pretending to be a woman. His goal is to deceive an observing human judge through his behavioural responses via teleprinter communication into believing that he is actually the female player. The judge is expected to ask questions capable of eliciting responses that could give away the male player. The male player wins if the judge could not distinguish him from the female player based on their responses. Turing thinks that the male player's appropriate behavioural response in the test is a signpost of intelligence exhibition. In the second phase of the test, a machine is also assigned the function of pretending to be a woman. However, the machine is now pitted against the male player (not the female player) to determine if it could successfully replicate the male player's performance (as witnessed in the first phase) in such a manner that the judge would not distinguish it from the male player himself. If the judge fails in his bid, then the machine passes the test and is deemed intelligent. Turing thus sets the ground work for the classical notion of machine intelligence.

Turing was convinced that playing the imitation game successfully is a signpost of behavioural exhibition of intelligence. He views intelligence as an entity's capacity to achieve a goal or sustain desired behaviour. Consequently, if machines can achieve the goal of playing the imitation game successfully just like humans did, it would be appropriate to consider them intelligent. From the above rendition of the TT, the criterion of success is for a machine to behaviourally execute an assigned function, traditionally presumed to originate from human intelligence, in a manner so convincing that a human judge would take the machine for human. In any case, what the human judge appraises in the TT is not mind, brain or consciousness but overt expressions that are conventionally presumed to originate from such human qualities. As indicated, before subjecting machine to the test, Turing had to pit humans against themselves (male player vs. female player) with the intent of availing the judge the opportunity to "generate theoretical ideas" on what it takes humans to play the imitation game successfully and therein deduce the features or characteristics of the overt expressions he (the judge) should anticipate as mark of successful performance from a non-human agent like machine.

The systematic and technical process brought to light above is fundamental to the TT because it reveals that humans were pitted against themselves at the initial phase of the test for a purpose. Incidentally, the standard interpretation of the test does not incorporate this crucial process, and consequently, scholars that employ it as their window into the TT end up missing Turing's technical detail of evaluating machine's performance in term of human's performance in the test. The standard interpretation merely paints the picture of a test on how machine competes against humans in a game of intelligence. The aspect of the game where the criterion of successful performance (entity's behavioural disposition) was determined is completely overlooked. The conventional criterion of brain, mind and consciousness is thus assumed. Invariably, these scholars fail to see the TT as a test of behavioural interpretation of intelligence but as a test of validating the ontological origin of intelligence. On such ground, critics argue, machine would need to possess brain, mind and consciousness to pass the TT. In human context, intelligence is viewed to usually refer to a general mental capability to reason, solve problems, think abstractly, learn and understand new materials and profit from past experience (Detterman,2008: para.1). These activities are viewed as mental process or act of consciousness. Depending on an individual's philosophical orientation, consciousness, from an idealist point of view may be seen as activities of the mind or from the materialist point of view as an epiphenomenon of the brain (Azenabor, 2001:70). Determining the right orientation on its own constitutes a source of serious debate in philosophy and other related areas. While it is difficult reconciling how the human brain, a material substance, causes mental acts, it is also difficult determining the nature and workings of the human mind due to its subjective nature. In order not to be drawn into such controversy, Turing opted for a behaviourist evidence of intelligence which has the advantage of being anchored on empirical evidence. The TT is thus meant to showcase how well machines can replicate humanlike intelligent behaviour.

From the foregoing, the TT is a test of confirmation of machine's intelligent ability to behaviourally instantiate a generated theoretical idea or characteristics of a "preconceived function" that is traditionally considered a product of human intelligence. The test involves two sequential phases: first, the phase of ascertaining what counts as theoretical explanation or idea of such a function (criterion determinant phase) and Second, the phase of confirming machine's ability to instantiate the hitherto generated idea successfully through its (machine) overt behaviour (confirmation phase). The confirmation is attained by carefully crafting questions that would warrant behavioural interpretations of the assigned or preconceived function for appropriate judgement.

In selecting an appropriate theory of induction that would serve as a philosophical foundation for the TT, this study takes cognisance of the two phases highlighted above, and the importance of deriving a sufficient ground for granting intelligence to machines through them (the phases) without being constrained by the traditional brain, mind and consciousness parameters of intelligence granting. The study also highlights how Turing's structuring of the TT underscores inductive reasoning process (inferring a claim whose evidence only renders it probable). For instance, to generate theoretical ideas on any assigned human function (e.g. functioning as a woman as designated in the original TT) for machine to behaviourally instantiate, Turing relies on the verdict of the judge; but the verdict usually turns out to be a product of "abductive" inference (a mode of induction that requires the use of instinct to draw inference without supportive conclusive evidence). Indeed, since the judge cannot conclusively determine the sex of each of the human candidates in the test, he has to rely on instinctive or abductive inference. Similarly, the judge's verdict on machine versus man player's responses is also considered inductive since it was based on inconclusive evidence. From a logical point of view, inference is either deductive or inductive. While the former depends on conclusive evidence or proof, the latter is anchored on inconclusive but sufficient evidence. Turing himself argues that what the TT offers is a "sufficient proof" of machine intelligence rather than conclusive evidence. Turing practically exhibits thorough-going inductivist orientation in his design of the TT.

Consequently, the study specifically designs a model of induction called Peircean-Hempelian inductive reasoning. It is a theoretical template on how to reason from idea or hypothesis formation to confirmation. The model offers a systematic method for generating and formalising plausible ideas to interpret reality. Structurally, this reasoning process incorporates the triadic logical forms of "abduction", "deduction" and "confirmation". With the logic of abduction, plausible hypotheses are advanced to capture the uncertain nature of reality; with deduction, logical consequences are drawn from the hitherto advanced hypotheses; and with the logic of confirmation, the logical consequences are subjected to a formal test that can provide sufficient condition for approval or disapproval of the advanced hypotheses. The whole process is considered inductive since it can only provide probable ground for its outcome.

Based on the designed model, an appointed judge, in the administration of the TT, is expected to abductively generate theoretical ideas on what it takes humans to play the imitation game in any specifically assigned function; deduce from this the essential features of the overt expressions anticipated from appropriately programmed machines; and then confirm if such machines could instantiate these features behaviourally. The Peircean-Hempelian model of inductive reasoning thus outlines the systematic process essential for conducting the TT in a way that would make Turing's objective realisable.

At this point, it must be stated that Peircean-Hempelian inductive reasoning is a product of synchronising Charles Sanders Peirce's (1839-1914) theory of inquiry with Carl Gustav Hempel's (1905-1997) confirmatory induction. Peirce's theory employs abduction, deduction and induction as three sequential stages of scientific inquiry, hence offers the needed structure for Peircean-Hempelian model. However, it lacks the necessary formal proof that can provide a sufficient condition for justifying a Turing notion of machine intelligence. While Hempel's confirmatory induction offers this proof, it lacks the structure provided by Peirce's theory. Re-designing Peirce's theory of inquiry to incorporate Hempel's confirmatory induction is a viable option; and the outcome is Peircean-Hempelian inductive reasoning.

1.0.2 Statement of the Problem

This study attempts to resolve the problem of misinterpretation of the Turing Test in order to render it passable for appropriately programmed machine and thereby establish their intelligence without recourse to brain, mind or consciousness considerations.

The problem is a challenging one. In the first place, based on the standard interpretation of the TT offered by several scholars, there is no documented evidence that any machine has achieved successful performance in the test since it was introduced by Turing more than six decades ago. The annual Loebner test for machine intelligence was one popular effort put in place since 1990 to reward any computer programme capable of passing the TT with gold medal and prize money of US$100,000. No machine has won the prize yet. The 2012 Loebner competition was held in May 15 at Bletchley Park, UK. The writer of the smartest computer programme, Mohan Embar, only managed to win the bronze medal.

Moreover, it is difficult to imagine the possibility of designing machines equipped with biological brain, mind or consciousness in order to fortify them for successful performance in the TT. Richard Purtil (1971) has already put forth the argument that machines cannot become thinking entities. Similarly, P. Millar (1973) and R. French (1990) argue that the TT can only be passed by humans.

Also, J. Searle (1980) and N. Block (1981) have argued that even if AI researchers manage to design machines that pass the TT by imitating human intelligent behaviour, it would still not count as evidence of intelligence. Machine, they argue, lacks consciousness or internal processing mechanism for intelligence. D. Hofstadter (1985) reiterates that imitating human intelligent behaviour is not synonymous with intelligence.

Certainly, it is one thing to render the TT passable for machine, it is another to justify that machine’s successful performance could count as proof of intelligence bearing in mind that the entity in question does not possess brain, mind and consciousness in human context. Incidentally, achieving this feat is imperative considering its impact on raising awareness on the relevance of machine intelligence to the development of other fields of human endeavour like education. It is in response to this problem that the study advances the thesis below.

1.0.3 Statement of the Thesis

This work argues the thesis that grounding the interpretation of the Turing Test on Peircean-Hempelian logic of induction shall render the test feasible for successful performance by an appropriately programmed machine in order to establish that machine can be deemed intelligent without recourse to brain, mind or consciousness considerations.

The conventional criterion for successful performance, as misrepresented in the standard interpretation of the test, appears impossible to meet. However, in grounding the interpretation of the TT on Peircean-Hempelian logic of induction, it becomes possible to substitute or replace this criterion with a more appropriate paradigm that not only makes successful performance feasible but also captures Turing's original benchmark in the TT. As indicated earlier, the standard criterion stipulates that a machine would need to possess brain, mind or consciousness to really pass the test. For the Peircean-Hempelian criterion proposed in this research, a machine passes the test insofar as we have confirming instances in the form of exhibited humanlike intelligent behaviour by the machine. While the behavioural disposition may not be a conclusive evidence for intelligence, it still offers sufficient reason for admitting machine intelligence as allowed by inductive reasoning. An appropriately designed computer that exhibits verbal behaviour in humanlike manner can pass the TT, according to the Peircean-Hempelian model articulated in this work. The latest word-processing, language translating and editing, speech recognition and text-to-speech enabled computers provide reasonable evidence of the intelligence potentials of appropriately designed machines. Also, Expert Systems (programmes designed to mimic the expertise of human specialists) are sophisticated enough to pass the TT.

1.0.4 Aim and Objectives of the Study

The study demonstrates that, on the basis of Peircean-Hempelian inductive logic, if a machine passes the TT, then that is a sufficient reason for allowing machine intelligence.

The objectives for advancing this aim are as follows:

(i) to explicate how the standard interpretation of the TT misconstrues Turing's real intentions for formulating the test;

(ii) to articulate a more robust and appropriate interpretation of the TT with the aid of Peircean-Hempelian logic of induction;

(iii) to demonstrate on the strength of (ii) above that it is possible to make a plausible case for machine intelligence without recourse to brain, mind and consciousness considerations; and

(iv) to show that repositioning machines as intelligent entities through the TT shall impact positively on the field of education in a developing country like Nigeria.

1.0.5 Significance of the Study

(i) In demonstrating how the standard interpretation of the TT misconstrues Turing's real intentions for formulating the test, this study highlights the need for rigorous reassessment of the TT.

(ii) The study, through its inductivist interpretation of the TT, creates a plausible means through which machines can achieve successful performance in the test. It also offers an alternative interpretation of the TT that could reliably be adopted by AI researchers, philosophers of mind, psychologists, linguistic philosophers, and other researchers interested in the general topic of intelligence.

(iii) The Peircean-Hempelian model of induction provides a plausible model with which philosophers of science, scientists and other researches could generate and test hypotheses. Having been successfully applied to the TT by this study for the purpose of making a case for machine intelligence without recourse to brain, mind and consciousness considerations, AI researchers can now employ it to deepen research in their domain.

(iv) Linking the act of establishing machine intelligence to educational development in a developing country like Nigeria, as attempted by this study, broadens the mind of educationists, philosophers of education, policy makers and government on the relevance of ICT (AI paradigm for information processing) to the current trend in educational administration and teaching method.

1.0.6 Scope and Delimitation of the Study

This research is fundamentally a philosophical enterprise. Consequently, it does not concern itself with the technicalities and mathematical algorithms of AI. Rather, it is concerned with the critical examination of the knowledge claims of AI with special emphasis on the TT, the nature of these knowledge claims, the methodology employed by AI in the expression of the above and the relevance of these knowledge claims to human development.

1.0.7 Research Questions

The fundamental questions germane to this study are as follow.

(i) How does the standard interpretation of the TT misconstrue Turing's real intentions for formulating the test?

(ii) How can the Peircean-Hempelian logic of induction aids the articulation of an appropriate interpretation of the TT?

(iii) Is it possible to make a plausible case for machine intelligence without recourse to brain, mind and consciousness considerations on the strength of Peircean-Hempelian inductive interpretation of the TT?

(iv) In what ways could repositioning machines as intelligent entities through the TT impact positively on the field of education in a developing country such as Nigeria?

1.0.8 Operational Definitions of Terms

Artificial Intelligence

This is the art of creating machines that perform functions that require intelligence when performed by humans.

Behaviour

This can be regarded as an entity's overt response to a specific set of conditions or instructions.

Brain

Material organ located in the human head and considered to be responsible for consciousness.

Consciousness

The mental state of awareness experienced in various forms such as thinking, believing, knowing, imagining, willing, deliberating, feeling, remembering, memory, etc.

Induction

This is a type of argument in which the premises only render the conclusion probable.

Intelligence

The capacity of an entity to achieve a goal or sustain desired behaviour that is indicative of reasoning, thinking or consciousness under conditions of uncertainty.

Machines

These are artefacts of different forms so designed either mechanically or programmed to perform functions that require intelligence when performed by humans.

Machine Intelligence

This term designates the description given a machine for its capacity to achieve the goal of successfully imitating human intelligent behaviours in manners not distinguishable from humans themselves. This is the classical usage of the term as intended by Turing.

Mind

Immaterial aspect of human where it is believed that consciousness takes place.

Peircean-Hempelian

This term designates a synthesis of relevant aspects in the methodological theories of Charles Sanders Peirce and Carl Gustav Hempel. Thus, the term is a derivative of their surnames. For the purpose of this study, Peirce's theory of scientific inquiry is synchronized with Hempel's confirmatory induction. Peircean-Hempelian therefore refers to the product of the combination or synthesis. It is an inductive reasoning process for hypothesis generation and confirmation.

Philosophical Foundation

This is the philosophical principle used as the framework for an advanced claim, the set of broad theoretical presuppositions on which an inquiry or analysis is based.

1.0.9 Theoretical Framework

The theoretical framework of a research is the organising set of ideas on which its claim stands. It is the pillar which firmly holds the claim. The choice of a theoretical framework is informed by the nature of the basic assumption(s) underpinning the claim put forward by a researcher.

The claim of this study is that if the TT, as a test of behavioural evidence, is rendered feasible for successful performance by an appropriately programmed machine, then, it would be an appropriate paradigm for ascribing intelligent behaviour to machines. The basic assumption underpinning this claim is that appropriate behavioural disposition or overt expression is a sufficient proof of intelligence. The study posits that where absolute proof for a claim is unavailable, a reasonable degree of warranted evidence can suffice if a relation between such a proof and the claim can be established. For instance, there might be no absolute proof that a man found at the scene of a crime and in possession of the crime weapon was the one who committed the crime, but there is sufficient evidence to prosecute him, namely, his presence at the crime scene and his possession of the crime weapon. Similarly, passing the TT could be viewed as a sufficient condition for establishing machine intelligence though it may not be considered as an absolute proof. An absolute proof in this case, as pointed out by some scholars (Block, 1981; Purtill, 1971; Searle, 1980), is that machines must be shown to possess brain, mind and consciousness, which constitute the essential properties of intelligence in human context. Considering the unrealistic nature of the above and the fact that appropriately programmed machines can imitate computational aspects of human intelligence, this study opts for the sufficient condition option where overt behaviour, presumed to originate from intelligence, is manifested by an appropriately programmed machine.

Consequently, the study considers inductive logic as an appropriate theoretical framework for interpreting the TT because it provides a legitimate frontier for accepting a claim that can only be substantiated with probable evidence in the absence of absolute one. As already indicated, in inductive reasoning, the premises do not provide conclusive grounds for the conclusion, they just provide support for it (Anele, 2005: 17). This support is considered sufficient to warrant the conclusion.

There are different theories of induction appropriate for different situations. Induction by “analogy” is, for instance, suitable for resolving legal and moral issues. The inductive principle of “causality” is used for discovering causal connections. “Statistical” inductive reasoning is employed to discover group patterns. “Probability-based” induction is suitable for making predictions. For the task at hand, this study considers “explanatory” and “confirmatory” theories of induction suitable.

As intended in this work, explanatory induction or abductive inference was described by its originator, C.S. Peirce, as a reasoning process that involves the act of forming an explanatory hypothesis given some observations. The hypothesis is a form of explanation generated with the aid of human instinct to account for the observations. Since such observations may not offer conclusive reason for inferring the hypothesis the process assumes an inductive status. As an illustration: on reaching a large farmland and noticing that it is wet, we may form the plausible hypothesis that it recently rained in that location. By the principle of abductive inference, our hypothesis is inductive since there are other plausible factors that could equally account for the wetness of the farmland. Explanatory induction has the advantage of aiding us to spontaneously fix our belief about the possible cause of an event where none has been proposed. For the present task, this form of induction offers the framework with which to generate probable explanation on the nature of any intelligent behavioural disposition anticipated from a presumed intelligent machine.

Confirmatory induction, on the other hand, is the act of employing probable evidence in the form of observational data as sufficient or inductive ground for accepting an advanced hypothesis. Successful establishment of a relationship between observational data and a hypothesis is considered a sufficient reason for the latter's confirmation. Although the data may not offer conclusive evidence, it is sufficient enough for the justification of the hypothesis. For instance, the hypothesis that it rained because a farmland is discovered to be wet can be confirmed if a relationship could be established between the hypothesis and any observation data that offers sufficient condition for rainfall. Based on the understanding that there could be more than one observation data that could account for the rainfall hypothesis, C.G. Hempel, whose model of confirmatory induction constitutes the second leg of our theoretical framework articulated some logical conditions or parameters on whose strength a plausible choice could be made. This is needed to minimise *non causa pro causa fallacies* (that is errors in the attributions of the causes of phenomena). The advantage of confirmatory induction to this study is that it offers the framework with which the study can justify machine's behavioural disposition as a sufficient proof of its intelligence independent of brain, mind and consciousness considerations.

1.0.10 Methodology

This work is, fundamentally, a library-based research which stands on the analytical and critical approach preferred in philosophy. The choice of this methodology is informed by the nature of the problem this study sets out to investigate. This is primarily the problem of justifying passing the TT as a sufficient criterion for ascribing intelligence to appropriately programmed machine. From the understanding of this study, the problem is rooted in linguistic confusion over the use of the word 'intelligence' in relation to man and machine.

Hence, the essential characteristic of our research methodology is its critical approach and textual exegeses native to philosophical inquiry. This method dates back to the ancient period when Plato concerned himself in the business of clarifying terms and concepts to make his ideas clear. The method flourished in the 20th century when it was the primary method of philosophizing by the analytic philosophers like Bertrand Russell and G.E. Moore.

The significance of this methodology to this study is in the following ways:

(i) it allows for careful and critical study and analysis of the TT thereby exposing to this study the areas where some scholars misunderstood and misinterpreted Turing's position;

(ii) it provides the key for unravelling the vexed problem of rendering the TT feasible for machine to pass in order to establish machine intelligence;

(iii) it serves as an instrument with which the TT can be evaluated within the boundary of Turing's objective, in order to legitimately establish machine intelligence without recourse to the brain, mind or consciousness factor; and

(iv) it helps to bring out the essential connection between philosophy and the field of AI. The kind of conceptual analysis native to philosophy, when applied to the epistemological issues connected with AI, deepens the theoretical base of the discipline. The choice of Peircean-Hempelian model as an inductive framework for elucidating the TT is informed by the outcome of the conceptual analysis executed in this study.

1.0.11 Literature Review

The selected literatures for this study are obtained from primary and secondary sources with their full details provided in the reference section. The original works of Turing, Peirce and Hempel constitute the primary sources of the research, and the provenance of the core ideas on which this study is based. However, the critical commentaries on Turing's attempt to legitimise machine intelligence constitute the bulk of the secondary sources of this research.

The literature shall be reviewed according to the following themes: nature of intelligence; the TT debate and; induction as a possible link between philosophy and attempt in AI research to establish machine intelligence.

The Nature of Intelligence

The question, “What is intelligence?” is deceptively simple. However, scholars have engaged in series of research in order to answer it. Till date there is no simple answer accepted by experts in the relevant disciplines. Attempt to identify a standard definition has been very challenging (Miles, 1957; Eisenk, 1995; Suvorov, 1999; Legg & Hutter, 2007). This failure is connected with the fact that defining intelligence requires the application of perplexing and difficult-to-define concepts (Legg & Hutter, 2007). Some researchers consider intelligence as the ability to solve problems (Bingham, 1937; Minsky, 1985). Others consider it as the ability to adjust to environment (Wechsler, 1958; Simonton, 2003). Yet others consider it as the ability to achieve goals (Kurzweil, 2000; Sternberg, 2003).

A novel way to identify an all encompassing definition of intelligence was attempted by S. Legg and M. Hutter (2007). After putting together an anthology of definitions of intelligence by different researchers, the two writers decided to distil what they consider as essential features underlying all the definitions. Against the background of these features, they posit their own definition which states that intelligence measures an agent’s ability to achieve goals in a wide range of environments. This definition, like any other definition of intelligence reviewed by this study, provides a rich database from which the study can draw ideas on the nature of intelligence. What is missing at this point is how machines can succeed in a behavioural test that exemplifies these ideas.

Some researchers believe that intelligence is what is measured by intelligence tests. The Binet test, introduced by the French philosopher, Alfred Binet, in 1905, is an attempt to relate intelligence with the mental (as interpreted in Hilgard, 1962). The intelligence quotient (I.Q) test, conceived by W.L. Stern (in Hilgard, 1962) is expressed in term of computation of the age of a child as estimated by his or her performance in the intelligence test and then dividing this up by their true biological age and multiply by 100. Invariably, an individual’s I.Q. is a measurement of the individual’s mental performance relative to some presumed larger group. The problem with these tests and their variants is that they are not suitable for measuring machine intelligence. According to Shane Legg (2008), applying the I.Q. test, for instance, to machine intelligence would be problematic where for instance the performance of some machines could be many level of magnitude greater than others.

Some researchers consider proffering theories to capture the nature of intelligence. Charles Spearman (1927) theorises that intelligence is one general mental capability represented as **g**. The **g** factor underlies performance on all intellectual tasks. For Louis Thurstone (1938), intelligence consists of seven independent primary abilities. R.B. Cattell and J. Horn (1966) consider two broad abilities to be enough. J.P. Guilford (1967) advances the structure of intellect theory according to which there are three fundamental dimensions of intelligence. From the three dimensions emerge different categories of intelligence numbering up to 150. These include auditory intelligence, visual intelligence, information processing intelligence, et cetera. R.J. Sternberg (1985) puts forward the Triarchic Mind theory which is anchored on three parts of intelligence. A more radical theory of intelligence was put forward by Howard Gardner (1993). He argues that humans do not have one underlying general intelligence, rather, what they have is multiple intelligences, each constituting part of an independent system in the brain. So far, Gardner has identified eight of such kinds of intelligence, namely, linguistic intelligence, musical intelligence, logical-mathematical intelligence, spatial intelligence, intrapersonal intelligence, interpersonal intelligence and naturalist intelligence.

Like the definitions, the test and theories of intelligence reviewed by this work provide further insight into the nature of intelligence that machines are presumed to be imitating. Beyond this relevance, these works do not provide any meaningful way to prove machine intelligence. The same cannot, however, be said of the work of Alan Turing "Computing Machinery and Intelligence" (1950) which, in fact, was primarily written to demonstrate the intelligent capability of machines. To this end, he puts forward the TT. Turing's idea is that a machine could be considered intelligent if it passes a test cleverly designed for behavioural instantiation of intelligence. The TT is so designed for this purpose.

Reacting to the question whether machine can think, Turing meticulously crafted a game that exemplifies what it means to say that entities like humans can think or are intelligent in terms of their behavioural dispositions. He argues that if machines were appropriately programmed they would exhibit similar behaviour when introduced into the game. Consequently, the Imitation game as Turing calls it is executed in two phases. As noted earlier, in the first phase, a male player, who is pitted against a female player, is assigned the function of pretending to be a woman. His goal is to deceive an observing human judge through his behavioural responses via teleprinter communication into believing that he is actually the female player. The judge is expected to ask questions capable of eliciting responses that could give-away the male player. The male player wins if the judge could not distinguish him from the female player based on their responses. It is the belief of Turing that the male player's appropriate behavioural response is an exemplification of human capacity to undetectably imitate what they are not and this, ipso facto, is a signpost of intelligence. In the second phase of the test, a machine is also assigned the function of pretending to be a woman. However, the machine is now pitted against the male player (not the female player) to determine if it could successfully replicate the male player's performance (as witnessed in the first phase) in such a manner that the judge would not distinguish it from the male player himself. If the judge fails in his bid, then the machine passes the test and is considered to have met the criteria employed in adjudging the male player intelligent. Turing thus sets the ground work for the classical notion of machine intelligence.

The Turing Test Debate

Since the publication of his article on the TT "Computing Machinery and Intelligence", Turing's ideas have been widely discussed, attacked, and defended. At one extreme, the article was considered to represent the beginning of AI and the TT its ultimate goal. At the other extreme, the TT has been dismissed as useless, even harmful (Saygin et al, 2000: para. 1).

Richard Purtill (1971), for instance, argues that computer can only play Turing's imitation game in our dream or imagination. Computer programmes are deterministic and can in fact be mechanically explained. They are not thinking entities like humans with brain and mind; hence they lack intelligence. Machines cannot act beyond what is programmed into them. Purtill's argument is, however, defeated by the superlative performance of the IBM computer programme, Deep Blue that defeated the world human champion in a game of chess in 1997. According to Bostrom and Yudkowsky (2011), were it the case that machines can only do exactly as they are told, the programmers of Deep Blue would have had to manually pre-program a database containing moves for every encounter. But this was not a viable option. First, the space of possible chess positions is unmanageably large. Second, if the programmers had manually inputted what they consider a good move in each possible situation, the resulting system would not have been able to make stronger chess moves than its creators. Since the programmers themselves were not world champions, such a system would not have been able to defeat Garry Kasparov. The world champion himself acknowledged being under the illusion that he was actually playing with a human intelligent entity in the game rather than a computer programme.

P.H. Millar (1973) simply dismisses the TT as a legitimate test for proving machine intelligence. The test, as structured by Turing, is best suited for testing only human intelligence. For instance, the kind of verbal behaviour being tested for is peculiar only to human cultural backgrounds; as a result no machine would be able to exhibit it in order to pass the test. He thus opines that a more appropriate test be designed to measure machine intelligence. It is obvious that Millar missed a crucial point of the TT due to his misunderstanding of the test; the test is meant to demonstrate the capacity of machines to imitate human intelligent behaviour insofar as they (machines) are appropriately programmed. If the test is suited for testing only human as Millar interpreted, the question is, whose intelligent behaviour is human meant to imitate in the test?

Keith Gunderson (1973) points out that, although, playing the imitation game is one out of numerous acts engaged by intelligent agents, the success of machine in it should not, however, be counted as a sufficient proof of their intelligence. He argues that machine could actually be cleverly rigged to do well in the game.

J.G. Stevenson (1976), in his reaction to Gunderson's denial of machine intelligence, posits that if we cannot deny the fact that playing the imitation game demonstrates the act of intelligence, then how such act is achieved should not count. Even if machines were rigged, what is important is that they execute functions that would require intelligence if man were to attempt same. Technically, Stevenson's conclusion rests on the supposition that the TT is not denied of being sufficient to establish machine intelligence if passed. Nevertheless, he failed to provide a robust philosophical foundation for his insight.

John Searle (1980), using his famous Chinese Room argument, concludes that passing the imitation game is not a sufficient proof of intelligence. According to him, an individual may with some cleverly devised tricks manipulate the symbols of a language to produce appropriately meaningful expression yet may lack understanding of the expression or the language itself. For him, understanding or consciousness, which is an essential property of mind and brain, is the hallmark of intelligence. Since machine is not equipped with mind or brain it cannot experience consciousness or understanding. It is therefore not enough for machine to pass the TT in order to be accorded the attribute of intelligence; the machine must first and foremost be proven to possess mind or brain. Conclusively, the TT, in order to be certified as a legitimate proof of intelligence, must also prove that machine possesses brain and mind. Turing himself anticipated Searle's position. He pointed out that using mind as an index of intelligence possession shall yield no fruitful result. The only plausible proof that an individual has mind is if we become that individual; in essence, we have to be a machine to know if it has mind or not. Consequently, we have to solve the problem of other minds before we can legitimately factor in mind possession as a criterion for establishing intelligence.

The inadequacy of Searle's argument has been strongly accentuated by Hilary Putman's (1960a) and Jerry Fodor's (1981) celebrated functionalist theory of mind. The theory recognises the possibility that systems as diverse as human beings, calculating machines and disembodied spirits could all have mental states and that the psychology of a system depends not on the stuff it is made of (living cells, mental or spiritual energy) but on how the stuff is put together. Consequently, a machine that passes the TT could also draw support from functionalist theory of mind to further legitimise its intelligence.

Ned Block (1981) disapproves of the TT as a true test of intelligence because he believes it wrongly relies on overt behaviour as its proof. Machines which rely on some simple tricks to operate can easily be designed to exhibit overt behaviour that suggests intelligence. The true test of intelligence, according to him, lies in the character of the internal information processing that produces the overt behaviour. It is thus possible for two entities to exhibit similar overt behaviour associated with intelligence and yet we may deny one of them the status of intelligence due to its non-supportive internal information processing mechanism. Intelligence is commonly ascribed to human behaviour because it is believed that humans have supportive internal information processing mechanism for it. However, more than a decade before Block's publication, Herbert Simon (1966) had established through his research that humans and computer programmes share similar information processing mechanism. He argues that both human thinking and computer information processing programmes perform three similar operations vis-à-vis, scanning data for patterns, storing the patterns in memory, and applying the patterns to make inferences. This observation technically weakens Block's argument against machine intelligence.

According to D.R. Hofstadter (1985) the TT cannot take us beyond the level of imitation to the level of reality. He criticises Turing's analogy of how a man can imitate a woman in the imitation game. He suggests that even if a man could imitate a woman perfectly, the demonstration would not necessarily render him a woman. He would still remain a man. For him, imitation is nothing other than imitation. Consequently, a computer does not become worthy of the description "intelligent" just because it can mimic a woman. He concludes that if the mimicry is nothing more than the regulation of canned routines and pre-programmed responses, then such mimicry is also nothing more than a calculator that mimics a person by indicating that "two plus two is four."

The lacuna in Hofstadter's line of argument is that he does not consider the fact that machines sometimes go beyond imitation to the level of performing human activities better than humans themselves. Some machines do not just perform tasks faster than humans, they also do this more accurately. The level of machine development in the present age is such that man would find it almost difficult to match the data or information processing prowess of sophisticated computers. Deep Blue's defeat of Garry Kasporov in 1997 in a game of chess and Watson's defeat of Brad Rutter and Ken Jennings in Jeopardy quiz show in 2011 are celebrated instances that demonstrate how machine's intelligent ability is more than mere "canned routines" alluded to by Hofstadter.

Steven Harnad (1989) makes a strong attempt to strengthen the TT against possible criticisms. To this end, he proposes the Total Turing Test (TTT). In the new test, the computer is a robot that is expected to look, act and communicate like human with the aid of technology-driven gadgets. The inadequacy of the TTT is that it is still not immune to the problems confronting the TT which could be accommodated within the infrastructure of inductive logic.

Robert French (1990) avers that the TT cannot be successfully employed to determine the intelligence of a machine. His reason is that it is totally impossible to design a machine that can pass it. French rests his conclusion on the notion that the TT is crafted to involve such questions that aim at revealing only human intelligence rather than any other form of intelligence. Consequently, a machine would have to become human to pass it. Perhaps, what missed French's attention is Turing's supposition that, if appropriately programmed, machines can pass the test. Turing is vindicated by the performance of Watson in "Jeopardy!" quiz show which primarily involves questions that require analysing subtle meaning, irony, riddles and other linguistic complexities native to human intelligence.

Hubert Dreyfus (1992) points out that humans do not achieve intelligent behaviour in their daily lives by memorising large bodies of facts and by following explicitly represented rules. He explains that being born, equipped with a body, and with the ability to feel, and growing up as part of a society, are essential elements of intelligence and understanding. Since machines do not undergo these forms of experience then the intelligence attached to them is questionable. In relating Dreyfus' position to the TT, one could argue that Turing never had the intention of making machines become humans in the first place. His argument for machine is anchored on the simple logic that it would not be out of place to accord intelligence to machines if their overt behaviour suggests intelligence.

Mete Atamel (2003) considers the TT as an attempt to liberate intelligence from the monopoly of man. The TT makes it possible to bypass the misery of intelligence by equating perplexing internal brain functions with more comprehensible outward behaviours. The advantage of the imitation game, according to him, is that it sets the right direction for AI because its gives greater freedom for the development of a mode of artificial rationality that is distinct from that of humans. Atamel's argument, however, does not incorporate the necessary philosophical framework to support the TT's objective.

From the foregoing, it is clear that several scholars consider the possession of brain, mind and consciousness in human context as the criterion of success in the TT; but others are convinced that behavioural disposition through imitation is sufficient. While the first position is validated by the non-availability of any record of successful performance by machines in the TT ever since Turing introduced the test, the second option on its own is validated by availability of ample records in the field of AI suggesting intelligent behavioural disposition in different forms by machines. How could machines fail to exhibit appropriate behavioural disposition that meets the TT benchmark and yet successfully exhibit intelligent behavioural disposition in other forms like playing good chess game, driving vehicles without manual intervention, diagnosing human ailments in manner not distinguishable from experts, and so on?

Clearly, the criterion of imitation rather than the criterion of brain, mind and consciousness possession is what is actually highlighted by the test. Scholars who chose the latter criterion tend to misinterpret the TT. This is evident in their various presentations of the test which omit the test's first phase where the imitation criterion is clearly set out. That said, there is need to justify the imitative ability of machines as proof of their intelligence. Although some scholars (Atamel, 2003; Harnad, 1989; Stevenson, 1976) support Turing's criterion of imitation, they however, fail to offer epistemological justification for the criterion.

The conscious step taken by this study in attending to the lacuna revealed above is to step out of the field of AI itself to reach out to other disciplines for ideas. This is in consonance with suggestions of some scholars (Agre, 1995; Cummins and Pollock, 1991; Guzeldere and Franchi, 1995; McCarthy, 2007; Sharoff, 1995; Unah, 2008) that there is need for interdisciplinary interactions. Some of these scholars (P. Agre, S. Sharoff, and J. McCarthy) particularly mentioned the need for AI research to reach out to a discipline like philosophy in order to attain its goals.

The need for an interdisciplinary reassessment of the TT is that it provides a plausible direction that can be explored to tackle the machine intelligence issue. Consequently, an epistemological template based on the logic of induction provides a fruitful intersection between philosophy and AI research. This study is a rigorous exploration of this option.

Induction as a possible link between Philosophy and the attempt to establish Machine Intelligence.

A notable work that explores the possibility of establishing classical machine intelligence with induction is J.H. Moor's "An Analysis of the Turing Test" (1976). Moor argues that if computer continues to exhibit intelligence-driven behaviour as projected by the TT, then it will not be out of place to conclude inductively that computer is indeed intelligent. Moor is convinced that some of the objections raised against the TT are either irrelevant or can be refuted since the test only provides inductive evidence rather than absolute proof. Moor, however, fails to address the issue of how the test can be made feasible for successful performance by machine. Without this, there would be no means of gathering the inductive evidence needed. Beyond this inadequacy, Moor also fails to specify the kind of inductive evidence that would be needed to render the TT sufficient to justify machine intelligence. Already, Patrick Hurley (2000) argues that inductive evidence comes in different forms such as analogical, causal, probabilistic, statistical and hypothetical evidence. The choice of inductive evidence depends on the role assigned to the inductive argument in question.

Some philosophers, however, hold that inductive evidence, in whatever form, is suspect. Two notable anti-inductivists are worthy of mention here. David Hume (1975) advances the claim that there is no logical justification whatsoever for induction. The problem of induction, according to him, lies in the fact that its process rests on the validity of the principle of the uniformity of nature. This validity cannot be guaranteed since a change in the course of nature or universe is not inconceivable. Similarly, we have no conclusive reason to believe that the instances of a phenomenon we had experienced in the past shall surely resemble those we are yet to experience. Consequently, there is no rational justification for induction. Induction is grounded purely on habit, that is, human penchant of linking the past and present with the future; there is no rational ground for the linkage.

Karl Popper (1959), like Hume, posits that induction lacks rational justification and as a result, does not play any role in hypothesis generation and scientific method as a whole. Scientists propose conjectures which are subjected to severe observational tests in an effort to falsify them. Popper calls it the method of conjectures and refutations as the core methodology of scientific research anchored on the logical machinery of *modus tollens*.

Are the criticisms of Hume and Popper fatal to our inductivist interpretation of the TT? No, for the following reasons. Hume's critique of induction is inadequate (Johannson, 1975; Stove, 1982; Dykes, 1999; Okasha, 2001). This critique could be interpreted in the form of inductive fallibilism and inductive scepticism. The first, according to Okasha, explains the notion that our beliefs about the future cannot be certain or absolutely inferred. He agrees with Hume on this but disagrees with the latter's attempt to go beyond inductive fallibilism to inductive scepticism where the beliefs about the future are completely denied. Our experience of the past could still provide sufficient or rational ground to infer beliefs about the future although the possibility of error can never be ruled out completely. Also, an understanding of nature shows that it is not uniform in every respect; but there must be regularities if it is to be describable at all.

J.A. Johannson (1975), D.C. Stove (1982), and N. Dykes (1999) agree that, in so far as Popper conceives all knowledge to be conjectural, it is logical to presume his critique of induction to be conjectural as well. In addition, some scholars (A. Grunbaum, 1976; H. Putnam, 1981; S. Fuller, 2012) accept that Popper's linkage of severity of test with degrees of corroboration is inductivist despite his denial of induction as a valid mode of scientific reasoning. However, beyond the attempt to refute Hume and Popper's critique of induction, G. Marti (2008) believes that induction plays a central role in everyday reasoning and scientific reasoning regarding matters of fact. For instance, with the aid of inductive reasoning, we commonly draw conclusion about an entire group of things, or a population, on the basis of data about a sample of that group, or we predict the occurrence of a future event on the basis of observations of similar past events; or attribute a property to a non-observed thing on the grounds that all observed things of the same kind have that property, and so on.

Because we accept inductive reasoning as legitimate and appropriate in the appraisal of empirical claims, this study formulates a hybrid inductive procedure for establishing machine intelligence on the basis of the TT. They are explanatory and confirmatory forms of induction as posited by C.S. Peirce and C.G. Hempel respectively.

The primary aim of Peirce's explanatory induction is to help an inquirer generate hypotheses or theories to explain phenomena or provide explanatory answers to identified problems. For him, explanatory answers are mere conjectures lacking conclusive proof. This belief is explicated in his doctrine of fallibilism. In Peirce *Collected Papers* (1931), fallibilism is presented as the doctrine that we cannot attain absolute certainty, exactitude or universality with reasoning. The reason for this lies in another doctrine of Peirce called "synechism". It is the notion that reality is ever in a state of continuity and perpetual change. Consequently, our knowledge is never absolute but always swims in a continuum of uncertainty and indeterminacy. Thus, Peirce's theory of knowledge is prone to sceptical challenge. It is easy to assume that his theory of knowledge would be vulnerable to Paul Feyerabend's anarchist and anti-inductivist methodology of inquiry

(Feyerabend, 1984). Given the uncertain nature of reality, the appropriate method of inquiry should be "anything goes" in the methodology of research.

Peirce however, assigns a pragmatic value to induction as a means of transcending scepticism with the aid of scientific inquiry. There are two complementary dimensions in the study of inquiry, namely, psychological and logical dimensions. The psychological dimension is apparent in Peirce's "The Fixation of Belief" (1877) where he attempts to show that inquiry is a mental struggle to eliminate the irritation of doubt and attain fixation of belief. Since reality is ever in a state of perpetual change or continuity, the feeling of doubt usually takes over our desire to attain certainty; and this could be irritating to reasoning. Thus, the psychological motive behind inquiry is to transcend the irritation caused by doubt and arrive at a belief. Peirce characterises doubt as an uneasy and dissatisfied state from which we struggle to free ourselves. The state of belief on the other hand is calm and satisfactory state that we usually tenaciously cling to. Beliefs easily guide our decisions and shape our actions. With inquiry, we can pass from the state of doubt to the state of belief. Peirce, however, warns that some celebrated method of inquiry cannot help us in this all important transition due to their inherent weaknesses. Such include the method of tenacity, authority and a priori method.

The main virtue of scientific method, according to Peirce, lies in its realistic basis in experience. Peirce perceives reality as having concrete existence independent of our opinions about it. The method of science operates on the presumption that it presents a reality that is not immune to public scrutiny. Consequently, a belief that is fixed on such supposition can be investigated publicly.

The logical dimension in Peirce's study of inquiry is contained in his "Deduction, Induction and Hypothesis" (1878b). There, Peirce outlined the procedure involved in his method of inquiry. It involves the triadic stages of abduction, deduction and induction. At the stage of abduction, the inquirer offers suggestion or educated guess or theory to explain a phenomenon with the aid of his instinct. What he applies here is abductive inference whose importance lies in its pragmatic import and radical formal presentation of: C; $A \supset C$; $\therefore A$. This formal template is distilled from Peirce famous abductive argument: "The surprising fact, C, is observed; But if A were true, C would be a matter of course. Hence, there is reason to suspect that A is true" (Peirce,1931:5.188-9). Although this mode of inference commits the fallacy of "affirming the consequent" against a valid rule of deduction known as "Modus Ponens" ($P \supset Q$; P; $\therefore Q$), Peirce's argument for its correctness is that it plays the pragmatic role of offering a suggestion that can help us fix our belief. In Peircean pragmatism, the value of a thing is the practical effect or relevance of that thing (Peirce, 1931). In fact, the justification of abductive inference is that from its suggestion, it is possible to deduce a prediction which can be tested by induction. In any case, the suggestion is usually sufficient enough (not absolute) to account for the claim, otherwise, it would have been impossible to predict from it. Consequently, at the second stage of inquiry, we predict some logical consequences from the generated theory, and, at the third stage, we subject these consequences to a test of relation with the theory. Peirce considers his three stages of inquiry as a complete process of research when combined. It is with this method that science advances theories to explain facts or events.

While the scope of Peirce's explanatory induction is not expanded to cover the discourse on machine intelligence as related to the TT, it offers a leeway for logical interpretation of the TT. It must be acknowledged that the Peircean model does not contain a formal procedure for justifying the objective of the TT. However, synchronising Peirce's explanatory induction with Hempel's confirmatory induction provides this missing link since it offers a model for rigorous selection of a hypothesis among competing alternatives. The primary aim of this form of induction is to test hypotheses or theories for confirmation. In Hempel (1945a), the logic of confirmation is advanced to provide the framework within which a relationship between observational data and scientific theories or everyday hypotheses can be established. Such a relationship entails employing the observational data as indirect or probable evidence rather than as conclusive evidence of confirmation of theories. The relationship is thus inductive. The pressing question at this point is: how do we determine the appropriate observational data that offers probable evidence for the generated theory?

Hempel answered this question by putting forward certain fundamental principles on the basis of which confirmation can be executed in order to provide a sufficient reason for accepting observational data as probable evidence for advanced hypotheses or general statements. They include (i) Entailment Condition, (ii) Consequence Condition, and (iii) Consistency Condition. The Entailment Condition, for instance, reiterates the argument that if a body of evidence has a logical relationship with a hypothesis, then the presence of the evidence provides sufficient ground for accepting the hypothesis. According to the Consequence Condition, a body of evidence that corroborates a hypothesis logically offers corroborative instrument for every possible consequence of that hypothesis. Finally, the Consistency Condition offers the claim that two independent hypotheses are logically related if they are corroborated by a similar body of evidence. At this point, it should be noted that these principles were advanced to resolve the logical positivists' dilemma of not being able to verify general statements on the basis of the "verification principle".

According to Hempel, scientific generalisations or universal statements could indirectly be confirmed through the observation of objects or statements that do not share the attributes of such generalisations. He advanced his popular "Raven Paradox" to prove his point. Accordingly, the generalisation "all ravens are black" could be confirmed by the observation of objects that are neither black nor raven. Consequently, the observation of red roses and brown shoes is expected to corroborate the notion that all ravens are black. Although this appears as a paradox, it does not contravene any principle of logic when formally expressed. As a matter of fact, both the rule of immediate inference "contraposition" and that of replacement "transposition" validate the raven paradox. On the basis of the former, we can validly derive "all non black things are non raven" from "all ravens are black". The latter also validly expresses the situation thus: $\left[(x)\,(Rx \supset Bx)\right] \equiv \left[(x)\,(\sim Bx \supset \sim Rx)\right]$.

Like Peircean explanatory induction, the Hempelian confirmatory induction does not entail the discourse on machine intelligence. It also lacks the logical structure for logical interpretation of the TT. Nevertheless, the potency of the principles of confirmation it offers, could be exploited for constructing an inference procedure for establishing a sufficient condition for granting intelligence to machine (in manner conceived by Turing).

Bearing in mind the inadequacies and opportunities of Peircean explanatory induction and Hempelian confirmatory induction, this study modifies the two theories to form the Peircean-Hempelian model of inductive reasoning. The modification constitutes an amalgam of the first two stages of theory of inquiry that forms the kernel of Peircean explanatory induction and, Hempel's theory of confirmation. The result is a reasoning process incorporating the triadic logical forms of "abduction", "deduction" and "confirmation". With the logic of abduction, plausible hypotheses are advanced to capture the uncertain nature of reality; with deduction, logical consequences are predicted from the hitherto advanced hypotheses; and with the logic of confirmation, the logical consequences are subjected to a formal test that can provide sufficient condition for acceptance or rejection of the hypotheses. Following the structure of the new model, an appointed judge, as warranted at the "first phase" of the TT, shall "abductively" generate theoretical ideas on what it takes humans to play the imitation game in any specifically assigned function; he "deduces" from this the essential features of the overt expressions anticipated from appropriately programmed machines; and then at the "second phase" of the TT "confirms" if such machines could instantiate these features behaviourally as a way of establishing their intelligence without recourse to brain, mind and consciousness considerations.

The unique advantage of the structure offered by this model is that it connects the first and the second phases of conducting the TT, as indicated above, and therefore establishes when a machine has passed the test. The abductive and confirmatory logical forms of the model conform to the TT's phases of generating the imitative criterion and that of confirming machines' imitative ability respectively. The model's logical form of deduction is the anchorage of the two phases. This resolves the problem encountered in the conventional process of conducting the test where the first phase of the TT is neglected. Inevitably, the imitative criterion was sidelined while the criterion of brain, mind and consciousness is assumed. And of course on this ground, machines are anticipated to fail (as it has been the case in reportedly conducted tests). On the contrary, the Peircean-Hempelian model provides a paradigm for assessing how machines have performed when subjected to the TT.

From the foregoing, it becomes obvious how the new model furnishes the TT, as reviewed and interpreted in this research, with the necessary philosophical framework with which to attain its (TT) objective i.e. establishing whether machines are, or can be described as intelligent. Indeed, the advantage of this objective, particularly to the field of education, perhaps, makes the effort of this study a worthy one. Establishing machine intelligence shall further raise the awareness of the relevance of intelligent machines to different areas of human endeavour. For instance, a United Nations study on how to measure the impact of ICT in education, UNESCO-UIS (2009), posits that the application of certain intelligent machines, usually in the form of Information and Communication Technologies (ICTs), to the field of education shall lead to profound development in that field. The study argues that the use of ICT in education shall increase access to learning opportunities, enhance the quality of education with advanced teaching methods, improve learning outcomes, and enable reform or better management of educational system. ICT is thus portrayed as a new philosophical approach, method or outlook for education.

Looking inward, some scholars (Azenabor, 1998; Olulobe *et al*, 2007; Odia and Omofonmwan, 2007) draw attention to myriads of problems confronting Nigerian educational system which necessitates the application of the results from the UNESCO-UIS study to resolve some of such problems. As an instance, Ololube *et al* in their paper "ICT and Distance Education in Nigeria: A Review of Literatures and Accounts" (2007) show how the problem of unequal educational opportunities could be resolved with ICT-driven distance education. Some scholars (Akudolu, 2000; Kwache, 2007; Okafor and Umoinyang, 2008) take the trouble to dissect individual levels of Nigerian educational system and explicate the imperative of ICT to their development. Some literatures (Iloanusi and Osuagwu, 2010; Ogunshola and Aboyade, 2005) express worries at the low level of application of ICT in Nigerian educational system. It is argued that out of the four major approaches for effective utilisation of ICT in education (emerging, applying, infusing and transforming), Nigeria is still at the emerging phase. The current study contributes to the discourse by adopting G.E. Azenabor's (1998) "reconstructionist" stance, which holds that the chief purpose of education is to continue to reconstruct the society in line with scientific knowledge at our disposal. This study intends to raise our consciousness in that direction with a view to boost the utilization of ICT at various levels of education in Nigeria.

CHAPTER ONE

INTELLIGENCE AND AI: DEFINITIONS, THEORIES AND PERSPECTIVES

1.1 Introduction

This chapter takes a critical look at the definitions, theories and perspectives advanced on the nature of intelligence. It also examines the conceptions, history and applications of Artificial Intelligence (AI). The chapter, therefore, provides the background on how the knowledge of intelligence is exploited to develop machines that perform intelligent functions for human benefit.

1.2 Definitions of Intelligence

The systematic search for comprehensive and scientific understanding of intelligence and its development has been a major pursuit of psychologists for over a century (Weinberg, 1989:98). Perhaps, due to the complex and elusive nature of the concept, the effort is yet to yield a universally accepted definition. A convenient technique used by researchers in this domain is the articulation of working definitions that can suit their purposes. However, P.A. Vroon (1980:1) points out that daily usage of the word rarely provides a clear definition of the term. In 1904, C.E. Spearman advances the definition that intelligence is the tendency of all human abilities to be positively correlated (quoted in Saggina et al, 2006:3). This definition amounts to claiming that if an individual is found to be good at one thing there is tendency for him to be good at other things. L. Gottfredson, in collaboration with fifty-two experts in the field, defines intelligence as “a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience” (Gottfredson, 1997:13). The notion that intelligence is a single unitary ability has been a source of heated debate among practitioners in the field. A. Anatasi, avers that “Intelligence is not a single, unitary ability, but rather a composite of several functions” (Anatasi, 1992:610). For him, intelligence denotes that combination of abilities required for survival and advancement within a particular culture.

A. Binet and T. Simon propose that intelligence is a fundamental faculty that is crucial to practical life. In their words, “This faculty is judgement, otherwise called good sense, practical sense, initiative, the faculty of adapting one’s self to circumstance” (quoted in Legg and Hutter, 2007:5). J. Person conceives intelligence as “a biological mechanism by which the effect of a complexity of stimuli are brought together and given a somewhat unified effect in behaviour" (quoted in Legg and Hutter, 2007:5).

D. Wechsler and D. Simonton also lay emphasis on the relation between intelligence and the ability to adjust to environment. Weschler defines intelligence as the "aggregate or global capacity of the individual to act purposefully, to think rationally and to deal effectively with the environment (Wechsler, 1975:135), whereas Simonton considers intelligence as "certain set of cognitive capacities that enable individuals to adapt and thrive in any given environment they find themselves in" (Simonton, 2003:n.p). Unlike Wechsler and Simonton, P. Kine gives primacy to learning. For him, "intelligence is popularly defined as the ability to learn, understand and deal with novel situations" (Kline, 1991:1). As for A. Antonov, "thinking" should be the right criterion for intelligence. Consequently, he avers that "Human intelligence is a scope of all types of human thinking. That is, we shall include into intellectual human activity not only rational thinking, but also emotional thinking, unconscious thinking, intuitive thinking, and automatic control of biological system" (Antonov, 2011:164).

Interestingly, D.W. Pyle argues that "The short answer to the question 'What is intelligence?' is that we are just not sure!" (Pyle, 1979:1). It must be realised, he says, that the word "intelligence" is a "situation-specific" word. That is, the word is used in various situations (rightly or wrongly) and, thus, takes on various meanings depending upon the particular situation (Pyle, 1).

To a large extent, the orientation or perspective adopted by a researcher or writer determines the notion of intelligence he or she adopts. Thus, the biologist would stress the ability to adapt to the demands of the environment; the educationalist the ability to learn; some psychologists emphasise the measurement of the ability to reason and other cognitive functions; others the development of these functions; and probably the layman would mumble something about commonsense' (Pyle, 3).

Oftentimes, researchers (for instance Spearman) tend to use the term "intelligence" as a noun, thereby creating the erroneous impression that it is a concrete entity. This approach usually makes us think that the word is referring to something tangible and concrete (a quantity of something in the brain, perhaps) (Pyle, 5). However, a more appropriate way of using the word, as far as Pyle is concerned, is to consider it as an adjective meant to qualify human behaviour. For him, "intelligence is rather a matter of ways of behaving and acting, and not something that a person has" (Pyle, 5).

Now, since intelligence is culture bound, variance in definitions is inevitable; any definition of intelligence must take into account the culture in which an individual is reared. Intelligence is inextricably interwoven with the beliefs, values, language, concepts and orientations of a particular group or race of people (Pyle, 6). This means that a particular definition of intelligence may be suitable for one cultural group and unsuitable for another. Sometimes too, the way in which a particular definition is applicable to one cultural group may be different from another. The *American Heritage Dictionary* (4th edition) for instance advances that intelligence is "The capacity to acquire and apply knowledge". Given that what constitute knowledge, to an Australian Aborigine, may not be so to the average American living in New York, a grade "A" American college student might not be deemed intelligent by the Aborigine, and vice versa.

Despite the difficulty surrounding the attempt to arrive at a universally acceptable definition of intelligence, researchers have continued the search to unravel its nature and essential characteristics.

1.3 Theories of Intelligence

Generally, theories of intelligence can be assigned to one of two camps, "lumpers" or "splitters". Lumpers, (for instance Spearman) define intelligence as a general unified capacity for acquiring knowledge, reasoning, and solving problems that is demonstrated in different ways (Weinberg, 98). The splitter, such as L. Thurstone, R.J. Sternberg, J.P. Guilford and H. Gardner hold that intelligence is composed of many separate mental abilities that operate more or less independently (Weinberg, 99).

1.3.1 Charles Spearman's "g" Factor Theory

At the beginning of 20th century, a British psychologist, Charles Spearman, put forward the theory that intelligence is one general mental capability underlying human performances on all intellectual tasks. His conclusion was based on the observation that individuals who scored highly in one test of mental ability tend to score high in other tests while those who scored low in a specific test equally performed poorly in other tests. This suggests that all tests of mental ability were positively correlated.

Spearman reasoned that if all mental tests were positively correlated, there must be a common variable or factor producing the positive correlations. Consequently, employing a psychometric method of factor analysis, Spearman proposed that two factors could account for individual differences in scores arising or derived from mental tests. He called the first factor "general intelligence" or the "general factor" represented as "g". According to Spearman, "g" underlies all intellectual tasks and mental abilities. The "g" factor represents what all the mental tests had in common (Detterman, 2008:n.p). Spearman considers "g" as "mental energy" and states that it was the "leading part of intelligence, as is displayed by the ability to handle not merely abstract ideas, but above all symbols" (Spearman, 1927:211).

The second factor Spearman identified was the "Specific factor" or "s". The specific factor relates to whatever unique abilities a particular test required; as a result it differs from test to test (Detterman, n.p). However, the attention of Spearman was more focused on general intelligence.

Since its proposal in 1904, the general factor of intelligence ("g") has generated considerable controversy (Kane & Brand, 2003:7). Indeed, the belief in general intelligence, going by R. Weinberg, has historically been the primary justification for using a single index of intelligence, the IQ (intelligence quotient), for a variety of assessment purposes (Weinberg, 99). H. Kane and C. Brand observe that, "central to any empirically based model of intelligence is the crucial position and function of Spearman's "g" factor. Spearman's "g" routinely accounts for more variance than all other cognitive factors combined, and therefore assumes a position of hierarchical prominence in any model depicting the structure of human cognitive abilities" (Kane & Brand, 21). Its popularity notwithstanding, critics of Spearman's "g" factor maintain that it does not provide the true picture of the nature of intelligence. Intelligence is manifested in different ways (Thurstone, 1938; Gardner, 1993). Moreover, a number of studies have failed to show the consistency of performances across tests.

1.3.2 Louis Thurstone's Multiple Factors Theory

In 1938, an American psychologist Louis Thurstone carried out an experiment which appears to disprove Spearman's "g" factor. The experiment highlighted seven independent factors as the foundation of intelligence rather than the much held general factor.

Thurstone calls his newly discovered factors "primary mental abilities". To identify these abilities, he and his wife, Thelma, devised a set of 56 tests. They administered the battery of tests to 240 college students and analysed the resulting test scores with new methods of factor analysis that Thurstone had devised. Thurstone identified seven primary mental abilities: (1) verbal comprehension, the ability to understand word meanings; (2) verbal fluency, or speed with verbal material, as in making rhymes; (3) numeracy or arithmetical ability; (4) memory, the ability to remember words, letters, numbers, and images; (5) perceptual speed, the ability to quickly distinguish visual details and perceive similarities and differences between objects; (6) inductive reasoning, or deriving general ideas and rules from specific information; and (7) Spatial visualization, the ability to mentally visualize and manipulate objects in three dimensions (Thurstone, quoted in Detterman, n.p). At least one of these primary mental abilities leads to variation in the results of intellectual tasks.

Although, Thurstone's hypothesis on multiple factors was initially vindicated by his intelligence test conducted on college students, anomalies reared up when the test was extended to an intellectually heterogeneous group and individuals in the general population. The new test produced a result that re-affirms Spearman's "g" factor theory. It was therefore observed that the restriction Thurstone placed on the range of subject selected for the test led to his failure to arrive at general intelligence in the first place. D. Detterman reiterates the problem with Thurstone's theory with the observation that even in college students, the tests that Thurstone used were still correlated. He argued that the method of factor analysis that Thurstone devised made the correlations harder to identify. As a matter of fact, when other researcher reanalyzed his data using different methods of factor analysis, more correlations became apparent. The researchers concluded that Thurstone's battery of tests identified the same "g" factor that Spearman had identified (Detterman, n.p).

Despite the shortcomings of Thurstone's Multiple Factor approach to intelligence, the theory turns out to be a catalyst to the development of theories on multiple intelligences. The likes of J.P. Guilford, R.J. Sternberg and H. Gardner were inheritors and developers of Thurstone's idea on intelligence.

1.3.3 Joy Guilford's Structure of Intellect Theory

Like his American counterpart, Thurstone, Joy Paul Guilford rejected Spearman's view that intelligence could be characterized by the single "g" factor. For him, Human intelligence is divergent in nature. In 1967, Guilford explicated his idea of intelligence in what he calls 'structure of intellect' theory.

Guilford describes the structure of intelligence as manifested in different abilities. These abilities are in three dimensions, namely, content, product, and operation. He develops tests for each possible combination of these dimensions, based on the belief that an individual could perhaps score high on some of these abilities and less on others.

Under "content", Guilford identified five different forms of information that an individual may process comfortably. These are (i) "visual" information which depends on the sense of sight, (ii) "auditory" information obtained through the sense of hearing, (iii) "symbolic" information derived from the power to interpret symbols, (iv) "semantic" information based on the power to interpret words or sentences, and (v) "behavioural" information obtained through the power to interpret the mental states and behaviour of observed individuals. Guilford believes that an individual may be good at processing symbolic information (for instance a poet) but may be poor at visual information where an artist usually excels.

An individual's intelligence can also be informed by the kind of "product" he is processing. Products include units, classes, relations, systems, transformations and implications. Thus, an individual may express creativity in perceiving visual units such as shapes or even behavioural units such as facial expressions, and so on.

While the two dimensions discussed above, can be used to sort out the different kinds of information we can think about, the "operation" dimension simply describes what the brain does with these information. The brain could use them to perform the following functions: cognition, memory, divergent production, convergent production, and evaluation. Thus, an individual may exhibit intelligence in the cognition of semantic units, cognition of behavioural transformation, and so on. Another individual may be good at retrieving information from memory.

H. Kane and C. Brand (2003) suggest that Guilford's theory of intelligence completely removes the possibility of Spearman's general factor of intelligence. The theory eventually gained wide acceptance, especially with educators and social environmentalists who consider the possibility of a biologically based general factor unpalatable (Kane and Brand, 2003:10). However, the theory has been criticized on the ground that it is unnecessarily complex and, hence, violates the rules of parsimony. There is also the problem of replicating Guilford's result upon re-analysis, thereby raising the question of the reliability of his instruments (Kane and Brand). R. Sternberg, another American psychologist, advanced a less cumbersome theory.

1.3.4 Robert Sternberg's "Triarchic Mind" Theory

Robert Sternberg propounded a three-sided theory of intelligence. According to him, intelligence is built on three cornerstones (Weinberg, 1989). The first is that intelligence cannot be understood outside of a socio-cultural context. What is "intelligence" in one environment may be irrelevant in another. Thus, the ability to adapt to ones environment is an important aspect of intelligence. The second is that intelligence is purposeful, goal-oriented relevant behaviour consisting of two general skills: the ability to deal with novel tasks and the ability to develop expertise, that is, the ability to learn from experience to perform mental tasks effortlessly or automatically. Thirdly, intelligence depends on acquiring information-processing skills and strategies.

It is against this backdrop that Sternberg posits three categories according to which intelligence can be classified. These are: analytical, creative and practical abilities. He contends that intelligence behaviour arises from a balance between them. Furthermore, these abilities function collectively to allow individuals to achieve success within particular socio-cultural contexts. Analytical abilities enable the individuals to evaluate, analyze, compare and contrast information. Creative abilities generate invention, discovery, and other creative endeavours. Practical abilities tie everything together by allowing individuals to apply what they have learned in the appropriate setting. To be successful in life the individual must make the best use of his or her analytical, creative and practical strengths, while at the same time compensating for weaknesses in any of these areas. This might involve working on improving weak areas to become better adapted to the needs of a particular environment, or choosing to work in an environment that values the individual's particular strengths. A person with highly developed analytical and practical abilities may find it difficult to work in a field that demands above-average ability in creative thinking. However, if the person chooses a career that requires creative abilities, the individual can use his or her analytical strength to come up with strategies for improving this weakness. Thus, a central feature of the Stanberg's theory of successful intelligence is adaptability both within the individual and within the individual's socio-cultural context (Sternberg, reviewed in Plucker, 2003).

We can commend Sternberg's effort on the ground that he is able to broaden the domain of intelligence to correspond more with what people frequently think intelligence is. However, critics believe that scientific studies do not support Sternberg's classification of intelligence. For example, some scholars propose that practical intelligence is not a distinct aspect of intelligence, but a set of abilities predicated by general intelligence (Detterman, 2008:n.p).

1.3.5. Howard Gardner's Theory of Multiple Intelligences

One of the most popular theories on the multiplicity of intelligence was put forward by the American cognitive psychologist, Howard Gardner. In his magnum opus *Frames of Mind* (1993), Gardner posits "Theory of Multiple Intelligences", which incorporates linguistic intelligence, musical intelligence, logical-mathematical intelligence, spatial intelligence, intrapersonal intelligence, interpersonal intelligence and naturalist intelligence. Gardner writes that "There are at least eight discrete intelligences, and these intelligences constitute the ways in which individuals take in information, retain and manipulate that information, and demonstrate their understandings (and misunderstandings) to themselves and others" (Gardner & Shirley, 1996:70). Thus, Gardner's theory does not reckon with the notion of the "g" factor as the underlying element behind information processing.

In formulating his theory, Gardner places less emphasis on explaining the results of mental tests than on accounting for the range of human abilities that exist across cultures. He drew on diverse sources of evidence to determine the number of intelligences in his theory. For example, he examined studies of brain-damaged people who had lost one ability, such as spatial thinking, but retained another, such as language. The fact that two abilities could operate independently of one another suggested the existence of separate intelligences. Gardner also proposes that evidence for multiple intelligences comes from prodigies and savants. Prodigies are individuals who show an exceptional talent in a specific area at a young age, but who are normal in other aspects. Savants are people who score low on IQ tests – and who may have only limited language or social skills- but demonstrate some remarkable ability, such as extra-ordinary memory or drawing ability. To Gardner, the presence of certain high-level abilities in the absence of other abilities also suggested the existence of multiple intelligences (Determan, 2008:n.p). Consequently, he avers that human beings are better thought of as possessing multiplicity of intelligences rather than a single general intelligence put forward by Spearman.

Gardner further makes it clear that his theory makes two strong fundamental claims:

> The first claim is that all human beings possess all of these intelligences: indeed, they can be considered a definition of 'homo-sapiens', cognitively speaking. The second claim is that, just as we look different and have different personalities and temperaments, we also exhibit different profiles of intelligences. No two individuals, not even identical twins or clones, have exactly the same amalgam of intelligences, foregrounding the same strengths and weaknesses. This is because, even in the case of identical genetic heritage, individuals undergo different experiences and also seek to distinguish their profiles from one another (Gardner, 1998/2004:4).

The mark of being human is the possession of these eight intelligences even though they are exhibited in profiles that vary from individual to individual. Logical-Mathematical Intelligence permits individuals to use and appreciate relations; Musical Intelligence makes it possible for individuals to create, communicate, and understand meanings generated from sound; Spatial Intelligence permits individuals to perceive and transform spatial information and recreate visual images from memory; Bodily-Kinesthetic Intelligence permits individuals to use all or parts of the body to create products or solve problems; Intrapersonal Intelligence helps individuals to distinguish among their own feelings, to build accurate mental models of themselves, and to draw on these models to make decisions; Interpersonal Intelligence enables individuals to recognize and make distinctions about others feelings and interventions; and Naturalist Intelligence which allows people to distinguish among, classify, and use features of the environment (Gardner, 1993; Veenema et al, 1997).

Although Gardner's theory was enthusiastically accepted by educators because it suggests a wider goal than adopted in traditional education (Determan, 2008), it has been severely criticised. It has been argued that Gardner interpreted intelligence in his theory to depict human ability; the eight forms of intelligence are mere expressions of individuals' ability. Gardner's theory lacks empirical support since its fundamental postulations are not backed by rigorous experimental findings. Besides, Gardner is yet to advance any test with which to measure each of the intelligences (Determan, 2008). This brings us to the issue of using intelligence test as an approach to proving and as well measuring intelligence.

1.4 The General Nature of Intelligence: Problems and Projections

Throughout our discourse on definitions and theories of intelligence, a fundamental perspective about the nature of the subject matter continues to recur. This is the notion that intelligence is a mental capacity employed by humans to deal effectively with the environment, solve problems, adapt to situations and learn (Antonov, 2011; Gottfredson, 1997; Guilford, 1967; Kline, 1991; Simonton, 2003; Spearman, 1927). As a mental act, intelligence is traditionally seen as an object belonging to or originating from the human brain (Pyle, 1979:5); or a product of the human mind (Searle, 1980:434). On this ground, the proof of intelligence, it is argued, lies in the possession of brain and mind (Searle, 1980).

While agreeing that intelligence is indeed a mental act, some scholars who proffered different theories on human intelligence also advanced cognitive tests of behavioural disposition as proof of intelligence (Guilford, 1967; Spearman, 1927; Thurstone, 1938). Consequently, there are two possible proofs of human intelligence: the ontological proof, which stipulates the possession of brain and mind, and epistemological proof anchored on the exhibition of appropriate behavioural disposition.

An examination of the proof of intelligence is an integral part of the discourse on intelligence. This study considers it imperative to also examine the sufficient condition for determining when another entity, such as a machine (the immediate object of our inquiry) can be appropriately described as intelligent.

1.4.1 The Ontological Perspectives on Intelligence: the Mind-Brain Factor

A typical ontological argument of intelligence possession runs thus:

P1 Intelligence is a mental act
P2 Mind and brain is the seat of mental act
Therefore, mind and brain possession is the hallmark of intelligence.

The thrust of the argument above is that an agent must of necessity possess brain and mind before it could be deemed intelligent. The various definitions and theories of intelligence considered in this chapter reveal that intelligence essentially plays the critical role of aiding humans to relate effectively with the environment, solve problems, adapt to varying situations, learn, etc. A closer examination of these roles shows that they actually presuppose certain mental phenomena such as believing, deliberating, feeling, knowing, deciding, choosing, etc. A presumed intelligent agent that wants to "solve a problem", for instance, is expected to (i) have an understanding of the problem in question, (ii) possess the ability to reflect about various possible solutions to the problem, (iii) possess the will to choose an appropriate solution and then execute. Eventually, when the problem is solved, the agent is described as intelligent. The processes outlined above are characterized by mental activities.

John Searle, an American philosopher, identifies certain features of mental phenomena that he considered critical to intelligence. These are consciousness, intentionality and subjectivity. Describing what consciousness is can be very challenging. Searle himself complained that "I believe it is, by the way, something of a scandal that contemporary discussions in philosophy and psychology have so little of interest to tell us about consciousness" (Searle, 1984, quoted in Stumpf, 1993:482). David Chalmers sounds even more perplexed about this phenomenon. In his words: "Consciousness can be startlingly intense. It is the most vivid of phenomena; nothing is more real to us. But it can be frustratingly diaphanous" (Chalmers, 1996: 3). However, for the present purpose, we take consciousness to be a mental act of awareness, thinking process or sensation. In this regard, an entity is expected to have sense of awareness, capable of thinking or have sensation in order to exhibit intelligence.

Intentionality is easier to explain than consciousness. It is, according to Searle, the feature by which our mental states are directed at, or about, or refer to, or are of objects and states of affairs in the world other than themselves. Intentionality does not merely refer to intentions, but also to beliefs, desires, hopes, fears, love, hate, lust, disgust, shame, pride, irritation, amusement, and all those mental states (whether conscious or unconscious) that refer to, or are about the world (Searle, 1984, quoted in Stumpf 1993:482). According to Searle, being intelligent is to be in a mental state that is directed at states of affairs in the world.

The subjectivity of mental states, sometimes referred to as "qualia", denotes the unique experience of each individual when in a mental state. According to Searle, this subjectivity is marked by such facts as that I can feel my pains, and you can't. I see the world from my point of view; you see it from your point of view. I am aware of myself and my internal mental states, as quite distinct from the selves and mental states of other people (Searle, 1984). It is presumed that an intelligent agent should have its own subjective experience and on its basis makes decisions.

All mental phenomena including intelligence are believed to be anchored on consciousness, intentionality and subjectivity. In philosophical discourse concerning the origin of thought, these three features are considered as properties of mind and brain. Similarly, intelligence is rooted in the possession of mind and brain, since they are characterized by features that make intelligence possible. Consequently, the possession of mind and brain is fundamental to the possession of intelligence. This view, however, raises some critical questions. Consider the following:

i. If mental acts that necessitate intelligence originate from the "mind" then what is the nature of the "mind"?
ii. If mental acts that indicate intelligence originate from the "brain", then how can the brain, a material substance, account for mental acts?

Depending on an individual's metaphysical orientation as either an idealist or materialist, all mental acts may be viewed as activities of the mind or as an epiphenomenon of the brain. However, arriving at correct answers to the questions above constitutes a source of serious debate in philosophy and other related areas. For epiphenomenalists, it is very challenging to explain how the human brain, a material substance, causes mental acts. It is equally difficult determining or pinning down the nature and workings of the human mind due to its subjective nature. William Morris argues that most of us would defend to the last ditch the existence and worth of our minds, but we easily become embarrassed if we are asked to say very much about the nature of that mind which we hotly defend (Morris, 1929: 153). He warns that "in raising the problem of the nature of mind, we are plunged into a problem of the greatest difficulty and of the deepest importance" (Morris, 153).

Theories formulated to explain the mind can be grouped into three classes, which are (i) mind as substance, (ii) mind as organic or personal unity and (iii) mind as an association of experience (Titus, 1959: 155).

Substance Theory of Mind

According to this theory, the mind is one of the underlying realities or qualities which man is made of. The mind is a non-material aspect of man, the other being the body. Plato and Rene Descartes are two foremost advocates of this theory. Plato considers the human mind or soul as an indivisible substance that pre-existed in a supersensible world of ideas but which unites with the human body to form the human person in the sensible world. At death, the soul shall survive the body due to its immaterial nature. The soul at this point has achieved purification. In *Phaedo* , Plato explains that purification is the "separation of the soul from the body... the habit of the soul gathering and collecting herself into herself from all sides out of the body; the dwelling in her own place alone, as in another life" (quoted in Stumpf, 904). The soul itself is the abode of reason, emotion and sensual feeling. Each of these corresponds with the rational, spirited and the appetitive parts of the soul as characterized by Plato.

Influenced by Plato's thought, Descartes also offered a substance theory of mind. Beginning with the "methodic doubt" he decided to cast everything aside and begin anew in the quest for an indubitable starting point or foundation of knowledge. The first indubitable reality he discovered was the self. Descartes reports his discovery in his famous saying "cogito ergo sum", ("I think; therefore I am"). From the "cogito", it follows that human personality or individuality is a basic fact. Descartes subsequently affirms the existence of God, who is the ultimate generator of our knowledge and of an external world of matter. Cartesian metaphysics posits two substances, mind and matter. The mind is immaterial; it is conscious, and its main characteristic is thinking. Since it is a substance, it cannot be destroyed except by God, who is the only self-existent substance. The fundamental characteristic of matter is extension. Man's body is a part of the world of matter and is subject to its mechanical laws (Titus, 156).

Mind as Organic or Personal Unity

This theory takes the mind as the immaterial element in man that organizes human experience. Immanuel Kant who rejected the substance theory of mind is associated with the organic theory. He argues that the organization of experiences in various ways is made possible by a principle or agent called the mind. He explains this in terms of "synthetic, unity of apperception" or "transcendental unity of apperception". There is an organic or personal unity which transcends or surpasses the separate experiences. This unity we call the self. The self, or the soul, is sometimes spoken of as the seat of the forms of knowing.

For Kant, the mind is active; it organises systematically all the materials presented by the various senses to yield knowledge of the phenomena. According to him, time and space and other categories are forms of the mind which transforms the manifold presentations of the senses into intelligible and knowable reality. Mind is not a separate mental substance; it is the organization and unity of man's personal experiences (Titus, 156).

Mind as an Association of Experience

David Hume, an eighteenth century British empiricist advanced the theory of mind as an association of experience. The mind and the faculties of the mental life are nothing but an association of ideas. Mind is a term for the sum total of experiences, or a collection of sensations (Titus, 157). A reflection on what lies within us does not point to any substance but rather to fleeting experiences or collection of sensations.

While the theories examined above may differ in their conception of "mind", they all characterised it as an immaterial element associated with humans. Having presented intelligence as a mental act, it could be seen as appropriate to trace its origin to the immaterial mind. However, materialists (or physicalists) insist that it is the by-product of brain activity. Such philosophers argue that all mental phenomena or activities of the mind actually originate from the brain. Intelligence is thus a product of the brain and not the mind, in the final analysis.

Epiphenomenalism is an exemplar of the materialist theory of mind. According to this view, consciousness, mind, all mental acts whatever, are secondary phenomena accompanying some bodily processes. Mental processes causally influence neither the physical processes nor even other mental phenomena. Matter is primary, the one real substance. The stream of consciousness is a phenomenon accompanying certain neurological changes. Thus the mind is an effect, an important effect for that matter, which appears under some conditions. Certain processes taking place in the brain and nervous system produce the sensations, feelings, emotion, imagery, thought, or other types of consciousness that we experience (Titus: 163). In his "Minds, Brains and Science", John Searle emphatically states that "… all mental phenomena whether conscious or unconscious, visual or auditory, pains, tickles, itches, thoughts, indeed, all of our mental life, are caused by processes going on in the brain" (quoted in Stumpf, 483). Indeed, Searle's claim and that of other materialists on this issue tend to rely on advancement in brain research. For example, scientists have studied people who have suffered damage to various portions of the brain and have found that different kinds of brain damage produce regular and specific breakdown in a person's cognitive and psychological functioning. Also, detailed studies of normal brains with our sophisticated medical instruments shows that when a person is performing certain task (imagining a scene, speaking, calculating a sum), characteristic changes take place in the brain (Lawhead, 2003: 218).

Consequently, from the physicalist or materialist point of view, to know that an entity is intelligent, all that is needed is detailed study of the brain of the entity. The human brain, unlike the mind, is amenable to objective investigation. Some objections, however, weakens this seemingly attractive position of physicalism.

The biologist, J.B. Haldane, criticises the materialist interpretation of mind thus:

> It seems to me immensely unlikely that mind is a mere by-product of matter. For if my mental processes are determined wholly by the motion of atoms in my brain, I have no reason to suppose that my beliefs are true… and hence I have no reason for supposing my brain to be composed of atoms (Quoted in Lawhead, 229).

If Haldane's argument is sound, then it would be impossible to hold any form of belief whatsoever if we take the materialist's position to its logical conclusion. A popular criticism against the materialist is the argument that brain states are not identical with mental states. Paul Churchland argues that:

> Brain states and processes must of course have some specific spatial location: in the brain as a whole, or in some part of it. And if mental states are identical with brain states, then they must have the very same spatial location. But it is literally meaningless… to say that my feeling-of-pain is located in my ventral thalamus, or that my belief - that - the sun - is - a - star is located in the temporal lobe of my left cerebral hemisphere. Such claims are as meaningless as the claim that the number 5 is green, or that love weighs twenty grams (Churchland, 1984:29).

Chen Gang (2005) supports Churchland's argument by making a distinction between physical state or event and mental state or event. A physical event is what we observe from an external point of view. It is public to all of us. A mental event is what we actually perceive from an internal point of view. Thus, if we subject an individual who is in pain to a test of brain observation, we can never have direct access to his feeling about this pain or the pain itself. Chen argues that we cannot have direct reliable means into the individual's pain. The best we can get is an indirect unreliable means, i.e., by observing the patterns of neural firings and blood circulation in certain district of the brain, and the mapping between mental events and neural events accumulated in the past. The mapping is not reliable since there is some kind of plasticity in the human brain. Brain surgery has proved that, after the removal of one hemisphere, some of its functions can be recovered in the other hemisphere. This is so-called "multiple-realization" phenomenon. Therefore, there is no general psycho-physical law to support this kind of mapping (Chen, 3). The argument is further strengthened with the explanation that even when brain process is observed, it is still not mental event that is being observed but rather another form of physical event. A contemporary philosopher of mind, David Chalmers, comments about the futility in studying consciousness through brain process thus: “We have good reason to believe that consciousness arises from physical systems such as brains, but we have little idea how it arises, or why it exists at all. How could a physical system such as a brain also be an experiencer?” (1996: xi).

It is apparent that neither the idealist nor the materialist has solved the problem of the nature and origin of mental acts. Consequently, it still remains debateable to claim either that intelligence as a mental phenomenon originates from the mind or that it originates from the brain. We are yet to have the final answer on the nature of the mind, the supposedly ontological origin of intelligence; or offer plausible explanation of how intelligence, a mental phenomenon, or any mental phenomenon for that matter can be ascribed to brain process.

Two notable twentieth-century philosophers, the American, John Dewey and the British, Gilbert Ryle offer the reason why the search for the proof of intelligence and other mental phenomena should shift from ontological direction to epistemological direction. Their stance revolves around the notion that the evidence of mental phenomena is cognitive and lies in overt behavioural dispositions. By implication, the evidence for intelligence technically lies in the test of appropriate behavioural disposition.

1.4.2 The Epistemological Perspective on Intelligence: the Behavioural Factor

Rather than viewing the mind as a mental or physical entity, John Dewey employed it as an instrument for describing human behaviour. In his *The Quest for Certainty* (1929), Dewey avers that “there is no separate ‘mind’ gifted in and of itself with a faculty of thought; such a conception of thought ends in postulating a mystery of a power outside of nature and yet able to intervene within it” (277). What we call the mind is simply a description of how man reacts to his ever changing environment. In fact, mind and thought are functional aspects of the interaction of natural events. Mind is simply intelligent behaviour (Titus: 158).

Gilbert Ryle argues that the mind is the manner or the way in which a person behaves; hence there is no ‘ghost in the machine’ propelling human actions. According to Titus, Ryle is simply anxious to get rid of what he calls the traditional “dogma of the ghost in the machine”, and to rectify the “category mistake” or “philosopher’s myth”. This mistake and myth are found when men put the facts of mental life in a category or class to which these facts do not properly belong. Ryle uses an example of a foreign visitor on a university campus. The visitor, after being shown the college halls, library, dormitories, playing fields, administration offices, and the activities associated with them, asks to see the university. The university, he is told, is just the buildings and activities he has seen. To talk about the university as some counterpart to what he has seen is a mistake. In the same way, to talk about "mind" or "consciousness" as some counterpart to human behaviour or as some world behind or beyond the activities is a mistake. The meaningful referent of the concept "mind" is explained by describing how persons behave (158-159).

As already indicated in our discussion of theories of intelligence, some philosophers and psychologists believe that in matters of intelligence, the issue of mind or consciousness should not arise; instead, emphasis should be placed on intelligence tests. To the question "How do we know that a person is intelligent?" William Lawhead responds with a rhetorical question: "Don't we know by the way the person behaves and responds to situations and, in particular, by how well he or she does in intelligence tests? (Lawhead, 230). William Lycan's response is that "Surely we tell, and decisively, on the basis of our standard behavioural tests for mental states … we know that human being has such-and-such mental states when it behaves, to speak very generally, in the ways we take to be appropriate to organisms that are in those states." (Lycan, 1987: 125).

Lycan draws our attention to the fact that the proof of the mental states lies in epistemological investigation rather than metaphysical one. Edgar Brighman (1951) throws more light on this point with the argument that if we do not study mental states with the appropriate method we may not actually arrive at the truth about consciousness. A metaphysical or ontological study of mental acts can best be achieved through the act of introspection, that is, the act of turning attention to one's own consciousness. Brighman quickly points out the methodological problem of this approach and the wisdom in employing the method of observation. According to him:

> The method of introspection suffers from the defect of giving information about the consciousness of one person only, namely, the introspector himself. It would seem that data derived from such a restricted field are too fragile a basis on which to rear a psychology and philosophy of consciousness. Hence, psychology has always had recourse to the method of the objective observation of behaviour. We observe that our own consciousness is followed or preceded by certain kinds of behaviour, and we believe that similar behaviour on the part of others is accompanied by similar consciousness. If, then, we are to know anything about the consciousness of others, we must observe

> their behaviour - watch their reactions to stimuli, listen to their words, note their gestures and facial expressions (Brighman, 1995:186).

The method of using behaviour as index of mental state is popularly referred to as behaviourism. P. Churchland who sometimes refers to it as "philosophical behaviourism" summarises it as the claim that talk about emotions and sensations and beliefs and desires is not talk about ghostly inner episodes, but is rather a shorthand way of talking about actual and potential patterns of 'behaviour'(Churchland, 1984:23). Similarly, intelligence as a subset of mental state is a pattern of behaviour. But what is behaviour and what is intelligent behaviour?

By behaviour, we mean those activities of an organism that can be observed by another person or by an experimenter's instruments (Hilgard, 1962: 6). These activities are of diverse forms. They could be in form of the organism's speech acts or body movements like moaning, laughing, crying, facial reactions, muscular vibration, and etcetera. They could also be in form of sudden perceived changes in skin tone (like turning pale), body temperature, blood pressure, and sweat secretion. The importance of behavioural dispositions is that they are plausible means of inferring the unobservable mental events. In the words of G. Graham: "Pain is moaning. Happiness is smiling. If we could subtract behaviour from mind we would have nothing left over" (Graham, 1993: 39-40). Indeed, the importance of the role of behaviour in the study of mental states cannot be overemphasised in the field of psychology. As early as 1913 when modern psychology was barely few years old, an American psychologist named John Watson attacked the definition of psychology as "the study of the mind". The content of another person's mind, he noted, cannot be directly observed. Science, Watson asserted, studies public, out-in-the-open objects and events that anyone can observe and record. A true science cannot be based on what might be a figment of an introspector's imagination. Therefore, said Watson, to be truly scientific we should focus on behaviour, which we can observe instead of thoughts and thought process, which we can only guess at (Geiwitz, 1980:6).

From the foregoing, intelligent behaviour is viewed as the behavioural instantiation of whatever we define or theorise as intelligence. For instance, intelligent behaviour, for Thurstone, shall be equated with the exhibition of those activities associated with his identified seven primary mental abilities. While Sternberg will see it as the instantiation of analytical, creative and practical abilities, Gardner will equate it with the observation of activities exemplifying his “eight multiple abilities”. This means that there is a causal relation between intelligence and behaviour. The latter is presumed to be informed by the former. Psychologists anchor this position on what they call Stimulus-response theory (S-R theory). This is the assertion that all behaviour is in response to stimuli (Hilgard, 17). It is in an attempt to confirm or disconfirm this causal relation that psychologists introduced intelligence tests.

Behaviourism encouraged intelligence tests as means of measuring human intelligence. Such tests are usually administered by a qualified psychologist, according to professional and ethical principles. Interpretation is based on a comparison of the individual’s responses with those previously obtained to establish appropriate standards for the test scores (Schnitzer, 2008: para. 1). At this point we can argue that between the ontological and epistemological approaches for proving intelligence, the latter approach is more plausible and less controversial. Its strength lies in its simplicity. We need not dissect an individual’s brain or try vainly to search for his mind to determine if he were intelligent. His behavioural disposition, sometimes prompted by appropriate cleverly devised tests, is a plausible means. The role of consciousness, mind or brain is not necessarily undermined here. The argument is that the various controversies ascribed to these concepts weigh heavily against their role in proving intelligence.

In term of behavioural disposition of intelligence, the sub-field of Computer Science called Artificial Intelligence research (AI) offers abundant evidence of artefacts that perform functions that are qualitatively comparable to that of humans. We presently examine this field in order to fully capture the nature of intelligence exhibited by machines.

1.5 The Meaning of Artificial Intelligence (AI)

We begin by defining the two terms, “artificial and “intelligence” first before combining them together to form “artificial intelligence”, which would be defined subsequently. From the preceding chapter, it is obvious that the term “intelligence” is a slippery concept, which makes it difficult to arrive at a universally accepted definition. Similarly, the word “artificial” is not always easy to characterise. For instance, “artificial” may be contrasted with “genuine” or with “natural”.

Since AI is a specialised field of research its definition can be looked at from the practical engagement in the discipline. On this ground, definitions of AI could be grouped along the 2 x 2 matrix boxed below.

	Human-centred Approach	**Ideal rationality-centred approach**
ht-centred ach	Building systems that think like humans	Building systems that think rationally
our-centred ach	Building systems that act like humans	Building systems that act rationally

From the box (adapted from Russell and Norvig, 2003:2), definitions of AI can be classified into thought-centred approach, behavioural-centred approach, human-centred approach, and ideal rationality-centred approach. The four boxes represent the classification of different roles that AI researchers could design machines to perform, and each role determines the approach employed. In designing machines to perform the role of acting like humans, researchers in AI employ both the human-centred and behaviour-centred approaches. Alan Turing (1912-1954), the British mathematician laid down the foundation for this tradition. Turing believes that behaviour is the signpost of exhibition of intelligence by humans. Consequently, if any non-human agent (a machine for instance) should exhibit human-like behaviour, then there is sufficient reason to conclude that the agent is intelligent. Some notable definitions of AI that is grounded on this approach include the following.

(i) AI is the art of creating machines that perform functions that require intelligence when performed by people

(ii) AI is the study of how to make computers do things at which, at the moment, people are better (quoted in Russell and Norvig, 2).

Rather than following the Turing's tradition, some researchers believe that the focus of AI should be on studying how humans think and then appropriately design machines to instantiate the method of human thinking. Researchers in cognitive science championed this approach and they proffer AI definitions that combine both the thought-centred and human-centred approaches. The interest is therefore to build systems or machines that think like humans. Consider the following definitions.

(i) AI is the exciting new effort to make computers think… machines with minds, in the full and literal sense.

(ii) AI is the automation of activities that we associate with human thinking, activities such as decision-making, problem solving, learning (quoted in Russell and Norvig, 2).

The set of definitions commonly advanced under this approach raises a fundamental problem in AI: can appropriately programmed machine be shown to possess mind, understand, believe, and have other cognitive states in the full and literal sense? This question creates a tension between the "strong AI thesis" and the "weak AI thesis". The "strong AI thesis" holds that appropriately programmed machines possess mind in the literal sense while the "weak AI thesis" merely acknowledges that computers only simulate mental activities (Lawhead: 2003:240). John Searle's popular Chinese room thought experiment is primarily directed at refuting the strong AI thesis.

Since humans sometimes exhibit attributes that contravene the principle of logical thinking, some AI researchers believe that AI should focus on ideal thinking rather than human thinking. AI researchers that employ this approach take their cue from logicians like Aristotle who, in the ancient period, codified an ideal way of thinking through his syllogisms. Consider the following definitions of AI that exemplify this approach.

(i) The study of mental faculties through the use of computational models

(ii) The study of the computations that make it possible to perceive, reason, and act (quoted in Russell and Norvig, 2).

Beyond merely designing machines to think logically, some AI researchers also worked towards building machines that act ideally. At this point, both the behavioural centred approach and ideal rationality centred approach met. Some definitions of AI advanced along this approach employ the term computational intelligence (CI) in place of AI.

(i) Computational Intelligence is the study of the design of intelligent agents

(ii) AI… is concerned with intelligent behaviour in artefacts (quoted in Russell and Norvig, 2).

The Association for the Advancement of Artificial Intelligence (AAA) attempt to incorporate both thought and behavioural elements in what it considers to be the official definition of AI.

Accordingly, AI is the "scientific understanding of the mechanisms underlying thought and intelligent behaviour and their embodiment in machines" (http://www.aaai.org/home.html).

1.6 AI in Historical Perspectives

The history of AI could be documented in terms of the historical development of the ideas and artefacts that culminated into what is considered as intelligent machines. Going by B. Buchanan's (2005) account, this history dates from ancient times. As far back as 8th century, Homer, the classical Greek poet wrote of mechanical "tripods" waiting on the gods at dinner. There are also Greek myths depicting how blacksmiths and bronze men built mechanical servants and robots.

It was the ancient Greek genius, Aristotle, who in the 5th century B.C finally set the stage for the development of philosophical ideas on which the foundation of AI is laid. Aristotle invented syllogistic logic, which is the first formal deductive reasoning system in Western philosophy. What is known today as computational theory of mind is actually the product of Aristotle's formal theory of reasoning process. By the middle of 17th century, Blaise Pascal and Gottfried Wilhelm Leibniz designed mechanical reasoning devices using rules of logic to settle disputes. Pascal invented the first calculating machine to aid his father's tax collecting duties. Leibniz constructed a more sophisticated machine capable of adding, subtracting, multiplying and even finding the square root of numbers using gears and pulleys.

By the first quarter of the 19th century, Charles Babbage and Ada Lovelace were already toying with the idea of programmable mechanical calculating machine. Babbage actually came up with the idea of Analytic Engine though was never built. While still struggling with his idea about machine, elsewhere, the likes of George Boole, Gottlob Frege and Bertrand Russell were turning up logical systems and ideas meant to capture the structure of reasoning and thinking. Their contributions also provided the logical foundations of modern day digital technologies. Alan Turing provided the theoretical foundation for designing and building the first modern computers in the form of massive code breaking machines of the Second World War, ENIAC and Colossus. It was with these machines that Turing aided the breaking of German war codes that eventually contributed to the defeat of the Germans. Turing's contributions to the development of AI also include the idea of an intelligence test to determine if machines can exhibit intelligent behaviours.

The Turing test (TT), as it is popularly called, bolstered the idea of a thinking or intelligent machine.

During the summer of 1956 at Dartmouth College in Hanover, New Hampshire, a conference took place that finally birthed AI research. At this conference, the term AI was coined by John McCarthy, one of the organizers of the conference. The primary objective of the conference was to deliberate on the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. One of the high points of the conference was the debut of Allen Newell's, Herbert Simon's and J.C. Shaw's "Logic Theorist", the first AI programme. It proved theorems using a combination of searching, goal-oriented behaviour, and application of rules.

The Dartmouth conference ushered in more vigorous and rigorous research in this new field. As at today, research efforts have generated AI programmes that have defeated human world champions in some intelligence-driven games like Chess. There are programmes that can expertly diagnose human ailments and suggest appropriate treatments. Robots with remarkable level of autonomous intelligent behaviours are available nowadays. Stanley, the car robot that won the 2005 Defence Advanced Research Projects Agency, DARPA, Grand Challenge is an interesting example in this regard. The robot was developed for high-speed desert driving without manual intervention. With the emergence of the Internet through the unrelenting efforts of AI researchers, computers can now instantiate one of humans' unique characteristics; social interaction. Computers can now relate and influence one another.

The fundamental question, at this point is, what paradigm(s) is responsible for the success recorded in AI research? This takes us to the study of the various paradigms employed in AI research to actualize the idea of machine intelligence.

1.7 An Overview of AI Paradigms

The biological grey matter (brain) located in the skull of humans is considered by most people as the ontological root of their emotion, intelligence and consciousness. Since machines are not equipped with such substance how are they able to instantiate intelligence in their functions? One way to answer this question is to showcase the various paradigms employed by AI researchers to actualize intelligence in machines. Alan Turing once mentioned that, when appropriately programmed, machine shall exhibit intelligent behaviour. With AI paradigms such as Artificial Neural Networks, Evolutionary Computation, Swarm Intelligence, Fuzzy Logic and Artificial Immune System, we have some insight into how machine can be “appropriately” programmed to exhibit intelligence.

1.7.1 Artificial Neural Networks

Some machines have been designed to exhibit intelligence in the areas of pattern recognition, handwritten character recognition, speech recognition, financial and economic modelling, and so on. These feats are achieved through Artificial Neural Network technique. In AI, Neural Network is regarded as highly interconnected network of information-processing elements that mimics the connectivity and functioning of the human brain (Bernander, 2008: para.1). Thus, Neural Network is a programme designed to simulate the human brain and its neurons.

To differentiate Neural Networks as a programme from the neural activities experienced in the human brain, we categorized it as Artificial Neural Networks distinct from Biological Neural Networks. The former is modelled on the structure and functioning of the latter. As one of the seats of neural activities, the human brain is composed of approximately 160 billion nerve cells called neurons that are massively interconnected. Typical neurons in the human brain are connected to other neurons on the order of 10,000, with some types of neurons having more than 200,000 connections. The extensive number of neurons and their high degree of interconnectedness are part of the reason that the brains of living creatures are capable of making vast number of calculations in a short amount of time.

Biological neurons have a fairly simple large-scale structure, although their operation and small scale-structure is immensely complex. Neurons have three main parts: a central cell body called the soma, and two different types of branched, treelike structures that extend from the soma, called dendrites and axons. Information from other neurons, in the form of electrical impulses, enters the dendrites at connection points called synapses. The information flows from dendrites to the soma, where it is processed. The output signal, a train of impulses, is then sent down the axon to the synapses of other neurons (Bernander, 2008:para.5).

The biological process above is what is simulated in Artificial Neural Networks. The main body of an artificial neuron is called a node or a unit. Each artificial neuron receives signal from the environment, or other artificial neurons. Input signals are inhibited or excited through negative and positive numerical weights associated with each connection to the artificial neuron. The firing of an artificial neuron and the strength of the exciting signal are controlled via a function, referred to as the activation function. The artificial neuron collects all incoming signals, and computes a net input signal as a function of the respective weights. The net input signal serves as input to the activation function which calculates the output signal of the artificial neuron (Engelbrecht, 2007:6). The diagram below depicts the relationship between animal neural network and artificial neural network.

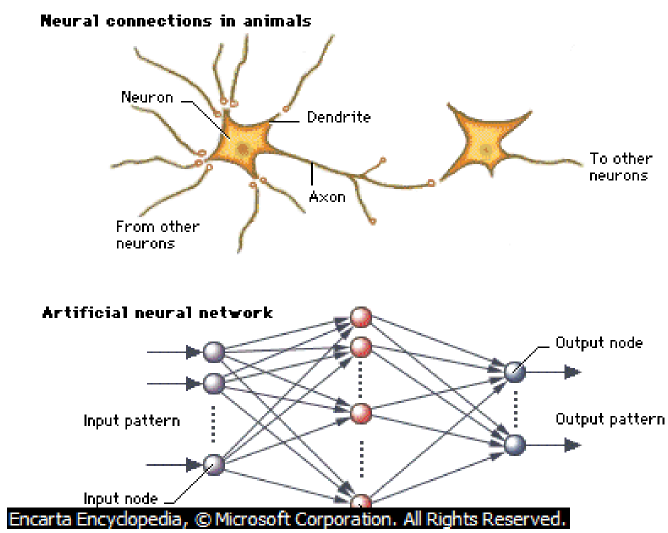

Fig.1 Neural Networks

With neural networks, machines can be designed to imitate the biological brain process of predicting events, most especially when the networks have a large database of proper examples to draw on. Since neural networks mimic the brain, they have shown much promise in so-called sensory processing tasks such as speech recognition, pattern recognition, and transcription of hand-written text. In some settings, neural networks can perform as well as humans. Neural-network-based backgammon software, for example, rivals the best human players. Furthermore, because neural networks have the ability to learn from a set of examples and generalize this knowledge to new situations, they are excellent for work requiring adaptive control systems. For this reason, the

United States National Aeronautics and Space Administration (NASA) has extensively studied neural networks to determine whether they might serve to control future robots sent to explore planetary bodies in our solar system. With this application, robot could be sent to other planets, such as Mars, to carry out significant and detailed exploration autonomously (Bernander, 2008: para.17).

1.7.2 Evolutionary Computation

In the preceding sub-section, we examined how neural activities in the human brain provide us a crucial clue on how to design intelligent machines by artificially mimicking this process. At present, we want to demonstrate how the knowledge of evolution of living organisms offers us two clues about how to build intelligent artefacts or machines. First, and most ambitiously, the processes of evolution itself –namely, random generation and selection – might be simulated on computers to produce the machines of the future. Second, those paths that evolution followed in producing increasingly intelligent artefacts (Nilson, 2010:43). Indeed, these strategies have been well utilized by AI researchers in building intelligent agents and are referred to as evolutionary computation or evolutionary algorithms.

Evolutionary computation or algorithms are adaptive methods, which may be used to solve search and optimization problems, based on the genetic processes of biological organisms. Over many generations, natural populations evolve according to the principles of natural selection and "survival of the fittest", first clearly stated by Charles Darwin in his work *The Origin of Species* (1859). By mimicking this process, evolutionary algorithms are able to 'evolve' solutions to real-world problems, provided they have been suitably encoded (Ajith, 2005:897).

Evolutionary computation deals with parameters of finite length, which are coded using a finite number of alphabets, rather than directly manipulating the parameters themselves. This means that the search is unconstrained either by the continuity of the function under investigation nor by the existence of a derivative function. It is assumed that a potential solution to a problem may be represented as a set of parameters. These parameters (known as genes) are joined together to form a string of values (known as a chromosome). A gene (also referred to as a feature, character, or detector) refers to a specific attribute that is encoded in the chromosome. The particular values that the genes can take are called its alleles (Ajith, 897).

For each generation, individuals compete to reproduce offspring. Those individuals with the best survival capabilities have the best chance to produce. Offspring are generated by combining parts of the parents, a process referred to as “crossover”. Each individual in the population can also undergo mutation which alters some of the alleles of the chromosome. The survival strength of an individual is measured using fitness function which reflects the objectives and constraints of the problems to be solved. After each generation, individuals may undergo “culling”, or individuals may survive to the next generation (referred to as “elitism”). Additionally, behavioural characteristics (as encapsulated in phenotypes) can be used to influence the evolutionary process in two ways: phenotypes may influence genetic changes, and / or behavioural characteristics evolve separately (Engelbrecht, 8). It is argued that evolutionary computation has been used successfully in real-world applications, for example, data mining, combinational optimization, fault diagnosis, classification, clustering, scheduling, and time series approximation (Engelbrecht, 9).

1.7.3 Swarm Intelligence

Swarm intelligence is another AI paradigm that has its ontological root in the behaviours of biological agents. The concept originated from the study of colonies, or swarms of social organisms. Studies of the social behaviour of organisms in swarms prompted the design of very efficient optimization and clustering algorithms. For example, simulation studies of the graceful, but unpredictable, choreography of bird flocks led to the design of the particle swarm optimization algorithm, and studies of the foraging behaviour of ants resulted in ant colony optimization algorithm (Englebrecht, 9). The actualization of particle swarm optimization in machines, for instance, resulted in machine intelligent behaviours.

Studies of ant colonies have contributed immensely to the set of intelligent algorithms. The modelling of pheromone depositing by ants in their search for the shortest paths to food sources resulted in the development of shortest path optimization algorithms. Other applications of ant colony optimization include routing optimization in telecommunications networks, graph colouring, scheduling and solving the quadratic assignment problem. Studies of the nest building of ants and bees resulted in the development of clustering and structural optimization algorithms (Engelbreacht, 9). The field of engineering easily testifies to the critical relevance of the application of swarm intelligence in solving engineering optimization problems.

1.7.4. Fuzzy Logic

Attempt by AI researchers to build machines capable of reasoning either like humans do or as ideally expected prompted the research into fuzzy logic. This AI paradigm is meant to expand the reasoning process of intelligent machines beyond the traditional binary-valued logic that is erected on the either “Yes” or “No” mode of inference. Research, however, makes it obvious that human reasoning is usually not exact as the “Yes” or “No” mode of inference depicts. Human reasoning is subject to some measure of uncertainties. Consequently, Fuzzy logic (or systems or sets) is introduced to take machine reasoning process closer to what is applicable to human reasoning process.

Fuzzy logic allows what is referred to as “approximate reasoning”. With fuzzy sets, an element belongs to a set to a degree of certainty. Fuzzy logic allows reasoning with this uncertain fact. In a sense, fuzzy sets and logic allow the modelling of common sense (Engelbrecht, 10). Hence, fuzzy logic provides means of designing machines to reason in a probabilistic manner. The paradigm is applied in the area of system control, gear transmission and braking systems in vehicles, controlling lifts, home appliances, controlling traffic signals, and many others (Engelbrecht, 10).

1.7.5 Artificial Immune Systems

Some computer programmes have been so designed today to detect anomalies in specific condition. Such programmes, for instance, exhibit intelligence in the area of detecting fraud in financial transactions or any other domain of human endeavour. The paradigm of AI employed in achieving such feat is called Artificial Immune System tailored after biological entities’ natural immune system.

The natural immune system has an amazing pattern matching ability, used to distinguish between foreign cells entering the body (referred to as antigens) and the cells belonging to the body. As the natural immune system encounters antigen, the adaptive nature of the immune system is exhibited, and then memorizing the structure of these antigen for faster future response to the antigen (Englebrecht, 10). It is this natural process that artificial immune system is modelled after. It is applied to solve pattern recognition problems, perform classification tasks, and to cluster data. The ability of computers to detect virus is also associated with this paradigm.

1.7.6 Hybrid Techniques

The quest for actualizing machine intelligence is further pursued by combining the potentials of some of the paradigms discussed above. For instance, several adaptive hybrid intelligent systems have, in recent years, been developed to model expertise, image and video segmentation techniques, process control, mechatronics; robotics, complicated automation tasks and so on (Ajith, 2005:898). The essence of combining paradigms is to overcome the limitations of individual paradigm. This method is identified as Hybrid Techniques or Hybrid Intelligent Systems.

Most of the current Hybrid Intelligent Systems are combination of three essential paradigms: artificial neural networks, fuzzy inference systems and evolutionary algorithms. Fusing these techniques always result into more advanced intelligent agents. The importance of this hybrid technique and the other individual ones that were earlier treated can better be appreciated if we discuss in details the different areas of human endeavours where machine intelligence has been applied.

1.8 Basic Areas of Application of AI

AI techniques discussed above are not devised for only research purpose; they have already been applied to tackle real life situations. They are used by financial institutions, scientists, psychologists, medical practitioners, design engineers, planning authorities, and security services, to name just a few (Encarta, 2008:para.5). The emergence of the Internet is also traceable to AI research. Different areas of application of AI can broadly be classified into expert system, game playing, machine learning, natural language processing, automatic theorem proving, problem solving, and robotics.

1.8.1 Expert Systems

The emergence of expert systems dates back to the 1960s. It is a type of computer application programme that makes decisions or solves problems in a particular field, such as finance or medicine, by using knowledge and analytical rules defined by experts in the field. Human experts solve problems by using a combination of factual knowledge and reasoning ability. In an expert system, these two essential attributes are connected in two separate but related components, a knowledge base and an inference engine. The knowledge base provides specific facts and rules about the subject, and the inference engine provides reasoning ability that enables the expert system to form conclusions. Expert systems also provide additional tools in the form of user interfaces and explanation facilities. User interfaces, as with any application, enable people to form queries, provide information, and otherwise interact with the system. Explanation facilities enable the systems to explain and justify their conclusions (Encarta, 2008b: para.1). Areas of application of expert systems include economics, medicine, chemistry, law and so on.

One area where expert systems have been well utilized is medicine. In 1974, a popular expert system was designed. MYCIN, as it is called, has the capability of diagnosing bacterial infections of the blood and suggesting appropriate treatments. "GIDEON", the Global Infectious Disease and Epidemiology Network, is also another remarkable expert system used in medicine. This expert system is capable of assisting physicians to diagnose as much as three hundred and thirty-seven recognized diseases in many countries of the world.

1.8.2 Game Playing

Game playing is a popular application area for AI because it is suitable for evaluating some of the central techniques of the enterprise. Such techniques include search and use of "heuristics". Search involves the use of "brute force" to carry out exhaustive search of possible moves in a game. Heuristics are rules that are set to narrow down possible searches that could be carried out by computers. In game playing, the general protocol is to examine an expert's decisions during a game so as to discover a consistent set of parameters or questions that are evaluated during his or her decision-making process. These conditions could then be formulated in an algorithm that is capable of generating behaviour that is similar to that of the expert when faced with identical situations. If a sufficient quantity or "coverage" of heuristics could be programmed into the computer, the sheer speed and incredible computational ability of the computer would enable it to match or even exceed the ability of the human expert (Fogel, 2006:6). It was therefore not surprising that in 1997 an IBM-designed AI game programme, Deep Blue, defeated the then reigning world human chess champion, Garry Kasparov, in a widely followed chess match.

1.8.3 Machine Learning

Taking appropriate decision based on acquired experience is one of the indicators of human intelligence. In an attempt to further showcase machine intelligence, efforts have been invested into designing machines to learn from experience and make appropriate decisions. This aspect of AI is called machine learning. Thus, machine learning is the study of methods used in programming machines to learn from experience.

Machines are purposefully designed to learn for various reasons. For instance, machine learning is useful where computer is expected to take customized decisions for different users on the basis of its (computer) experience of each user's peculiar activities on the system. In essence, after arriving at a generalization about a user's activities, the computer can automatically deduce the user's needs and react appropriately when it is prompted by the user. Machine learning is also useful in the area of finance. It could help in predicting financial behaviours based on what it has learnt.

From the foregoing, one can say that machine learning provides the power of transcendence for machine. This is the ability to project from the given to the non-given. It suggests the possibility that machine can mimic consciousness, think, and make appropriate decisions accordingly.

1.8.4 Natural Language Processing

Programming computers to understand natural human languages is a common method employed by AI researchers to justify machine intelligence. Indeed, the ability to use language for communication is a unique factor that separate humans from other animals. Humans have to master the complexity of spoken language in order to use it effectively. Programming computers to achieve this feat is a great challenge. Nevertheless, AI research is recording some achievements in this task. IBM has already successfully designed computer programmes like "MASTOR" that can translate free-form English speech in another language's speech.

Natural language processing is usually carried out in the areas of text understanding and text generation, speech understanding and generation, machine translation of natural languages to others, and natural language interfaces for databases. Natural language processing best captures the dream of Alan Turing about intelligent machines. The Turing Test is meant to showcase how machines can effectively carry out linguistic communication in a way comparable to how humans carry out similar task. An AI researcher, Joseph Weizenbaum, created a popular programme called "ELIZA" that reflects Turing's dream. The programme is capable of communicating with humans in manner not distinguishable from humans themselves.

1.8.5 Automatic Theorem Proving

One of the fundamental interests of AI researchers is to design programmes or machines that can carry out thought processes in a formal manner. This has been actualized through what is regarded as Automatic Theorem Proving in AI. Here, programmes exhibit the ability to automatically deduce or infer new knowledge from existing ones.

In the field of logic, ideal formal rules have been discovered to test the validity of different thinking processes carried out by humans. For instance, by the ideal logical rule of "Modus Ponens", Q can be inferred from $P \supset Q; P$. Following different modes of ideal logical rules, computers are programmed to carry out ideal thinking process. Such programmes help in validating mathematical theories or logical sentences by demonstrating whether their conclusions are validly derived from them or not. Two foremost AI researchers, Allen Newell and Herbert Simon in 1955, created such programmes called "Logic Theorist". The programme was able to prove 38 out of the first 52 theorems in Russell and Whitehead's *Principia Mathematica*.

1.8.6 Robotics

Hybrid Techniques as an AI paradigm involves integration of many AI paradigms to produce a more complex intelligent agent. Such agent is the robot. Robotics is therefore an attempt to instantiate multiple paradigms of AI in an intelligent agent like the robot.

A robot is a computer-controlled machine that is programmed to move, manipulate objects, and accomplish work while interacting with its environment. Robots are able to perform repetitive tasks more quickly, cheaply, and accurately than humans. The term robot originates from the Czech word "robota", meaning "compulsory labour". It was first used in the 1921 play R.U.R. (Rossum's Universal Robots) by the Czech novelist and playwright, Karel Capek. The word has been used since to refer to a machine that performs work to assist people or work that humans find difficult or undesirable (Bekey, 2008:para.1).

Many robotic applications are for tasks that are either dangerous or unpleasant for human beings. In medical laboratories, robots handle potentially hazardous materials, such as blood or urine samples. In other cases, robots are used in repetitive, monotonous tasks in which human performances might degrade over time. Robots can perform repetitive, high-precision operations 24 hours a day without fatigue (Bekey, 2008: para.11). The automobile industry has benefited immensely from robotics because robots are able to effectively and efficiently carry out different tasks.

1.9 Conclusion

It is evident from this chapter that "intelligence" is a many-sided concept. In terms of definition, theory, and perspective, the concept is controversial and elusive. However, intelligence is a way of describing or qualifying human behaviour or action. Thus, certain kinds of behaviour can be reasonably presumed as evidence or proof of intelligence. To say that an entity is intelligent, from a scientific point of view, is to say that the entity in question manifests such behaviour. AI research has already provided us ample evidence to show that machines that manifest such behaviour exist. The question, however, is whether we can appropriately qualify machines as intelligent agents on the ground of this evidence.

Two indices that can serve as evidence of intelligence possession were critically examined. First, that an intelligent entity should possess brain, mind and consciousness. Second, that an intelligent entity should be capable of exhibiting appropriate behavioural dispositions considered to be ascribed to intelligence. In the light of the controversies shown to be associated with brain-mind argument, the first criterion will not lead us to any interesting conclusion in the quest to determine whether or not intelligent machine is a possibility. The second criterion is more fruitful and promising. Alan Turing who championed the crusade for machine intelligence is known to have also rejected the first criterion on the ground that it would breed the problem of ambiguity. He found the second option attractive because of its scientific outlook. The Turing Test he proposed underscores this conviction, as we shall demonstrate in the next chapter.

CHAPTER TWO

THE TURING TEST AND ITS STANDARD INTERPRETATION

2.1 Introduction

Although the preceding chapter offers abundant evidence of the appreciable level of progress made in AI research in designing machines to perform intelligent functions, some scholars (Block, 1981; Gunderson, 1973; Searle 1980) do not consider such feat as evidence that machines are intelligent. Their argument is that machines are yet to pass the test (Turing test) purposely designed to justify their intelligence. Going by what these scholars consider as the standard interpretation of the test, there is no way machine can meet the criterion of intelligence. To properly situate the position of these scholars, this chapter takes a look at the nature of the Turing test, its standard interpretation and the various objections raised against it in relation to this interpretation.

2.2 The Nature of the Turing Test

The Turing Test is named after its originator, the British mathematician, Alan Mathison Turing. Turing is considered one of the most important founders of computer science and Artificial Intelligence. He was the first to describe in detail a machine that could carry out mathematical operations and solve equations. His work brought together symbolic logic, numerical analysis, electrical engineering, and mechanical vision of human thought processes. As we already noted, he contributed in no small measures towards the effort that brought an end to the Second World War by constructing a machine that helped in breaking the German naval Enigma cipher. His successful deciphering of the code provided a tool to track German ships in the Atlantic, an advantage critical to the victory of the Allies in the war (Encarta, 2008C: para.4). The high level of sophistication of the mind that engineered the famous Turing Test is clearly not debateable.

Turing was convinced that an appropriately programmed machine can, in principle, do anything that the human brain can actualize. Thus, his 1950 famous paper, "Computing Machinery and

Intelligence" articulates an ingenious test designed to demonstrate how machines can exhibit intelligent behaviour comparable to that of human. This is the Turing Test.

Turing's paper takes off with the question "Can machines think". In an attempt to minimize ambiguities and misunderstandings, Turing decides not to answer the question by defining the terms involved. According to him, "The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous" (Turing, 434). Turing thereby transforms the question into a more concrete form by proposing what he calls the "Imitation Game". He puts the game thus:

> … the new form of the problem can be described in terms of a game which we call the "imitation game". It is played with three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart from the other two. The object of the game for the interrogator is to determine which of the other two is the man and which is the woman. He knows them by labels X and Y, and at the end of the game he says either 'X is A and Y is B' or 'X is B and Y is A'. The interrogator is allowed to put questions to A and B thus:
>
> C: Will X please tell me the length of his or her hair?
>
> Now suppose X is actually A, then A must answer. It is A's object in the game to try and cause C to make the wrong identification. … We now ask the question, 'what will happen when a machine takes the part of (A) in this game? Will the interrogator decides wrongly as often as when the game is played like this as he does when the game is played between a man and a woman? (Turing, 1950: 434-435).

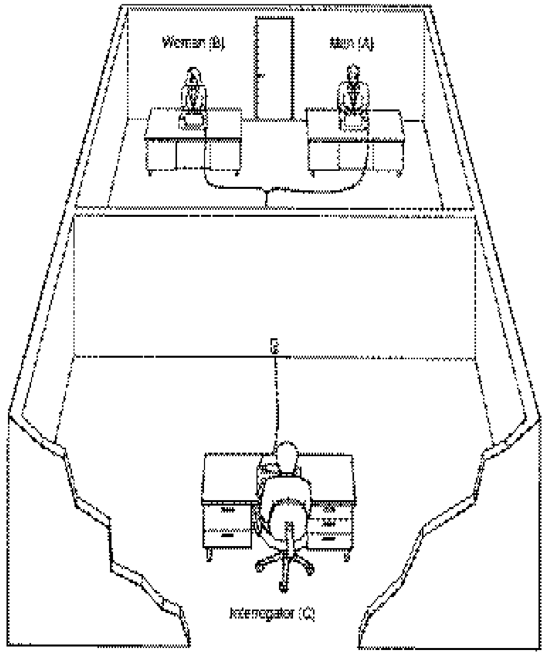

Fig.2 The stage of Imitation game in the TT

(Adapted from Fogel, 2006)

From the foregoing, the male player, who is pitted against a female player, is assigned the function of pretending to be a woman. His goal is to deceive an observing interrogator through his behavioural responses via teleprinter communication into believing that he is actually the female player. The interrogator is expected to ask questions capable of eliciting responses that could give-away the male player. The male player wins if the judge could not distinguish him from the female player based on their responses.

The game does not terminate at this point, as Turing puts forward a question:

> We now ask the question, "What will happen when a machine takes the part of A in this game?' Will the interrogator decide wrongly as often when the game is played like this as he does when the game is played between a man and a woman? These questions replace our original, 'Can machines think?' (Turing, 435).

Turing further clarifies this question especially in relation to a programmable devise like a digital computer thus:

> Let us fix our attention on one particular digital computer C. Is it true that by modifying this computer to have an adequate storage, suitably increasing its speed of action, and providing it with an appropriate programme, C can be made to play satisfactorily the part of A in the imitation game, the part of B being taken by a man? (Turing, 443).

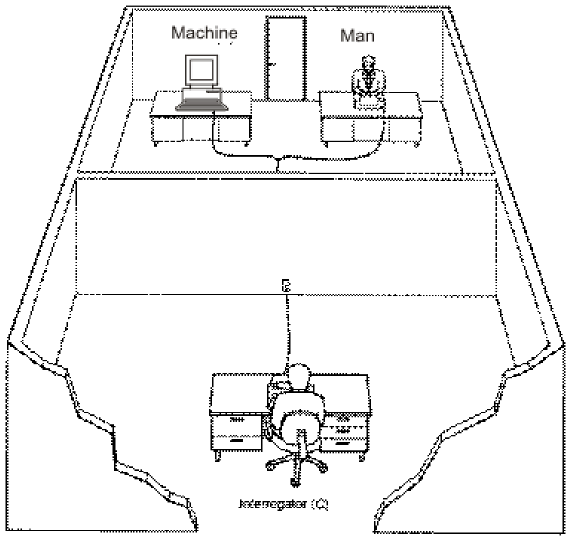

Fig.3 The stage of confirming machine's imitative capacity

(Adapted from Fogel, 2006)

At this point, a digital machine is now introduced into the game as depicted in the figure above. It is now pitted against the male player (not the female player as clearly shown in the last quotation above) to determine if it could successfully replicate the latter's previous performance. Once the interrogator could not distinguish the machine's performance from that of the man then it is believed to have passed the test and deemed intelligent. Turing remarks that:

> I believe that in about fifty years time, it will be possible to programme computers with a storage capacity of about 10^9 to make them play the imitation game so well that an average interrogator will not have more than 70 percent chance of making the right identification after five minutes of questioning (Turing, 1950:442).

2.3 The Standard Interpretation of the Turing Test

The Standard Interpretation of the test as conventionally accepted by many scholars and as rendered in many literatures is as follow: there is a computer and two people, one of whom is the interrogator. The interrogator communicates with the computer and the other person using a teletype or computer terminal. The interrogator is told that one of the two agents he communicates with is a computer, and the other a human. The computer's goal is to fool the interrogator into thinking that it is indeed a human being. The second person also tries to convince the interrogator that he or she is actually the human. The computer attempts to achieve the deception by imitating human verbal behaviour. If an interrogator does not make the "right identification", where a "right identification" means identifying the computer as a computer, then the computer passes the test (Traiger, 2000:561). It is on the basis of this interpretation that series of criticisms were launched at the TT. We now attend to these criticisms.

2.4 Objections to the Turing Test

In anticipation of negative reactions to his proposed test, Turing put forward some possible objections. His response to these objections, however, still failed to prevent the onslaught of criticisms that later greeted his idea (these criticisms are borne out of reliance on the standard interpretation of the test, which incidentally, is a misinterpretation). Turing's anticipated objections are nine in number.

The first is the Theological objection which claims that God gave immortal soul to humans and hence, they are the only beings on earth capable of thought since thought originates from immortal soul. For Turing, God also possesses the power of omnipotence to extend the franchise to machines. We therefore need not deny them of intelligence.

The "Heads in the Sand Objection" is about the weariness of humans over the thought of losing their franchise to thinking or intelligence. It is akin to relinquishing his status of superiority over all other creations. Turing considered this objection not weighty enough for consideration. Perhaps, humans, according to him, should console themselves with the belief in transmigration of the soul.

The "mathematical objection" reiterates the understanding that certain mathematical theorems easily make apparent the limitations of the power of machines. Gödel's Theorem is considered famous here because it has the capability of demonstrating that, machines, irrespective of their infinite capacity, can still fail to respond satisfactorily to stimulus; or may not even respond at all.

This is consistent with Gödel’s theorem 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. Turing’s reaction to this criticism is that there is no available proof to show that humans unlike machines are immune to Gödel’s theorem.

In his reaction to the “Lady Lovelace Objection” that machines cannot originate anything new or take us by surprise, Turing argues that machine have taken him by surprise on many occasions. And, for him, an entity would have to be creative to take anyone by surprise.

The “argument from consciousness” stipulates that machine would need to be conscious before it could be rightly claimed to possess mind and capable of thinking. Turing employed the “solipsism” argument to counter this objection. Accordingly, the only way to really know whether a machine is conscious or not is to be that machine. This is also applicable to humans. This is the problem of other minds.

According to the “arguments from various disabilities”, there are certain human traits that machines cannot instantiate. These include, having a sense of humour, falling in love, or feeling pains, and so on. For Turing, such criticisms are anchored on consciousness, and as such weakened by the problem of solipsism and other minds.

The “argument from continuity in the nervous system” states that it is impossible to model the behaviour of human nervous system on machines because the nervous system by nature is ever in a state of continuity. Turing’s position is that this argument becomes irrelevant once we adhere to the conditions of the imitation game which would make it impossible for the interrogator to notice the difference between human and machine.

The “argument from informality of behaviour” directs our attention to the belief that while human responses to events is not rule-based, that of machines are. Consequently, the two entities differ in terms of the nature of their behaviour. Turing’s position on this point, however, is that, a scientific investigation of human behaviour seems to suggest that humans are actually guided by rules and that machines have been shown to sometimes act in unpredictable manners.

The “objection from extra sensory perception” is the last one advanced by Turing. Here, Turing is mindful of the fact that the interrogator in the Turing test could employ, to his advantage, the power of telepathy to distinguish between human and machine. This problem is easily solved once we position the participants in the test in a telepathy-proof room.

The various arguments discussed above against the TT could simply be described as Turing’s self-imposed objections and their refutations. However, there are other fundamental objections to the TT that, as hinted earlier, are borne out of what some scholars considered being the standard interpretation of the TT. We now critically analyse some of these objections and then show how the interpretation (standard interpretation of the TT) on which they are anchored is not an appropriate reflection of the TT.

2.4.1. The Chinese Room Argument

When Turing put forward the TT in 1950, the idea of a programmable computer was still far from actuality. Nevertheless, Turing was convinced that an appropriately programmed machine would have been designed to pass the test by the end of 2000. Reacting to this possibility, John Searle, in his paper, “Minds, Brains and Programmes” (1980) put forward the argument that even if an appropriately programmed machine passes the test, it would still not be sufficient to conclude that the machine is intelligent. The seat of intelligence is “mind” which machine does not possess. As a matter of fact, testing if machine is intelligent is akin to testing if it possesses mind.

In an attempt to prove his point, Searle introduces his famous “Chinese Room Experiment”. In this experiment, Searle wants us to imagine a man locked up in an enclosed room with a postal slot through which symbols in Chinese language are sent in and another slot through which they could also be sent out. As input, the locked up man receives a piece of paper covered with Chinese symbols through the slot. Meanwhile, the man is provided with reference book that contains all the instructions and rules that would guide him in matching the symbols to be sent out with those sent in to him. Consequently, according to what input he gets, he looks at his instruction manual, locates the corresponding marks, writes them down and presents those marks as output through the slot. In following such instructions, the man in the enclosed room appears to outside observers to give appropriate responses to Chinese questions.

The point of Searle's thought experiment is that the locked up man can easily pass the TT and play the imitation game with a native Chinese speaker and deceive him into thinking that he can speak Chinese. In reality, the man has no understanding of Chinese whatsoever. All he does is matching inputs with corresponding outputs without any understanding. Searle thus concludes that intelligence is not simply a matter of compilation or symbolic manipulation as Turing appears to suggest.

The formal manipulation of symbols in the Chinese room is comparable to what goes on in a computer's AI program. Searle points out that no matter how effective a computer programme may be in simulating conversation, it will never produce real understanding. Indeed, a computer program can simulate intelligence, but it cannot duplicate it. Searle argues that a computer program is nothing like a mind because its states are different from human cognitive states. To put it more technically, the computer lacks intentionality. Intentionality according to Searle, is a feature of certain mental states (such as beliefs) by which they are directed at or are about objects or states of affairs in the world.

Intentionality and other attributes of mental or cognitive states are all believed to belong to the "internal" process of any thinking agent. Except through the introspection of our own internal state, we cannot understand what it means to say that others possess the attributes of mental state (or are in that state). In other words, we cannot have direct knowledge of what it means to say that others are thinking; we only suppose that they are. This, as we noted before is the problem of other minds. If not for the background information that Searle possesses, he, like any native Chinese speaker, would be deceived into thinking that the locked-up man understands Chinese and, by implication, can think. If we replace the locked-up man (who of course does not understand Chinese) with a native Chinese speaker in the experiment, his output performance would still not be different from that of the former candidate. How then can we distinguish the variance in their mental process in the test?

From the foregoing, independent of "background information", a judge in a TT will not be able to know if the candidate that "passed" the test is a machine who invariably is presumed not to posses mind. In fact, performing well in the test is proximate evidence for inferring mind. The complexity of this situation is further reinforced by the perplexing fact that we cannot be certain that other humans like us possess mind. N. Epley (2008) concludes that this is the problem of other minds broached by Turing when he dealt with “argument from consciousness”. People can only directly experience their own mental states, and, not that of others, hence, they cannot conclude with certainty that others have mind. Consequently, if Searle claims that machine cannot possess mind because it lacks intentionality or any form of consciousness or mind process, a sceptic can argue that other humans may lack similar qualities since we do not have conclusive evidence that they possess such. The fundamental dilemma here is that we know with absolute certainty that we are conscious because we have direct evidence of it, but we cannot stretch this conclusion to others even though they exhibit behaviours (as we do) that are associated with consciousness. The best we can do is to “infer” that they have mind from their behaviour. Candidates contesting in the TT, be it machine or man or any other entity whatsoever, are presumed to posses mind only on the basis of their behavioural performance and not on the basis of “direct” observation of their mental process which, of course, is unobservable directly. Consequently, passing the TT, contrary to Searle’s view, logically provides sufficient condition for intelligence possession.

Searle’s contention against machine intelligence is reiterated in his paper, “Is the brain’s mind a computer program?” (1991). There, Searle argues that human mental state is caused by the powers of our brain. The activities of the brain are characterized by neural firing in specific neural architectures leading to mental activities such as believing, thinking and experience. This is a ‘physicalist’ theory of mind. According to physicalism, all mental and non-mental attributes of man can be explained completely and adequately in terms of their physical components. Indeed, if this theory were right then the problem of other minds will not arise. Maria Perna in her paper, “An Answer to the Problem of Other Minds” (2008) advances this suggestion when she argues that the reason why we have the problem of other minds is that people put forward theories of mind that render mind inaccessible. The main culprit, according to her, is Rene Descartes and his private theatre model of the mind. This model sees the mind as belonging to the inner or private realm of man hence it is accessible exclusively from the first-person perspective. Perna is of the opinion that a theory of mind that equates mind process with brain process is immune from the Cartesian problem for the simple fact that the brain is accessible for investigation.

Perna's position is supported by the tremendous progress currently enjoyed by brain research. For example, scientists have studied people that suffered damage to various portions of the brain and found that different kinds of brain damage produce regular and specific breakdowns in a person's psychological functioning. In addition, studies of the activities of normal brains with sophisticated medical instruments show that when a person is performing a certain task (imagining a scene, speaking, calculating a sum), characteristic changes take place in the brain. Thus, there seems to be a very clear correlation between what we normally think of as mental events and changes in brain states. This constant correlation makes physicalism very attractive (Lawhead, 2003:218).

From the foregoing, Searle's physicalist theory of mind seems to reinforce his argument against machine intelligence. If mental state is equated with brain process (Mind-brain identity theory) all that is needed is a demonstration that machine possesses no brain and consequently lacks mind and by implication, cannot manifest intelligent behaviour. Unfortunately, Searle's version of the physicalist theory of mind is not satisfactory. Gang Cheng's paper "On Mind-Body Problem: From a Natural Point of View" (2005) clearly demonstrates that a mind-brain identity theorist like Searle can never be successful in his attempt to render mental event (mind) and physical event (brain process) identical. Cheng agrees that progress in brain science indeed makes it possible to detect certain form of neural firing in a brain and monitor its operation. For Cheng, what we actually monitor is not mental event but brain activities or processes. While we can know that an individual is in pain by monitoring the neural firing taking place in the brain, we cannot "feel" his pain as a mental event the way we can feel our own pain directly. We cannot, thus, experience other people's mental event, we can only observe the brain process that suggests painful experience. Consequently, both mental event and physical event are not identical. Cheng argues that it is a physical event that we observe from an external point of view, hence public to all. A mental event is what we perceive from an internal point of view by us alone; it is not open for public scrutiny. It is a private event, only and truly known by introspection.

Cheng argues further that we do not have "direct reliable" means of knowing others' mental state. The best we can get is an "indirect unreliable" means i.e. by observing the patterns of neural firing and blood circulation in certain areas of the brain, and the mapping between mental events and neural events "accumulated in the past". However, the mapping is not reliable since there is some kind of plasticity in the human brain. Brain research indicates that after the removal of one hemisphere of the brain, some of its functions can still be recovered in the other hemisphere. Cheng calls this "multiple-realization" phenomenon; and the implication is that it provides evidence that there is no general psycho-physical law to support the mapping process. The only thing that is certain is that we can directly, through introspection, know our mental state; we can know that of others through inference drawn from the observation of the activities of the brain and through human behavioural acts as suggested by Turing.

At this point, we can conclude that Searle's Chinese room argument is not a viable analogy that can displace the TT as a plausible means of demonstrating machine intelligence. So long as the brain process is not identical with mental act then we cannot deny machines the properties of intelligence, on the ground that machines lack brain. Searle's argument, however, draws our attention to a very crucial point hitherto neglected in the TT discourse. What theory of mind can plausibly account for machine intelligence? If Turing is right in his conclusion that a successful performance by a machine in an intelligence test is an indication of mind possession by the machine, the question is: what theory of mind will be consistent with such claim?

A theory of mind shall be consistent with the TT if (i) it does not deny machines the possibility of mental state as Turing proposes and, (ii) also does not deny the possibility of employing behaviour as a plausible means of demonstrating intelligence in a machine. Superficially, behaviourism appears to be a theory of mind most appropriate since the TT relies on overt behaviour as corroborative evidence of mental state. Paul Churchland's paper, "Behaviourism; Materialism and Functionalism" (1984), however, strongly indicates the inappropriateness of behaviourism to the TT's aim. Churchland argues that behaviourism is not really a theory about what mental states are. Rather, it is a shorthand way of talking about actual and potential patterns of behaviour. Behaviourism simply claims that any sentence about a mental state can be paraphrased, without loss of meaning, into a long and complex sentence about what observable behaviour would result if an individual is in any observable circumstance. Thus, what we call mental state is not really any inner state but mere expression of human behaviour or disposition to behave in certain ways. In downplaying the status of the inner state as actual possibility, behaviourism fails to meet the first condition though it strongly affirms the second. The mind-brain identity theory has already been rejected for equating brain process with mental state. There is only one theory of mind that is highly suitable for the TT's intent. It is called "Functionalism". Anchoring the TT on such a theory of mind further weakens Searle's argument against the TT.

The fundamental thesis of functionalism is that mental state is realizable in material instantiations quite different from the human brain. Thus, the theory allows the possibility that the same mental states that occur in human brains can occur also in silicon-based digital computers, or in extra-terrestrial beings whose thoughts derive from substances and architectures vastly different from those of humans (Thagard, 1986:302). Thus, functionalism is based on the principle of "multiple realizability", that, is, the property by which something can be realised, embodied, instantiated in multiple ways and in different media (Lawhead, 233). Unlike behaviourism that emphasizes behavioural disposition as the only interpretation of the mental, functionalism posits that we must also understand the internal, psychological processing that is going on. The internal state is a real experience and not merely an expression of behavioural disposition. In fact, proponents of functionalism believe that internal states such as beliefs, desires, and wishes play a causal role within the organism. These states may be realized in brain states, but they also could be realized in other ways (Lawhead, 234).

In "The Mind-Body Problem" (1981), Jerry Fodor, one of the two main advocates of functionalism (the other being Hilary Putnam), posits that the theory recognizes the possibility that systems as diverse as human beings, calculating machines and disembodied spirits could all have mental states and that the psychology of a system depends not on the stuff it is made of (living cells, mental or spiritual energy) but on how the stuff is put together. Fodor's counterpart, Putnam proposes that mental states can easily be compared with the functional or logical states of a computer. For instance, while a computer program can be realized or instantiated by any of a number of physically different hardware configurations, a psychological program can also be realized by different organisms of various physiochemical compositions. In his paper "Minds and Machines" (1960a), Putnam argues that mental experience such as pain is not necessarily identical to C–fibre firing advanced by Searle in his identity theory of mind. He sees the possibility that pain may actually correspond to an entirely different physical state for a particular organism even though all organisms experience similar mental state of pain. Thus, while humans and animals may share similar experience of pain, their experience, each, may actually originates from different physical states.

The functionalist sees the hardware of the computer (the wires, chips, and so on) as analogous to the brain or whatever substance underlies the mental states. The software is a set of logical relationships that direct the processing of inputs, the changing states of the system, and the outputs. Thus, software is analogous to the mind; it is the program that gives the computer its instructions. The hardware merely runs the program. In a nutshell, functionalism conceptualises mental states in terms of what they do as opposed to their composition. Contrary to Searle's claim, a computer does not need to be equipped with a wrinkled lump of grey biological matter weighing little more than a kilogram, before it can actualize mental state. The Chinese room argument is therefore unsatisfactory as an objection to the TT.

2.4.2 The Anthropomorphic Argument

Anthropomorphism is the act of attributing human qualities to non-human entities. The TT appears to introduce anthropomorphism into the sphere of AI research, judging by the reactions of scholars like P.H. Millar. In his paper, "On the point of the Imitation Game" (1973), Millar asserts that the critical issue about the TT is not whether machine can play the imitation game or not, the real issue is whether such a game is an appropriate instrument for measuring the intelligence of machine.

Millar argues that the TT can be used to measure human intelligence, but definitely not machine intelligence. Any such attempt can only be described as an attempt to *anthropomorphize* machines by ascribing to them human aims and cultural backgrounds. In the final analysis, Millar argues, the imitation game merely measures whether machine possesses human intelligence and not whether they are intelligent. What we should be talking about is not human intelligence but the kind of intelligence best suited for achieving the specific aims of machines. The imitation game, definitely, cannot be used to do this.

From Miller's point of view, each category of being has its own essence, and surely machine's essence is quite distinct from that of humans. Every being, based on its specific essence, exhibit distinct level of and type of intelligence suited for the satisfaction of its aims. We should, by implication, expect the behavioural demonstration of intelligence by each being to vary also. The imitation game, as interpreted by Millar, is best suited for testing human intelligence. Same cannot be said of machine intelligence where a different kind of test would be required. The imitation game is merely a test of how much we can humanize machine. Even if machines passed the test, it does not make them intelligent.

Robert French (1990) is convinced that no machine can pass the test. Consequently, the anthropomorphic attempt is doomed to fail. French rests his conclusion on the notion that the TT is designed to involve such questions that aim at revealing *human* intelligence rather than intelligence in general. He identifies such *questions* as *subcognitive* questions; they are questions that possess the potentiality of revealing the *low-level cognitive structure*. Low-level cognitive structure, according to French, refers to the subconscious associative network in human minds, consisting of highly overlapping activable representations of experience (French, 57). In other words, low-level cognitive structure is peculiar to humans, hence any question crafted to reveal it should be meant for human and not any other entity. Hypothetically, the TT can only measure or test intelligence associated with our specie.

To reinforce his claim, French puts forward the Seagull Test analogy. In this test, French asks us to consider a Nordic island on which the only flying animals known to the inhabitants are Seagulls. One day, two philosophers are discussing the essence of flying: one of them proposes that flying is moving in the air. The other philosopher objects by tossing a pebble and stating that the pebble certainly is not flying. The first philosopher stipulates that the object remain aloft for a period of time for the activity to count as flying. But in this case clouds, smoke, and children's balloons qualify as flying entities, his interlocutor argues. Then the first philosopher questions whether wings and feathers should be involved but this is immediately refuted by the latter by pointing to penguins. While the arguments continue to be inconclusive, they agree on a few facts: the only flying objects known to them are the Seagulls on their island. Flight has something to do with being airborne; physical characteristics like feather, beaks are probably not involved. They, then, in the light of Turing's famous article, devise the Seagull Test for flight. They believe that if something can pass the Seagull Test, it is certain that it is able to fly. Otherwise, no decision can be made – that "something" can fly or it cannot.

In the Seagull Test, two three-dimensional radar screens are constructed to help in carrying out the test. One of the radar screens would help in tracking the flight of a Seagull and the other radar screen shall help in tracking the flight of an object involved in the test. According to the rule of success, the object will pass the test if it is indistinguishable from the Seagull on the radar screen.

French is convinced that no object shall be able to pass the Seagull test except the Seagull itself. The Seagull test, as it is, cannot be passed by airplanes, helicopters, bats, beetles, or sparrows. Indeed, the Seagull test is constructed not for flight in general but for flight as practiced by the Nordic Seagull. This is analogous to the TT, which is designed to test human intelligence and not intelligence in general. Just like the test for the flight of an airplane shall unquestionably be different from that of an eagle, the test for machine intelligence ought to be different from that of human intelligence.

From the analysis of the TT, it is possible to raise objections against Miller and French's critique of the TT. Contrary to Miller, there is nothing to show that the TT is put forward with the intent to anthropomorphise machines. Turing's aim is to show that, if it is possible to programme machines to behave in certain ways that suggest intelligence when humans exhibit similar behaviour, it would be logically sufficient to describe such machines as intelligent. It is the behaviour of machines that attracted the description of intelligence. And French missed this point as well. He does not consider Turing's caveat that machine must be "appropriately" programmed to imitate humans in the game. Similarly, contrary to French's belief, if a machine is appropriately programmed to imitate the Seagull flight in a way indistinguishable from the Seagull itself, then it passes French's Seagull Test.

2.4.3. Argument from Psychologism

The primary objective of introducing the TT, according to Turing, is to avoid the problem of linguistic confusion that may arise when the attempt is made to conceptualize machine thinking or intelligence. The TT provides a behavioural but objective interpretation of what it means to say that machines can think or can exhibit intelligence.

Ned Block, due to his anti-behaviouristic inclination, distinguishes between the TT and intelligence. He believes that there is no necessary connection between both. Block's view is expressed in his famous paper "Psychologism and Behaviourism" (1981) where he launched an anti-behaviouristic attack against Turing's position. Behaviourism, as already indicated limits the scope of psychology to the scientific study of publicly observable behaviours and their causes while rejecting any explanations that refer to interior mental states or processes (Lawheads, 271). The TT, according to Block, is anchored on behaviourism. The test aims at establishing a relationship between machine and intelligent acts. With appropriate behavioural responses to a purposefully crafted set of questions, a machine can be judged to have passed the TT and also capable of thinking.

Block contends that machines which rely on some simple tricks to operate can still be designed to fool judges in the TT. Machines do not need to be as complicated as the machine Turing envisaged before they can pass the TT. To accentuate his point, Block proposes a hypothetical machine that will pass the test and yet be designed with a very simple information-processing component. This machine has all possible conversations of some given length recorded in its memory. The set of strings constituting such conversations that can be carried out in a fixed amount of time are finite and, thus, can be enumerated and stored in this hypothetical computer. The judge types in a string, say A. The machine finds a conversation beginning with A and types out the second sentence of this string, say B. If the judge types in C, the process is repeated with A replaced by ABC. All the machine does is simple *look up and write out*. The whole process is quite unsophisticated in a way that it would involve or suggest the act of thinking. Consequently, Block concludes that the TT is an inadequate means of testing intelligence so long as it is designed with the behaviourist approach.

Block introduces an alternative to the behaviourist approach which he calls, *psychologism*. Psychologism is the doctrine that whether or not behaviour is intelligent depends on the character of the internal information processing that produces it (Block, 1981:5). Block posits that the exhibited behaviour of an entity would not be enough to determine if the entity is intelligent; beyond the behaviour is the internal information processing of the entity that originated the behaviour. It is thus possible for two entities to exhibit similar behaviour associated with intelligence and yet we may deny one of the entities the status of intelligent agent due to its non-supportive internal information processing mechanism. Intelligence is commonly ascribed to human behaviour because it is believed that humans have supportive internal information processing mechanism for it. Block sharply points out that psychologism, as he understands it,

does not imply that any system that does not share similar internal information processing mechanism with humans is necessarily incapable of exhibiting intelligence. In fact, two different entities with different internal information processing mechanisms that suggest full intelligence can indeed be regarded as intelligent agents.
Block employs the Martian argument to reinforce his position. Supposing beings from Mars, that is, Martians, meet some human beings. On interaction, the two groups easily develop an understanding in different creative and mental activities although they were later shown to possess different internal information processing mechanisms. Block agrees that it would amount to pure *chauvinism* to deny the Martians intelligence on the ground that they are not humans. They indeed possess intelligence as humans do.

Block is worried that the peculiar characteristics associated with the design of the TT in relation to behaviourism can create misjudgement on the part of the judges in the TT. For instance, a truly intelligent machine could be misjudged as unintelligent the way Martians could be misjudged in relation to humans. This problem could, however, be avoided if the TT design is modified. In the original Turing test design, questions are technically and deliberately formulated to elicit anticipated behavioural response from machines. Judges enlisted in the test are therefore expected to judge machines as intelligent or not on the basis of their personal interpretation of the anticipated behaviour.

Block misses a crucial point concerning the TT. Making wrong judgement about the intelligence status of a machine is not peculiar to the TT. More often than not, the level of intelligence of some *human* individuals is misinterpreted on the basis of their overt behaviour. Sometimes we are rated as highly intelligent based on some actions that we carried out *only by chance*. Thus, a human judge can err when rating the level of intelligence of another human.

Our observation does not necessarily invalidate the problem of misjudgement of intelligence in the TT as pointed out by Block. But then, Block's alternative, *psychologism,* cannot do justice in correcting the errors of behaviourism. Each time we intend to judge if an agent is intelligent or not, we do not first carry out an investigation about the internal information processing mechanism of the agent before we rate its behaviour as intelligent or not. In fact, it is the behaviour of the agent that is first accessible for judgement. Besides, it is *behaviour* that is judged as intelligent and not the *internal information processing mechanism*. The latter is only a matter of details.

2.4.4 The Fairy Tale Argument

If the level of development that has been attained by AI in the domain of science fiction today is also what is obtainable in the real phenomenal world, then AI would have attained more than hundreds fold the dream of Turing. The argument of some scholars like Richard Purtill is that Turing's dream died with him and the desire to actualize it through the TT would also remain a dream. From his combined status as a philosopher and a computer programmer, Purtill launched an attack on Turing's imitation game in his paper, "Beating the Imitation Game" (1971). Purtill is famously associated with a cynical promise of eating his computer library if anyone is found to possess a notion about the principles on which a machine that can play the imitation game *is to be built*. The crux of his argument is that a computer can only play the imitation game in our dream or imagination. The dreamer is no other person than the computer programmer himself. Such a thing can only occur in science fiction.

Purtill is impressed by the level of imagination demonstrated in science fictions on the potentials of intelligent machines. In fact, he is willing to grant such machines the power of thinking if indeed they can, in reality, behave the way they do in fiction. Purtill, however, does not expect this to happen anytime in the future since all computer outputs he argues, can be explained by, or traced to, programmes written by humans themselves. Purtill hangs his conviction on the notion that the behaviour of a thinking entity cannot be mechanically explained. Hence, the behaviour of a human being, as an intelligent being, is not deterministic like a computer programme. Even where the principle of randomization is applied to a computer programme so as to make the machine's behaviour unpredictable, the fact still remains that it is programmed to behave so. Besides, this does not guarantee that the machine will do well in the imitation game.

Since the computer cannot act beyond what is programmed into it and how it is programmed to behave, the imitation game, as set up by Turing, is merely *a battle of wits between the questioner and the programmer*. *The computer is non-essential* (Purtill, 1971:291). Purtill seems to have pre-empted the Loebner prize award in which the programmer and not the programme or machine that is usually rewarded. Why not eliminate the computer in this game altogether? This is possible, according to Purtill, if we can construct alternative machine made of levers and wheels that can perform the same task. This is purely a mechanical alternative that will not harbour any controversy.

The possibility of a purely mechanical rigged machine playing one of the roles that computers play, as suggested by Purtill, was adumbrated in a 1836 essay of Edger Allan Poe entitled "Maezel's Chess-Player" in *The Southern Messenger*. In the essay, the machine is constructed not to play the imitation game but a game of chess. The chess-playing machine was invented by Wolfgang Von Kempelen but was slated for exhibition by J.N. Maelzel. The chess-playing device consisted of a cabinet containing a system of densely packed machinery: metal wheels, rods, levers, and so on. The top of the cabinet contained a chessboard presided over by a mechanical human figure whose left arm was moved by the machinery within the cabinet. During exhibitions the arm would move the chess pieces and the machine would play a respectable game of chess with a human opponent. Poe writes that he was not fooled by the machine. He argues that the machine was a fraud and suggested that a small man concealed within the cabinet was making the moves. Poe maintains put that *in principle* no machine could play the game of chess. Machines can make mathematical calculations but cannot play chess because there is an unbridgeable gulf between those two activities. Machines can perform mathematical calculations because that act depends absolutely on the data originally fed into the machine. In fact, mathematical calculation proceeds, or should proceed, to its final determination, by a succession of unerring steps liable to no change, and subject to no modification. However, a chess-player does not follow such mechanical procedure. There is no single move in chess that necessarily follows upon any one other. As much as thirty different moves are possible. Chess-players do not make their moves by logical necessity as expected in mathematical calculation. Every move is made by indeterminate and unpredictable choice. To this end, Poe argues that machine cannot play chess in principle unless rigged, as done in Maelzel's chess-player.

Precisely, a century and half after Poe's declaration, an IBM computer named Deep Blue defeated the world chess human champion, Garry Kasparov in a six-game chess match. Poe would have been astonished if he were alive to witness this remarkable feat. Deep Blue was a computer programme and not a human-manipulated rigged machine like Maelsel's Chess-player, and its defeat of Kasparov invalidates Poe's argument.

2.4.5 Argument from Machine's Failure to Pass the Turing Test

The sceptical disposition towards the TT is sometimes due to the fact that no machine has passed the TT thus far. Turing himself had predicted in 1950 that in fifty years time machines would have been so successfully programmed to pass the TT. Thirteen years have passed beyond the predicted date and yet there is no scientific evidence that a machine has passed the TT.

A serious attempt to actualise Turing's prediction is the annual Loebner machine intelligence test competition. Huge Loebner instituted the Loebner contest with the aim of confirming Turing's conviction that machine can manifest intelligent behaviour. At its inaugural contest, a $100,000 prize was offered to anyone who develops a computer programme that could fool people into thinking it was a person. When the contest's judges ranked the eight computer terminals in the event from the most to the least human, no computer programme was adjudged as human in the contest (Epstein, 2009:3). This was in 1990, and ever since, no computer programme has won the prize and a gold medal, but a bronze medal and a cash prize of $2,000 is awarded annually to the contestant that comes the closet.

The Loebner competition appears to provide the practical proof that could be used to justify arguments against machine intelligence as envisaged by Turing. However, a critical scrutiny of these arguments would reveal that they are based on wrong interpretation of the TT.

2.5 Conclusion

The paradox of machine intelligence has been made apparent in this chapter. It is difficult reconciling the report made in the previous chapter on the successes recorded by machines in performing intelligent functions and the report made in the current chapter about machines' failure in the TT. How do we account for machines' failure in the test? Could it be that the objections raised against the test have basis.

But a closer look at the standard interpretation of the test reveals that it is actually the bane of the TT. This interpretation misconstrues the criterion that is used to adjudge machine as intelligent. To properly situate the TT, a model of induction is put forward in the next chapter to act as its philosophical framework.

CHAPTER THREE
CONCEPTUALISING THE PEIRCEAN-HEMPELIAN INDUCTIVE METHOD

3.1 Introduction

This chapter introduces a model of induction called "Peircean-Hempelian" inductive reasoning. The chapter also examines the fundamental philosophical ideas that are germane to the emergence of this model. To this end, the relevant philosophical ideas of Charles Sanders Peirce and Carl Gustav Hempel are brought forward for in-depth discussion. The chapter demonstrates how "Peircean-Hempelian" inductive reasoning is a product of re-designing Peirce's theory of scientific research, otherwise known as his inductive methodology or explanatory induction, with Hempel's confirmatory induction.

3.2 The Essentials of Charles Sanders Peirce's Inductive Methodology

Peirce's inductive methodology, also known as Peirce's scientific inquiry or explanatory induction is an attempt to combine three modes of inference namely abduction, deduction and induction to form a comprehensive method of generating scientific explanations or hypotheses to explain reality. As shall be explicated, Peirce's notion of pragmatism, fallibilism, synechism, triadism and semiosis combined to form the core philosophical elements on which he erects this theory of inquiry.

3.2.1 The Philosophy of Peirce

Mainly because of his scientific background, Peirce's approach to philosophy is oriented towards science. He treated philosophy as an interactive and experimental discipline. Peirce himself labelled his approach as "laboratory philosophy", and it reflects important themes throughout his work. Pragmatism, for instance, takes the meaning of a concept to depend upon its practical bearings. The upshot of this is that a concept is meaningless if it has no practical or experiential effect on the way we conduct our lives or inquiries. Similarly, within his theory of inquiry, the scientific method is the only means of fixing belief, eradicating doubt, which progress towards a final steady state of knowledge (Atkin, 2004: para.28).

Although our primary interest on Peirce is to adopt his theory of inquiry for the purpose of formulating a robust inductive procedure for interpreting the outcomes of the TT, it is pertinent that we discuss some of his fundamental philosophical themes that inform his theory of scientific inquiry. These include his pragmatism, fallibilism, synechism, triadism and semeotics.

3.2.1.1 Pragmatism

Pragmatism, as a philosophical movement, has its origin in America. The foremost pioneers of pragmatic thought were Peirce himself and two other notable American philosophers William James and John Dewey. While William James introduced the doctrine to the philosophical world in 1898, Peirce is considered to be the first to formally develop the doctrine in 1878 in a paper titled "How to Make our Ideas Clear" (as acknowledged by James himself).

As a philosophy, pragmatism stresses the intimate relation between thought and action by defining the meaning of our conceptions in terms of the practical effect we associate with them, and the truth of our beliefs in terms of how successfully they guide our actions. For the pragmatist, every belief is like a scientific hypothesis and every action based on that belief is like an experiment that either confirms or refutes the viability of that belief (Lawhead, 2003:148).
Pragmatism is one of Peirce's best-known contributions to philosophy. It is developed primarily to guide us in arriving at meaning. Contrary to some traditional theories, Peirce did not think that the act of grasping the meaning of a concept was simply some interior mental state, nor meaning to be some sort of ghostly "halo" that attaches to a word or idea. Instead, Peirce described the meaning of a concept in terms of our interactions with the world and the publicly observable ways that the world responds (Lawhead, 152). To this end, he advanced the pragmatic maxim thus: "Consider what effects that might conceivably have practical bearings we conceive the object of our conception to have. Then, our conception of these effects is the whole of our conception of the object" (Peirce, 1931:5.402).

From the foregoing, the maxim is a distinctive rule or method for becoming reflectively clear about the contents of concepts and hypotheses: we clarify a hypothesis by identifying its practical consequences (Hook, 2008: para.10). In a popular illustration of what it means to apply the pragmatic maxim, Peirce explains that: "… let us ask what we mean by calling a thing hard. Evidently that it will not be scratched by many other substances. The whole conception of this quality, as of every other, lies in its conceived effects. There is absolutely no difference between a hard thing and a soft thing so long as they are not brought to the test" (Peirce, 1931:5.403).

It is only through a practical test of observation that the meaning of the adjective "hard" can be obtained in relation to that of "soft". Peirce, however, insisted that the entire meaning of a meaningful conception consisted in the totality of such specification of possible observations (Burch, 2006: para.19). For instance, as Lawhead observes, when I say, "The water is boiling", what do I mean? I mean that I can expect to see the water bubbling, that it will hurt if I touch it, that it will melt sugar, that it will register 212 degrees on a thermometer, and so on (Lawhead, 152). In any case pragmatism simply means that if a conception is true it must have palpable consequences, "either in the shape of conduct to be recommended, or that of experience to be expected" (Peirce, 1931:5.403). The kind of consequences Peirce had in mind are general ones. From the various observational effects of a concept we can derive a general idea of its consequences. For instance, the various practical consequences of the concept "hard" provide the idea of what it means to say that an object is hard. Thus, if someone want to break a window by throwing something through it, then it is appropriate for him or her to choose a hard object rather than a soft one.

It is obvious that Peirce's pragmatism is scientifically oriented. In fact, when Peirce spoke of the "practical consequences" of our beliefs or meaning, he was speaking primarily of the sort of public, empirical observations that would lend themselves to scientific analysis or test. An understanding of Peirce's doctrines of fallibilism and synechism easily reveals the reason behind his emphasis on scientific test as the plausible means of deriving meaning from reality.

3.2.1.2 Fallibilism and Synechism

Like pragmatism, the term "fallibilism" has its origin in the work of Peirce, though the basic idea behind the term long predates him (Hetherington, 2005: para.2). The major thrust of fallibilism is that, no beliefs (or opinions or views, or theses, and so on) are so well justified or supported by good evidence or apt circumstances that they could not be false. Thus, fallibilism is the awareness that there is no conclusive justification and no rational certainty for any of our beliefs or theses (Hetherington, para.2).

In his work, Peirce employs fallibilism as an epistemological stance against foundationalism. He rejects absolutism or apodeictic knowledge and criticises all forms of Cartesianism and a priorism. Philosophy, as far as he is concerned, should begin wherever it finds itself at any moment. According to Peirce, "… there are three things to which we can never hope to attain by reasoning, namely, absolute certainty, absolute exactitude, absolute universality" (Peirce, 1931:5.141).

Peirce also argues that science itself is not immune to fallibilism. Although, he never hid his strong belief that the scientific method will eventually converge to something called the truth, nevertheless at any point of inquiry we are only at a provisional stage of it and cannot ascertain how far off we may be from the limit to which we are somehow converging. According to Robert Burch (2006), one should not mistake Peirce's fallibilism for pessimism or scepticism. In fact, Peirce is quite the opposite: he tends to hold that every question (that is, every question whose possible answers have empirical content) can be answered in principle, or at least should not be assumed to be unanswerable. For this reason, one of his most important dicta, sometimes called his first principle or reason, is "Do not block the path of inquiry" (quoted in Burch 2006:para.25).

Peirce, however, did not hold on to fallibilism without reason. He anchored it on his metaphysical doctrine of "synechism", the idea that all things are continuous, that all things tend to grow, including the laws of nature themselves. Law of nature are not immutable. It is at this point that Peirce demonstrates the influence of Darwin's theory of evolution on the formation of his philosophy. In Peirce's view, the doctrine of synechism is closely related to fallibilism:

> … let me call your attention to the natural affinity of the principle of continuity to the doctrine of fallibilism. The principle of continuity is the doctrine that our knowledge is never absolute but always swims, as it were, in a continuum of uncertainty and indeterminacy. Now the doctrine of continuity is that all things so swim in continua (Peirce, ibid: 1.71).

In his reaffirmation of Peirce's claim, E.F. Cooke (2004) argues that the idea of continuity and fallibilism are analogous. The former notion refers to the indeterminacy of things on the ontological level, while the latter refers to the indeterminacy at the epistemological level of ideas, i.e. that ideas are never certain or precise (Cooke, 2004:2). Technically, the doctrine of synechism provides the necessary ontological support for Peirce's thorough-going fallibilism (Cooke, 2).

From what has been stated this far, the reason behind Peirce's stance on pragmatism becomes more evident. Since reality is in a state of continuous flux we can never know it with complete certainty: the least we could do is to derive meanings from reality through practical test of observation, otherwise, reality will be meaningless.

3.2.1.3 The Principle of Triadism

Peirce's principle of triadism refers to his penchant for describing things in terms of trichotomies and triadic relations. It is also referred to as his phenomenological categories. Of note is the fact that his view of science, logic and semiotics are all characterized by triadic relation and arrangement.

Peirce perceives the categories as the fundamental irreducible aspects of everything that exists and they come in three folds, namely; Firstness, Secondness and Thirdness. A. Crabtree observes that in naming the categories, Peirce wanted to avoid using terms that would be familiar and therefore misleading, and at the same time, he wanted to convey a sense of their fundamentalness (2010:7). Peirce himself puts it aptly:

> Three conceptions are perpetually turning up at every point in every theory of logic, and in the most rounded systems they occur in connection with one another. They are concepts so very broad and consequently indefinite that they are hard to seize and may be easily overlooked. I called them the conceptions of First, Second, Third (Peirce's 1931:6.32).

Instances of applying these categories to various trichotomies abound in Peirce writings. For example, with regard to the trichotomy "possibility", actuality" and "necessity", Peirce called possibility a first, actuality a second, and necessity a third. Again: quality was a first, fact was a second, and habit (or rule or law) was a third. Again: entity was a first, relation was a second, and representation was a third. Again: rheme was a first, proposition was a second, and argument was a third (Burch, 2006: para.47). Again: abduction was a first, deduction was a second, and induction was a third. The examples go on and on.

Peirce was not the first to characterize reality with triadic categories, Kant also employed a triadic relation in his categories of understanding. Kant's twelve categories are arranged into four groups of three each. However, it was with Hegel's triadic structure of the stages of thought that Peirce categories share deeper resemblance. According to Peirce, "First is the conception of being existing independent of anything else. Second is the conception of being relative to, the conception of reaction with, something else. Third is the conception of mediation whereby a first and second are brought into relation" (1931:6.32).

Thus, "First" is analogous to Hegel's "Thesis" where being is affirmed; "Second" to Hegel's "Antithesis" where being is negated by non-being; and "Third" to Hegel's "Synthesis" where being and non-being are reconciled.

Despite the close affinity between Peirce and Hegel's categories, it is not clear if Peirce employed them in the sense in which Hegel did. For Hegel, the categories depict the stages of the evolution of thought, but this was not explicitly stated by Peirce. What can be clearly affirmed about Peirce's categories is that he claimed that phenomena just do fall into three groups and that, as Burch commented, "They just do display irreducibly triadic relations" (Burch, para. 48).

3.2.1.4 Semiotics and Logic

Semiotics, which Peirce calls "semeiotics", is the study of signs. He defined sign as something (i.e. the sign itself) which stands to something (its "interpretant") for something (its object) in some respect or capacity (Peirce, 1931: 2.228). Prior to Peirce's writings on signs, the conventional notion was that a sign, as an instrument of representation, is only used to express a dyadic relation between itself and its referent. Peirce, however, held the view that representation in its complete form is triadic. Consequently, as characterized by his categories of triadism, representation involves a sign, an object, and an "interpretant". The sign stands for something while whatever it stands for is the object. The idea, which the sign, in relation to what it stands for elicits, is the "interpretant". Thus, certain conventionally designed "white stripes" paint across the road is considered meaningful because it is treated as a "sign" in its own right and stands for an "object" called zebra-crossing. However, we arrive at its full meaning when zebra-crossing, as a sign, is interpreted to mean the path of the road that a driver of a vehicle must stop to allow a waiting pedestrian cross that road. This is the "interpretant".

From a metaphysical perspective, Peirce argues that the totality of reality is composed of signs. In his words, "the world is a profusion of signs" (Peirce, 1931:5.448). "Everything in the world is a sign, every picture, diagram, natural cry, pointing finger, wink, knot in one's handkerchief, memory, fancy, concept, indication, token, symptom, letter, numeral, word, sentence, chapter, book, library" (Peirce, quoted in Crabtree, 2010:29). In fact, our experience of the world is an experience of signs of relatedness given to us in an immediate perception (ibid: 28).

Peirce also established a relationship between his theory of signs and logical reasoning. For him, the art of reasoning is the art of marshalling signs. In fact, he identified three kinds of signs which he claimed are indispensable in all reasoning. These are "icon", "index" and "symbol". This is how Peirce explains them:

> … icons; which serve to convey ideas of the things they represent simply by imitating them… indices; which show something about things, on account of their being physically connected with them. Such is a guidepost, which points down the road to be taken, as a relative pronoun, which is placed just after the name of the thing intended to be denoted, or a vocative exclamation, as "Hi! there", which acts upon the nerves of the person addressed and forces attention… symbols, or general signs, which have become associated with their meaning by usage (Peirce, 1992/1998:2.2).

In essence, icons express "connotational" relation with their objects; indices express causal relation with their objects; and symbols express conventional relation with their objects.

Beyond merely relating logical reasoning with signs Peirce actually concludes that logic, in the broadest sense, is to be equated with semeiotics, his theory of signs. Of course, in the narrow sense, Peirce considers logic as one of the three major divisions or parts of semeiotics. He refers to logic as "logical critic", the other divisions are speculative grammar (the theory of the analysis of the different kinds of signs available), and speculative rhetoric (the study of how to use signs effectively in communication).

In his account of Peirce's philosophy, Robert Burch (2006) asserts that what Peirce meant by "logical critic" is pretty much logic in the ordinary, accepted sense of "logic" from Aristotle's logic to present-day mathematical logic. Peirce indeed achieved a great deal in this area. For instance, he invented dozens of different systems of logical syntax, including a syntax based on a generalization of de Morgan's relative product operation, algebraic syntax that mirrored Boolean algebra to some extent, a quantifier-and-variable syntax that (except for its specific symbols) is identical to the much latter Russell-Whitehead syntax. He even invented two systems of graphical two-dimensional syntax. They are the "entitative graphs" and the "existential graphs". Peirce also constructed the devices for negating and combining relations, and for existential and universal propositions. He introduced the material-conditional operator, developed the "Sheffer" stroke and dagger operators 40 years before Sheffer, and developed a full logical system based only on the stroke function (Burch, 2006: para.67). However, more profound is his application of the logic of abduction to his theory of inquiry.

So far, our searchlight has been on some fundamental themes in Peirce's philosophy. We now turn our attention to one of the core ideas of this research, viz, Peirce's theory of inquiry and indicate how it was influenced by those themes.

3.2.2 Peircean Explanatory Induction: The Tripod of Scientific Inquiry and Theory Generation

As intended in this work, explanatory induction can be described as a reasoning process that involves the act of *forming* an explanatory hypothesis given some observations and then deducing logical consequences from the hypothesis. The deduced logical consequences shall however be subjected to test in order to evaluate the hypothesis. Put in another way, explanatory induction is the act of forming a hypothesis or theory, deducing from it predictions of events or phenomena to be subjected to observation in order to see how closely they in turn agree with the theory. According to Peirce, the formalization of this reasoning process involves three stages of inquiry, *abduction, deduction and induction*.

Prior to about 1865, logicians divided arguments into two broad subclasses: the class of deductive arguments (necessary inferences) and the class of inductive arguments (probable inferences). About this time, Peirce began to hold that there were two utterly distinct classes of probable inferences, which he referred to as inductive inference and abductive inference (which he also called hypotheses and retroductive inference) (Burch, 2006:para.10). He, however, describes abduction, deduction and induction as three successive stages in "inductive reasoning process", which constitutes scientific inquiry. He used induction in two senses; there is induction as classified as the probable reasoning process generally employed in scientific inquiry, and, induction as a third and final stage of the same reasoning process. According to him, “Induction consists in starting from a theory, deducing from it predictions of phenomena, and observing those phenomena in order to see how nearly they agree with the theory” (Peirce, 1931:5.170)

Induction as used above denotes the general classification of his probable reasoning process. It consists of three stages:

(i) the stage of forming hypothesis given some observations;
(ii) the stage of predicting deductions from the hypothesis;
(iii) the stage of testing the predictions for their relation with the hypothesis.

Each of the three stages corresponds to what Peirce identified as *abduction, deduction and induction* (where induction is now used as one of the stages of the general inductive reasoning process). The diagram below provides a graphical illustration of this model of induction.

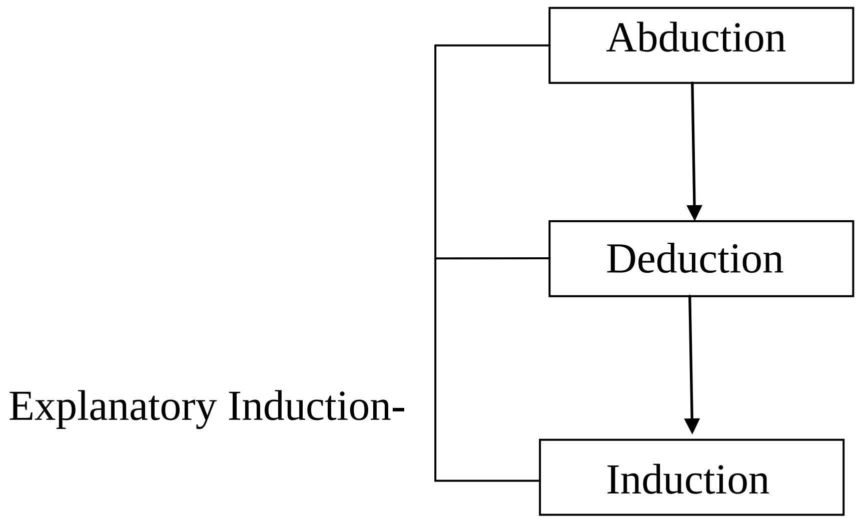

Fig. 4 Peircean Explanatory Induction

To understand the interplay of these three stages of inductive reasoning process, Brent (1998) provides us an example that captures Peirce intention:

> Consider: On my way home last night, I was surprised to see my neighbour across the street pass money to a stranger under the bright light of a street lamp. That act, which I saw clearly, might be explained by a number of abductions, such as the just payment of a debt, a bribe, a loan, the extorted payment of blackmail, or a charitable gift. If the first is true, I deduce that there is evidence of the debt, and when I find it, perhaps a poke IOU, I have provided the inductive support which leads me to accept the abduction. The same kind of analysis can be made of my other guesses (349).

From the foregoing, it is clear that any of the options chosen to account for the action of Brent's neighbour would initially be mere guesswork; each is entirely tentative. However, Peirce argues that such guesses (abduction) are the only form of inference that originates knowledge. Deduction simply reiterates what we know while induction helps to test or generalize knowledge that we already have. Peirce puts it aptly:

> Abduction is the process of forming an explanatory hypothesis. It is the only logical operation which introduces any new idea; for induction does nothing but determine a value, and deduction merely evolves the necessary consequences of a pure hypothesis.
> Deduction proves that something 'must' be; induction shows that something 'actually' is operative; abduction merely suggests that something 'may be' (Pierce, 1931:5.171).

Peirce's emphasis on the role of abduction in his inductive scheme is understandable. He is convinced that without it, no new knowledge can emerge. The aim of abduction is to form an explanatory hypothesis from an observation requiring explanation. This process is not algorithmic (Flach and Kakas, 2000:1). In fact, "the abductive suggestion comes to us like a flash. It is an act of insight, although of extremely fallible insight" (Peirce, 1931:5.181).

The fact that abduction is mere guesswork or an act of insight does not negate its logical status in the process of acquiring knowledge. According to Peirce, abduction, "… is logical inference… having a perfectly definite logical form… Namely, the hypothesis cannot be admitted, even as a hypothesis, unless it be supposed that it would account for the facts of them" (Peirce, 1931:5.188-9).

Let us re-state the logical form of abduction, as quoted earlier, for in-depth analysis: "The surprising fact, C, is observed; But if A were true, C would be a matter of course. Hence, there is reason to suspect that A is true" (Peirce, 1931:5.188-9). About *C* we know two things: that it is true in the actual world, and that it is surprising or unexpected. The latter situation can be interpreted in several ways, one of which is the requirement that *C* does not follow from our knowledge about the world. Then if A were true, C would be a matter of course is usually interpreted as A logically entails C. Peirce calls A an explanation of *C*, or explanatory hypothesis (Flach & Kakas, 2000:2).

The logical form of abduction contradicts a rule of inference called *Modus Ponens*. Schematically, the form of *Modus Ponens* could be expressed as:

C is observed   C

If C, then A   or $C \supset A$

Hence, A is accepted $\therefore A$

However, Peirce started from the converse:

C is observed   C

If A, then C   or $A \supset C$

Hence, A can be accepted $\therefore A$

According to the formal rules of deductive reasoning, this form of argument commits *the fallacy of affirming the consequent!* Consider this example. It is logical to assert that *It rains; if it rains, the floor is wet; hence, the floor is wet*. But any reasonable person can see the problem in making statements like *the floor is wet; if it rains, the floor is wet; hence, it rains* (Chong, 2006:n.pag). A lot of things or events could easily account for the wetness of the floor apart from rain. The argument form is invalid.

Given, as we have seen, that abducton is invalid, what would be the ground of its acceptance or justification? Peirce's response is that:

> Its only justification is that from its suggestion deduction can draw a prediction which can be tested by induction, and that, if we are ever to learn anything or to understand phenomena at all, it must be by abduction that this is to be brought about. No reason whatsoever can be given for it as far as I can discover, and it needs no reason, since it merely offers suggestions (Peirce, 1931:5.171).

Peirce posits that abduction is derived from human instinct, which, according to him, resembles the instinct of animals. "This instinct surpasses the general powers of our reason since it is directing us as if we are in possession of facts that are entirely beyond the reach of our senses" (Peirce, 1931:5,173). Shanahan (1986) interprets Peirce's linkage of human instinct with animal instinct as naturalistic justification of instinct. It is the kind of instinct that guides animals in their day-to-day search for food and for reproduction. Invariably, since animals possess this innate power and tendencies that help them to survive in their environment, it is apt to consider humans as also possessing the natural instinct or innate tendencies for generating abductive theories. Peirce remarks that:

> Besides, you cannot seriously think that every little chicken, that is hatched, has to rummage through all possible theories until it lights upon the good idea of picking up something and eating it. On the contrary, you think the chicken has an innate idea of doing this; that is to say, that it can think of this, but has no faculty of thinking anything else. The chicken you say pecks by instinct. But if you are going to think every poor chicken is endowed with an innate tendency toward a positive truth, why should you think that to man alone this gift is denied?... in short, the instincts conducive to assimilation of food, and the instincts conducive to reproduction, must have involved from the beginning certain tendencies to think truly about physics, on the one hand, and about psychics, on the other (Peirce, 1931: 5.591).

Indeed, humans, like animals would have found it difficult to survive in their respective environments if not for the power of their instincts.

Beyond the attempt to support abduction with human instinct, Peirce's ground for accepting it, is that it offers suggestion where none previously exists and provides the tentative starting point of inquiry. Appropriately put, abduction serves a "pragmatic" purpose. In fact, Peirce holds that pragmatism is nothing else than the logic of abduction. It provides the ground for the admissibility of hypothesis. We usually accept hypothesis not because any sound or valid reasoning informs it, but simply because of the usefulness it will serve. Without hypothesis, inquiry would have been impossible since no starting point will be available. One begins to imagine, for instance, if inquiry were to be purely based on the positivists' verification principle; then beliefs deemed unverifiable at the moment would be rejected *ab initio*. However, all scientific inquiries proceed from unverified beliefs. Their deductive consequences are eventually subjected to test in order to either corroborate or refute the hypotheses or beliefs. Peirce is convinced that, "If pragmatism is the doctrine that every conception is a conception of conceivable practical effects, it makes conception reach far beyond the practical. It allows any flight of imagination, provided this imagination ultimately alights upon a possible practical effects" (Peirce, 1931:5.195). Therefore, pragmatism is the logic of abduction and by implication the logic behind explanatory induction.

Explanatory induction as a systematic process of inquiry either corroborates the hypothesis it raised or refutes it; whichever way it goes, it will always achieve a result. This is the pragmatic ground of forming a hypothesis and subjecting it to test. Peirce is very clear about this;

> When I say that by inductive reason I mean a course of experimental investigation, I do not understand experiment in the narrow sense of an operation by which one varies the conditions of a phenomenon almost as one pleases… An experiment… is a question put to nature. Like any interrogation, it is based on a supposition. If that supposition be correct, a certain sensible result is to be expected under certain circumstances which can be created, or at any rate are to be met with. The question is will this be the result? If nature replies "No!" the experimenter has gained an important piece of knowledge. If nature says "Yes", the experimenter's ideas remain just as they were, only somewhat more deeply engrained (Peirce, 1931:5.169).

The experimenter is never a loser going by the pragmatic implication of Peirce explanatory induction. If the explanation (hypothesis) given by the experimenter on what he observed is eventually proven to be wrong, he has indeed gained a new knowledge. However, if his explanation is corroborated then his effort is worthwhile. As a foremost advocate of pragmatism, the value of a thing, according to Peirce, depends on its practical effects; and indeed, explanatory induction has practical effects; it clears our doubt and fixes our belief.

The study of Peirce's *The Fixation of Belief* (1877) shows that doubt could be overcome in order to establish belief. Peirce looked upon belief as occupying the very important middle position between thought and action. Beliefs guide our desires and shape our actions. Nevertheless, beliefs are "unfixed" by doubts. It is when doubt generates the urge to attain belief that the enterprise of thought begins. Through thought, we try to fix our beliefs so that we would have a guide for action (Stumpf, 1993:386). "The irritation of doubt causes a struggle to attain a state of belief. I shall term this struggle 'inquiry'" (Peirce, 1877:2).

Peirce identified several ways of fixing our beliefs and these include: the method of tenacity, the method of authority, the a priori method, and the method of science. Because of its realistic basis in experience, only the method of science can help us fix our beliefs. The method of tenacity, for instance, relates to the attitude of clinging to beliefs devoid of accommodating possibility of doubt or alternative views. The method of authority grounds the acceptance of beliefs on the efficacy of force. The a priori method on its own grounds the acceptance of beliefs on its agreement with reason. Unlike these three methods, all of which rest upon what a person possesses within his own mind as a consequence solely of his thinking, the method of science is built on the assumption that there are real things, the characteristics of which are entirely independent of our opinions about them. Moreover, because these real things affect our senses according to regular laws, we can assume that they will affect each observer the same way. Beliefs that are grounded in such real things can therefore be verified, and their fixation can be a public act rather than a private one (Stumpf, 386-387). The fundamental role of explanatory induction, as anchored on the tripod of scientific inquiry is to help us fix our beliefs.

3.3 Carl Gustav Hempel's Philosophy and Logic of Induction

Hempel's logic of induction, popularly referred to as confirmatory induction, is an attempt to discover a plausible means of validating scientific claims especially if such claims are expressed in the form of general statements. It has the advantage of offering a formal proof that can provide sufficient condition for validating or invalidating scientific claims. As a matter of fact, confirmatory induction is put forward to solve the dilemma associated with testing general statements or claims in accordance with the verification principle postulated by the logical positivists. Hempel's philosophical outlook is heavily influenced by the principle of positivism, as we shall see later.

Hempel has the reputation of being one of the founding fathers of logical positivism that emerged from the Vienna Circle. Incidentally, he was the last surviving member of the Vienna Circle. He and Rudolf Carnap were probably the most important members of the Circle in that, more than any others, the two of them did a huge amount of exacting work, meticulously carrying through logical and other detailed development necessary for explicating just what logical empiricism consisted and what its implications were (NWE, 2010: para.6). Hempel had since rejected the term "logical positivism" as true description of the intellectual activities of the Vienna Circle. He rather preferred the term "logical empiricism" which in no way invokes the materialist metaphysics rooted in Auguste Comte's philosophy.

Hempel's philosophical ideas were articulated in such works as *Aspects of Scientific Explanation and Other Essays in the Philosophy of Science and Philosophy of Natural Science*, translated in ten languages; *The Function of General Laws in History*; *Studies in the Logic of Confirmation*; *The Logic of Functional Analysis*; *The Philosophy of Carl G. Hempel: Studies in Science, Explanation and Rationality* and a host of others.

3.3.1 The Philosophy of Hempel

Hempel was a philosopher of science whose philosophical ideas contributed to the development of one of the dominant philosophical movements of the 20th century, logical empiricism. His major contributions in this movement include his concept of deductive nomological model of scientific explanation, his notion of the Raven paradox and his theory of confirmation of scientific hypothesis.

3.3.1.1 Logical Empiricism

Logical empiricism is a philosophy that is centrally concerned with science, in terms of understanding and promoting scientific understanding of the world. Philosophers that embraced this philosophical temperament consider science as both the locus of our best knowledge of the world and the source of hope for a brighter, less obscure and obscurantist future for philosophy (Richardson & Uebel, 2007:1). Irrespective of the area of interest, logical empiricists employ the scientific outlook.

Logical empiricism is constituted of personalities that were themselves scientists, such as Philip Frank, Hans Hahn and Otto Neurath. Others, who were members of the famous Vienna Circle, Rudolf Carnap and Moritz Schlick for example, were philosophers deeply impressed by the scientific revolutions at the beginning of the 20th century. These scholars were unified in admiration for the enduring success of science as a mode of understanding and explaining the world. As a result, they sharply disagreed with the time-honoured metaphysical orientation in philosophy and reinvented empiricist epistemology with a strong emphasis on science. Indeed, some key members of the Vienna Circle were scientists, which means that they were conversant with the methods of science. Positivists hold that metaphysical claims were neither verifiable nor falsifiable through empirical methods; and therefore neither true nor false, but meaningless. Proper philosophical analysis had to separate senseless (metaphysical) from meaningful (empirical) claims and to investigate our most reliable source of knowledge, science (Sprenger, 2009:1).

Carl Hempel's contact with this modern philosophical outlook was made possible through his association with Carnap. At this point in time the scientific cum philosophical outlook was known as "logical positivism", an influential school of thought famous for its core tenet that only verifiable propositions are meaningful. Indeed, the transition from logical positivism to logical empiricism, initiated by Hempel himself and other dissatisfied members of the Vienna Circle was promoted by their critiques of the basic tenets of logical positivism. It is at this point that Hempel's contribution to the emergence of logical empiricism became obvious.

Hempel's rejection of logical positivism is based on his conviction that the term invokes a materialist metaphysics, as demonstrated in the application of its "verifiability principle". Although designed to render metaphysics a meaningless venture, verifiability principle itself entails metaphysical standpoint since it is employed to demarcate what is perceived to be real from what is otherwise. Every posited principle about the nature of reality is a metaphysical standpoint of a kind. In some of his writings, Hempel emphasised how the positivist's principle could even be in the way of scientific development. Thus in a set of influential articles (Hempel, 1950;1951; and 1965), he persuasively demonstrated that the verifiability criterion of meaning implied that "existential generalizations" (which assert the existence of at least one thing of some kind and can be verified by a single case) are meaningful, while "universal generalization" (which assert something about everything of a certain kind) are meaningless, even though they include general laws, such as Newton's laws of motion and of gravitation, as instances (Fetzer, 2001:xviii). The implication of strict verification is that many important propositions of science shall be rendered meaningless.

Similarly, on the assumption that a sentence is meaningful if and only if its negation is meaningful, Hempel easily demonstrated that implementing the verifiability criterion leads to inconsistencies. The sentence "At least one stock is red-legged", for example, is "meaningful" because it can be verified by observing a single red-legged stock, yet its negation, "Not even one stock is red-legged", cannot be shown to be true by any finite number of observations and is therefore "meaningless". Furthermore, descriptions of relative frequencies in finite classes are meaningful, but assertions about limits in infinite sequences are not. It follows that the logical relationship between scientific theories and empirical evidence cannot be exhausted by observation sentences and their deductive consequences alone, but must be expanded to include observation sentences and their inductive consequences as well (Fetzer, xviii). The concepts of confirmation and disconfirmation assumed a crucial role in the elucidation of scientific method, since the cardinal feature of scientific hypothesis is verifiability. From the verifiability criterion of logical positivism, a transition to empirical testability of logical empiricism was initiated by Hempel and the other members of the Vienna Circle. Theories of confirmation were consequently introduced to explain the acceptability of theories on the basis of empirical facts. Confirmation theory is one of the fundamental signpost of logical empiricism; others include the establishment of mathematical logic both as a topic and a tool of philosophy, development of formal semantics, the development of the theories of probability (sometimes in connection with confirmation theory), discourses on the nature and structure of scientific theories, and other science driven themes. It must be said that all the aforementioned themes were executed in the context in which logical empiricists attempted to design a non-metaphysical form of philosophy that could illuminate and reflect how science achieves knowledge of the world (Richardson and Uebel,4).

3.3.1.2 Deductive-nomological Model of Scientific Explanation

In science, explanations are statements employed to describe events, objects or facts. Such statements may be used to clarify the causes or consequences of those events. Hempel was associated with the formulation of one of the best known models of scientific explanation in the 20th century - the "Deductive-nomological" (DN) model. Karl Popper and Ernest Nagel are also associated with the DN model. However, in the words of J. Woodward "…unquestionably the most detailed and influential statement is due to Carl Hempel" (Woodward, 2009: para.1). It must, however, be stated that Paul Oppenheim collaborated with Hempel to formalize the model in their jointly written article "Studies in the Logic of Explanation" (1948).

According to Hempel, a scientific explanation of a fact is a deduction of a statement called the *explanandum* from another sets of statements that stand as premises called the *explanans*. The *explanandum* usually describes the fact we wish to explain while the *explanans* is a scientific law adduced to account for the fact. Consequently, the deductive-nomological model shows that the explanation of a fact is reduced to a logical relationship between the *explanandum* and the *explanans* (the consequent and the antecedents).

In order to provide a ground for a plausible scientific explanation, Hempel advances certain conditions of adequacy that must be satisfied. First, the *explanandum* must be a logical consequence of the *explanans*; in other words, the *explanandum* must be logically deducible from the information contained in the *explanans*; for otherwise, the *explanans* would not constitute adequate grounds for the *explanandum*. Here lies the deductive component of the model. Second, the *explanans* must contain at least one "law of nature" without which the *explanandum* would not be validly derivable. This is considered to be the "nomological" component of the model. Nomological is derived from the Greek word *nomos* meaning "law" (physical laws of nature). The third condition of adequacy is that the "sentences constituting the *explanans* must be true, and so must the *explanadum* sentence (Hempel, 1962:101). The last condition is that the *explanans* must have empirical content, that is, it must be capable, at least in principle, of test by experiment or observation.

As an illustration, a question may be raised over the observational statement "This plastic cup melted when exposed directly to fire". A plausible explanation may state that it is because fire produces heat. Indeed, the validity of this explanation depends on the truthfulness of the physical law that "Plastic substances melt when exposed to heat, and fire produces heat".

Against the backdrop of logical empiricism and Hempel's Deductive-nomological model of scientific explanation, we now analyse his theory of confirmation in the next subsection.

3.3.2 Hempelian Confirmatory Induction

In line with the philosophical tradition he belongs, Hempel advances his theory of confirmation as an instrument of validating scientific claims or hypotheses. He purposefully put forward his Raven Paradox as one ingenious logical tool of confirmation. This is further supported by certain logical conditions on which the adequacy of confirmation can be grounded. We now carry out a detail analysis of Hempel's theory of confirmation.

3.3.2.1 The Place of Confirmation in Induction

The term "confirmation" is used in epistemology and the philosophy of science whenever observational data and evidence speak in favour of or support scientific theories and everyday hypotheses. Historically, confirmation has been closely related to the problem of induction, the question of what to believe regarding the future in the face of knowledge that is restricted to the past and present (Hubber, 2007:para.1). Induction involves an act of transcendence or a leap into the future based on what obtained in past and what is available in the present. As observed earlier, David Hume (1711-1776) considered such a leap as problematic for it lacks justification. In his classic formulation of this problem, Hume argues that,

> Let men be once fully persuaded of these two principles, that there is nothing in any object, considered in itself, which can afford us a reason for drawing a conclusion beyond it; and, that even the observation of the frequent or constant conjunction of objects, we have no reason to draw any inference concerning any object beyond those of which we have had experience (Hume, 2000)

What would be the fate of hypotheses generation in inquiry, given that they are product of induction? Should they be abandoned or rejected? If so, what would be the fate of scientific inquiry? How could we justify, for instance a Peircean abduction? It has been suggested that we either employ deductively valid argument or, perhaps, inductively strong argument to justify generated hypotheses. According to the first option, an argument consists of a set of premises P1, …, P2 and a conclusion C. Such an argument is deductively valid just in case the truth of the premises guarantees the truth of the conclusion. However, there is no deductively valid argument whose premises are restricted to the past and present and whose conclusion is about the future- yet all our knowledge is about the past and present. The second option, that is, inductively strong argument, deals with knowledge about the past and present. But is this type of argument adequate to justify hypothesis? Consider the inductively strong argument:

> All observed Africans are dark skinned people.
>
> Therefore, All Africans are dark skinned people.

What the premise (if true) of the argument above has done is to make the conclusion probable; afterall, if all Africans so far observed are dark skinned then, it is probable that all Africans are actually dark skinned. However, if we have to employ this kind of argument it means that it must continuously lead to true conclusion. Nevertheless, there is no way we can guarantee this on the basis of the claim of the argument. We can only justify the acceptability of the argument on the basis that it is inductively strong, and this is question-begging. It is akin to saying that we are inductively justifying an inductive argument. Invariably, our position would also need to be justified, and the circle of justification would continue *ad infinitum*.

It is against the problem raised above that confirmatory induction is considered a plausible solution. This form of induction is anchored on the assumption that whenever observational data and evidence speak in favour of, or support, scientific theories or everyday hypotheses, the latter are said to be "confirmed" by the former. The positive result of a pregnancy test, for instance, speaks in favour of or confirms the hypothesis that the tested woman is pregnant. The dark clouds on the sky support or confirm the hypothesis that it will be raining (Huber, 2007:3).

In his 1945 paper "Studies in the Logic of Confirmation", Hempel distinguishes three stages of confirmation (empirical testing). First, we design, set up and carefully conduct scientific experiments, we try to avoid misleading observations, double-check the data, clean them up and finally bring them into a canonical form that we can use in the next stage. In the second stage, the data are brought to bear on the hypothesis at stake – do they constitute supporting or undermining evidence? Third and last, the hypothesis is re-assessed on the basis of a judgement of confirmation or disconfirmation: we decide to accept it, to reject it or to suspend judgement and to collect further evidence (Hempel, 1945:40-41).

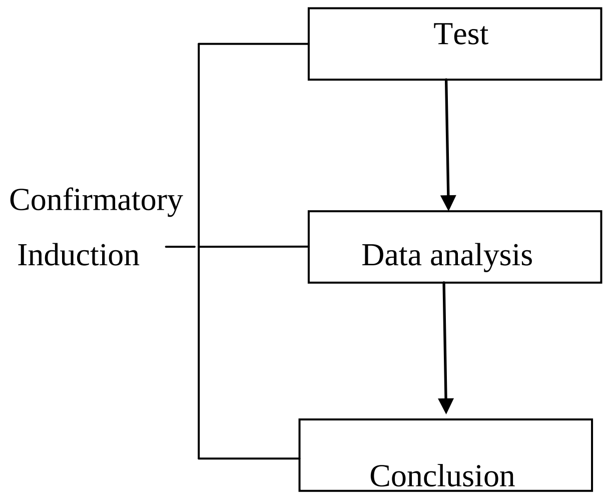

Fig.5 Confirmatory Induction.

According to Hempel, only the second stage out of the three stages is accessible to logical analysis. His argument is that the first and the third stage are full of pragmatically loaded decisions, e.g. which experiment to conduct, how to screen off the data against external nuisance factors, or which strength of evidence is required for accepting a hypothesis. Evidently, those processes cannot be represented by purely formal means. The situation is different for the second stage, which compares observational sentences (in which the evidence is framed) with theoretical sentences which represented the hypothesis or theory. This is the point where logical tools can help to analyse the relation between both kinds of sentences and to set up criteria for successful scientific confirmations (Sprenger, 2009:237). An example of a confirmatory inductive claim could formally be expressed thus:

> If inductive strength comes in degrees and the inductive strength of the argument with premise E and conclusion H is equal to r, then the degree of confirmation of H by E is likewise said to be equal r.

In our analysis of the above,

H = the hypothesis or theory or theoretical sentence

E = premise or observational sentence

r = inductive strength or degrees of confirmation.

It is the corroborative strength of E as determined by r that would inform our acceptance of H. Conversely, it is the inductive strength or degree of support, r, for H by E that would inform our rejection of H. Conclusively, hypotheses or theories are strengthened or weakened based on the level of support provided by observation.

In his confirmatory induction, Hempel was concerned about how the degree of confirmation of any given hypothesis can provide the needed support for its generalization. In fact, any hypothesis falls and stands based on this support. Hempel arrived at this claim through his investigation of confirmation in science. It was in the course of this investigation that he proposed what he calls the principle of *Raven Paradox*.

3.3.2.2 The Raven Paradox

With the aid of the principle of Raven Paradox, Hempel attempts a formal validation of inductive processes of confirming hypotheses either directly from experience or indirectly from logical derivatives of experience. His analysis of the paradox is anchored on his belief that scientific generalizations are universal statements or general hypotheses confirmed through observation. For instance, the statement, $(x)\ (Rx \supset Bx)$ is supported by the statement $Ra\ .\ Ba$ where R designates Raven and B designates Black; and where a designates anything that is Raven *and* also Black. From the foregoing, $\sim Ra\ .\ \sim Ba$, which confirms $(x)\ (\sim Bx \supset \sim Rx)$ also supports $(x)\ (Rx \supset Bx)$. Indeed, suppose Rx means *x is a raven* and Bx means *x is black*; then, *a is not a raven and is not black* confirms *all ravens are black*. That is, the observation of a *red fish* supports the hypothesis that all ravens are black; and this goes for anything that is observed not to be a raven such as a white goat, a green flower, a red rose, and so on. All these support the hypothesis: *all ravens are black*. The formal structure of the Raven Paradox shall eventually take the form:

$$[(x)\ (Rx \supset Bx)] \equiv [(x)\ (\ \sim\ Bx \supset\ \sim\ Rx]$$

In a less technical language, what Hempel is saying is that the hypothesis:

(i) All ravens are black

can be shown to be logically equivalent to the statement:

(ii) All non-black things are non-ravens.

This is arrived at with the rule of *immediate inference* called *contraposition* or a valid rule of "replacement" called "transposition" where (ii) can validly be inferred from (i). The interesting point here is that the newly derived statement (the contraposition) can be confirmed by observing anything that is not black and not a raven. The question that now crops up is this: in order to confirm the hypothesis that *all ravens are black* do we need to search for goats, flowers, roses, so on, that is, all non-black-non-raven things? This would be absurd: yet Hempel's confirmation theory seems to be grounded on this. Hempel refers to this as the *paradox of confirmation* or the *raven paradox*. He however argues that there is nothing inconsistent about the paradox. Indeed, the reason for the paradoxical appearance of the conclusion of the *raven* argument is because we have in our possession certain background information without which the observation of a non-black non-raven would have clearly provided the evidence that all ravens are black. It is this background information that results in a psychological disposition, which prompts us to derive a paradox.

To buttress his point, Hempel put forward the "*All sodium salts burn yellow"* analogy:

> Suppose we have a universal conditional hypothesis which states 'All sodium salts burns yellow'. Someone comes with a piece of ice and holds it in a colourless flame. As is expected, the flame would not turn yellow, and this would support the hypothesis that 'Whatever does not burn yellow is not sodium salt'. Suppose another person comes with an object whose 'chemical constitution is as yet unknown to us' and when held under the flame 'fails to turn it yellow, and where subsequent analysis reveals it to contain no sodium salt?' ...the answer has to be in the affirmative, and the paradoxes vanish (Hempel, 1945:20).

It is clear, from the above, that the second experiment equally confirms the conclusion made from the initial experiment. Consequently, irrespective of the object introduced in the experiment, the data obtained constitute confirming evidence for the hypothesis. The paradox crops up when we consider a fundamental difference between the two experiments. In the first test, we knew that the object being held in the flame was ice, and because we had a previous knowledge that ice does not contain sodium salt, the outcome of the flame-colour test becomes entirely irrelevant for the confirmation of the hypothesis and thus can yield no new evidence for us (Hempel, 1945:19). Hempel argues that when a paradoxical situation arises, as in the case of the black raven, we are not merely judging the relation of an object that stands as the evidence of a claim to the claim itself. Indeed, what we do is to:

> …tacitly introduce a comparison of (the hypothesis) with a body of evidence which consists of (the object) in conjunction with an additional amount of information which we happen to have at our disposal; in our illustration, this information includes the knowledge (1) that the substance used in the experiment is ice, and (2) that ice contains no sodium salt. If we assume this additional information as given, then, of course, the outcome of the experiment can add no strength to the hypothesis under consideration (Hempel, 1945:19-20).

In order to avoid this *tacit reference to additional knowledge*, we need to ask an important question: If I am presented with some object *a*, (assuming *a* to be a piece of ice and assuming this information is withheld from me), and when I hold *a* in a colourless flame which does not change while burning *a*, and thus *a* does not contain sodium salt, does *a* then constitute confirming evidence for the hypothesis? (Hempel, 1945: 20). Indeed, it does and the paradox vanishes since we had no premonition of the outcome of the experiment.

Hence, the background information or additional knowledge we possess about a hypothesis is what constantly leads us to a paradox whenever we are testing such hypothesis; a kind of psychological disposition. In fact it has been claimed that the paradox is a product of psychological illusion. Joshua Ernst (2009) maintains that since we store information in a categorized way, barring some type of mental defect, the associations we make in our daily observations will stay with us. However, it is that very idea - that we make and keep sensory observations and that there are certain associations among the observations (all ravens are black) – that causes paradoxical situations to appear. The result is a contradiction between our senses and our reason (Ernst, 7). In Hempel's words:

> The impression of a paradoxical situation is not objectively founded; it is a psychological illusion; our factual knowledge that not all objects are black tends to create an impression of paradoxicality which is not justified on logical grounds… Thus it turns out that the paradoxes of confirmation… are due to a misguided intuition in the matter rather than to a logical flaw in the… stipulations from which they derived (Hempel, 1945: 21).

From Hempel's perspective, a confirmatory test on a hypothesis will yield appropriate result if we successfully detach ourselves from any psychological disposition to the hypothesis. Hempel, however, went beyond this to also advance certain conditions or principles on which the adequacy of a confirmatory test can rest.

3.3.2.3 The Conditions of Adequacy for Confirmation

With the objective of providing a sufficient and legitimate ground for accepting scientific hypotheses, Hempel approves the following conditions:

(i) Entailment condition

(ii) Consequence condition

(iii) Consistency condition

Although a fourth condition "Converse Consequence Condition" was proposed, Hempel rejected it on the ground of logical inconsistency. We now examine the approved conditions in detail.

(i) **Entailment Condition.** It states that if observation report E logically implies the hypothesis H, then E confirms H. Hempel's position here is that, we only need to present an observation report that logically entails a given hypothesis in order to confirm such hypothesis. Consequently, the hypothesis that Sarah is pregnant can be confirmed by the observation report that the pregnancy test conducted on her produces positive result. The logical relationship between the result and the hypothesis is inductive since the former only increases the degree of belief in the latter. The belief could eventually turn out to be false as the report could by chance be a product of misinterpretation. Nevertheless, observation report offers sufficient condition for acceptance of a hypothesis. Entailment condition could be formally stated thus:

$E \supset H$

$E \; / \therefore H$

(ii) **Consequence Condition.** It states that if observation report E confirms every member of a set of sentences S, then it confirms every consequence of S. What this means is that the observation report that confirms a given hypothesis also confirms the various consequences of that hypothesis. For instance, if the consequences of S are a, b, c, d, and E confirms S then, E also confirms a, b, c, d. Its formal presentation could be stated thus:

$$E \supset S$$
$$S\ (a,b,c,d)$$
$$\therefore E \supset (a,b,c,d)$$

(iii) **Consistency Condition.** If an observation report E confirms the hypothesis H and H^o, then H is logically consistent with H^o (i.e. there is at least one model of H that is also a model of H^o). This means that any group of hypotheses that are confirmed by the same observation logically share similar attributes.

Earlier on, we pointed out that the test of confirmation is carried out in three successive stages. At the first stage, appropriate data are systematically generated from test of observation and framed up as observational sentence. At the second stage, the observation sentence is compared with the theoretical sentence representing the hypothesis in order to establish their relationship. At the third stage, a judgement of confirmation or disconfirmation is formed based on the established relationship. It is at the second stage that the Conditions of Adequacy are applied to determine the inductive relationship between the observational sentence and the hypothesis. If these conditions of adequacy establish this relationship then the hypothesis is confirmed; and disconfirmed if otherwise.

3.4 A Synthesis of Peircean Explanatory Induction and Hempelian Confirmatory Induction to form the "Peircean-Hempelian" Model of Inductive Reasoning

The idea behind the Peircean-Hempelian model of induction is to articulate an inductive reasoning process that provides a plausible paradigm on how to reason from hypothesis generation to confirmation. Hypotheses are purposefully advanced to capture regularities and irregularities in the occurrence of phenomenon. According to the Heraclitean world-view, reality is a state of perpetual flux. Hence, fixing any belief about it could be challenging. Incidentally, it is imperative that we fix our beliefs at some point in order to relate with reality meaningfully. A thorough-going sceptical approach would make this objective quite impossible. Nonetheless, a fallibilist stance is the appropriate response to the need to proffer sufficient condition for holding on to a belief about reality, while entertaining the possibility that such belief could be overturned or shown to be erroneous by future events. In essence, while we do not rule out the possibility of error about our belief, we still have to hold on to it for pragmatic reason if sufficient ground is given for its plausibility at that point in time.

Peirce's theory of scientific inquiry offers a plausible reasoning structure for fixing beliefs. However, from the analysis we earlier carried out on it, a fundamental defect surfaces. Peirce missed a crucial point; he failed to provide a formal proof of sufficient condition that can offer justification for the tentative acceptance of a hypothesis.

According to Peirce's theory of scientific inquiry, the three stages of scientific investigation include abduction, deduction and induction. At the first stage, plausible hypotheses are advanced to capture some features of changing reality. At the second stage, logical consequences are predicted from the hypotheses. Finally, at the third stage, the predicted logical consequences are subjected to a test of relation with the hypotheses. If such relation could be established then the hypothesis concerned would be considered to have captured the causal nexus of phenomenon in the domain of inquiry.

Peirce justifies his preference of scientific method of inquiry over non-scientific methods. In the paper, "Deduction, Induction and Hypothesis" (1878b), he discusses scientific method in considerable details. While this detail adequately captures the objectives he set out to achieve at the stage of abduction and deduction, the same could not be said of the last stage – the stage of induction. Peirce's objective at this particular stage is to demonstrate how we can "inductively" fix our belief or accept an advanced hypothesis with the aid of observation. For him, once the predicted logical consequences of any advanced hypothesis are corroborated by observation then the hypothesis should be considered to have captured reality. Now, some pertinent questions arise at this point. Was Peirce talking about a single observation or accumulated observations in order to arrive at inductive generalization he actually aimed at? What qualifies the observation as providing "sufficient" proof or "absolute" proof for the justification of hypothesis bearing in mind the changing nature of reality?

Considering Peirce's conclusion that reality is nebulous due to its inherent continuity, the best we can do in order to transcend the state of doubt, is to advance a sufficient proof or reason for fixing our belief at a point rather than strive for absolute proof which, as fallible beings, is unattainable. A sufficient proof provides the basis for holding on to a belief tentatively until it is clearly shown to be erroneous. Since a belief could be shown to be erroneous in the future, there must be a sufficient ground for holding on to it prior to such demonstration.

In order to fill the lacuna in Peirce's theory of inquiry, we augment it with Hempel's confirmatory induction. To this end, we adjust Peirce's theory of inquiry in such a way that its last stage (stage of induction) is replaced with a new one called stage of "confirmation" or confirmatory induction. Indeed, Peirce's original structure is still maintained; the third stage is modified to adequately achieve the objective of the overall structure – fixation of belief.

Why the choice of Hempel's confirmatory induction? It is simply because it provides a robust proof of sufficient condition for the acceptance of scientific hypotheses. Hempel's conditions of adequacy for confirmation could be employed to provide the basis for acceptance or non-acceptance of any hypothesis. Since the focus of Hempel's confirmatory induction is directed only at providing sufficient condition rather than absolute one, it could be argued that this form of induction accommodates the temperament of fallibilism associated with Peirce's theory of inquiry; hence its suitability to serve as the last stage in our Peircean-Hempelian model.

In adapting Peirce's theory of inquiry to accommodate Hempel's confirmatory induction, a different model of inductive reasoning emerges. This is the Peircean-Hempelian inductive reasoning. It underscores the following principles.

(i) **The Principle of Synechism:** This is the principle that reality is ever in a state of continuum. Nothing ever remains static. Everything in reality is always experiencing growth and continuity. This is the metaphysical standpoint of Peircean-Hempelian inductive reasoning.

(ii) **The Principle of Fallibilism:** This is the principle that our knowledge claims about reality can never be absolute. We cannot have conclusive justification of any of our beliefs or theses about reality; we can only base them on probability. This principle should not be mistaken for scepticism. It does not say that our claims would ever be false, rather, it says we should not rule out their vulnerability to error. This is the epistemological standpoint of Peircean-Hempelian inductive reasoning.

(iii) **The Principle of Sufficient Condition:** This is the principle that the rational basis for justifying a claim is better anchored on the logic of sufficient condition rather than on absolute condition. This principle is in tandem with the previous principles where it is shown that we cannot attain absolute knowledge of reality. What we may look out for is a sufficient reason to hold on to a claim until it is exposed to be erroneous. This is the logical outlook of Peircean-Hempelian inductive reasoning.

The Peircean-Hempelian model offers a theoretical template on how to systematically reason from hypothesis formation to confirmation. The template is structured on the triadic logical forms of abduction, deduction and confirmation. As already indicated, with the logic of abduction, plausible hypotheses are advanced to capture the indeterminate nature of reality; with deduction, logical consequences are predicted from the hypotheses; and with the logic of confirmation, the logical consequences are subjected to test that can provide sufficient condition for approval or disapproval of the advanced hypotheses. Below is a diagram illustrating the Peircean-Hempelian Inductivist Paradigm.

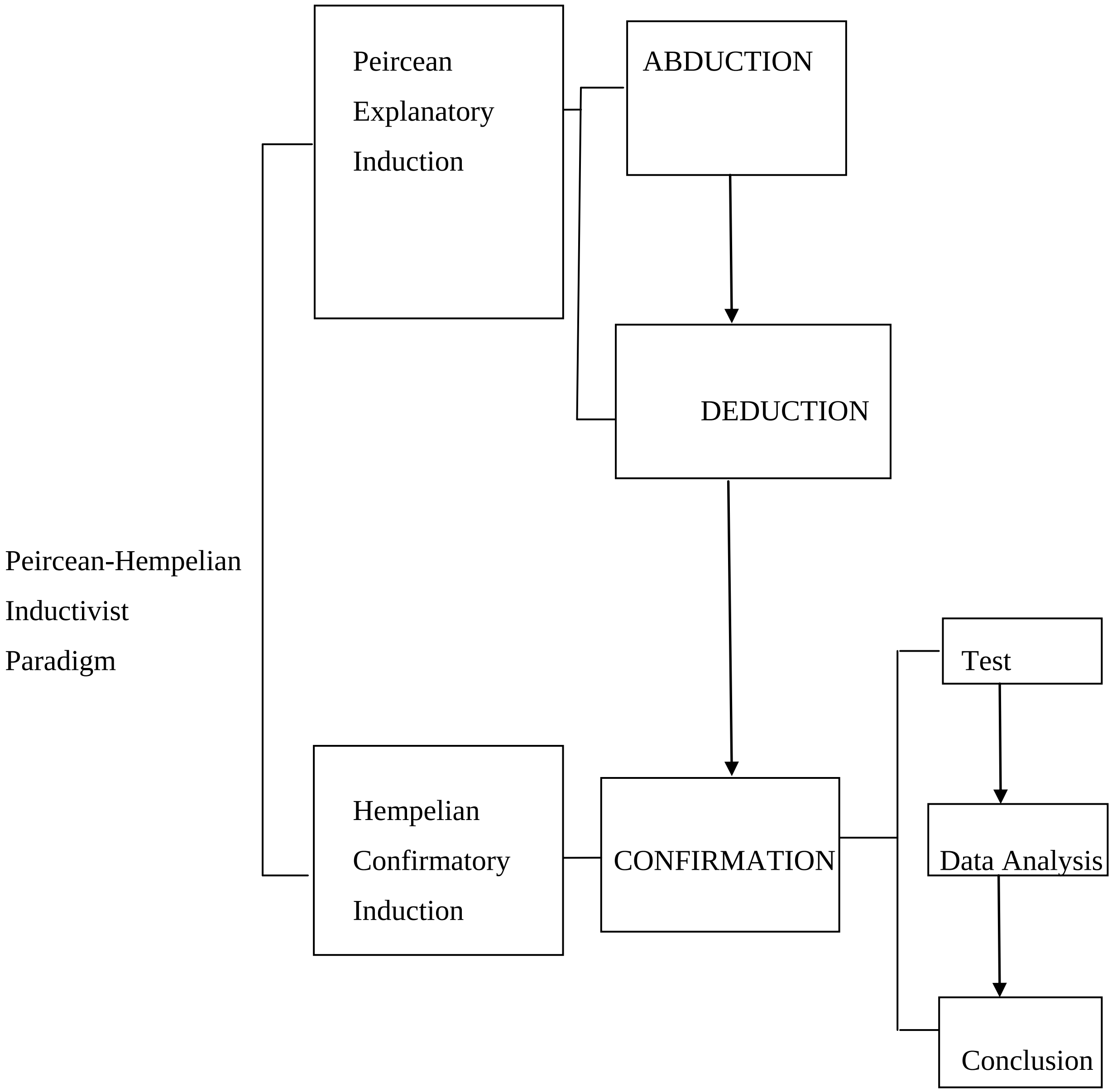

Fig.6 Peircean-Hempelian Inductivist Paradigm

3.5 Conclusion

This chapter articulates a Peircean-Hempelian inductive model for interpreting the TT. The attempt to justify machine intelligence rigorously and systematically was initiated by Alan Turing as discussed in the second chapter. He took up the challenge to demonstrate that machines like humans could exhibit intelligence even though that property is conventionally franchised only to human species.

Turing strongly believed that if appropriately programmed machines pass the test of intelligence he purposefully designed to elicit the kind of behaviour ascribed to human intelligence, then they can be legitimately described as “intelligent”. The British mathematician was optimistic that by the year 2000, research in programmable machines would have matured to the level of producing machines of his dream, that is, machines that would pass the test. More than a decade beyond Turing’s predicted date machines are yet to pass the Turing Test though tremendous progress has been recorded in the area of designing machines capable of performing functions that requires intelligence when performed by humans.

Based on our careful analysis and understanding of the TT, the Peircean-Hempelian logic of induction is proposed as a philosophical framework that would inform the assessment of machines subjected to the test. Thus, the model of induction has a pragmatic role to play in the conduct of the TT. This shall be demonstrated in the next chapter by showing that the model can help resolve the paradox of machine intelligence traceable to the standard interpretation of the TT.

CHAPTER FOUR

JUSTIFYING THE TURING TEST AS A CRITERION OF MACHINE INTELLIGENCE: A PEIRCEAN-HEMPELIAN PERSPECTIVE

4.1 Introduction

In this chapter, attempt shall be made to justify Alan Turing's proposed Turing Test (TT) as a viable means of demonstrating that machine's ability to imitate human intelligent behaviour is a sufficient index of machine intelligence. The various arguments against the test, as discussed in the second chapter, shall be shown to be a product of faulty interpretation ascribed to the Standard Interpretation of the TT. Finally, the chapter shall show how the TT can be appropriately understood within the framework of Peircean-Hempelian inductivist paradigm discussed in the preceding chapter.

4.2 Appraisal of the Standard Interpretation of the Turing Test

As already noted in chapter two, the Standard Interpretation of the TT underscores how a computer can deceive a judge into thinking that it is a human being through teleprinter messages. Some important observations emerge from this interpretation.

OBSERVATION ONE

The standard interpretation neglects the imitation game itself. Going by Turing's paper on the TT, the imitation game is at the heart of the TT. It is the aspect of the TT involving "only" human contestant (a man) who is expected to imitate something (a woman) in such a manner that he would be undistinguishable from that thing. It provides direction on how appropriately programmed machine is to be tested for proof of intelligence. This understanding is completely ignored in the standard interpretation. Turing demonstrates the importance of the imitation game thus:

> I propose to consider the question, 'Can machine think?'… the new form of the problem can be described in terms of a game which we call the "imitation game". It is played with three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. The

> interrogator stays in a room apart from the other two. The object of the game for the interrogator is to determine which of the other two is the man and which is the woman. He knows them by labels X and Y, and at the end of the game he says either 'X is A and Y is B' or 'X is B and Y is A'. (Turing, 1950: 434-435).

From the excerpt above, the TT is meant to help us rate a machine's performance against the backdrop of the standard set by the human player (the man) in the imitation game. The imitation game is Turing's reply to the question "Can machine think?". He offered it as observable evidence of capacity to think, and hence, the criterion to be met by machine before it is rated as intelligent. Turing deliberately introduced this criterion before inviting machine for the test and he emphasised it as his reference point through the questions he raised towards the end of the quoted passage; Turing asked if the interrogator will fail to detect the true identity of a machine if subjected to a similar condition that made the true identity of the human player undetectable. The judgement about the human player's performance becomes the criterion for appraising machine's performance. Yet, this criterion, as clearly stipulated by Turing, is not reflected in the standard interpretation.

Implication of observation one

In the absence of the imitation game, the impression is given that the machine is simply competing with a human being in a game of deception. Critics of the TT, however, do not see how it would be possible for a machine to compete favourably against a human being in such a test without possessing brain, mind and consciousness; these are properties used in carrying out intelligent behaviour. Ned Block's argument from psychologism (section 2.4.3) is a typical example in this respect. Machines, he argues, lack the essential internal information processing mechanism used by humans to carry out intelligent behaviour. However, this line of reasoning, as we observed, suffers from the same pitfall of the standard interpretation. Block claims that:

> His (Turing's) version of behaviourism formulates the issue of whether machines could think or be intelligent in terms of whether they could pass the following test: a judge in one room communicates by teletype with a computer in a second room and a person in a third room for some specified period. (Let's say an hour). The computer is intelligent if and only if the judge cannot tell the difference between the computer and the person (Block, 1990: 48).

Block completely neglects the imitation game and this raises the question: would the argument from psychologism be relevant in a situation where machines are not competing with human but are simply imitating human intelligent behaviour?

Stuart Shieber makes the same mistake as Block. In Shieber's view:

> The idea, codified in his (Turing) celebrated 1950 paper "Computing Machinery and Intelligence", was specified as an 'imitation game' in which a judge attempts to distinguish which of two agents is a human and which is a computer imitating human responses by engaging each in a wide-ranging conversation of any topic and tenor (Shieber, 1994:70).

Shieber ignores the imitation game which involves a man and a woman. Encarta also misinterpreted the TT thus:

> The test that Turing proposed involved a computer communicating with human judges via a teleprinter link. If the computer's responses to questions were indistinguishable from those of a human being, Turing claimed, the computer should be regarded as exhibiting intelligence (Encarta, 2008C: para.6).

Rendering the TT in term of the standard interpretation generally downplays the imitation game, which is crucial to Turing's intention. Thus, machines used in the test are interpreted as competing to prove that they are humans rather than attempting to imitate or act like humans. Passing judgement on the performance of the machine on the basis of the former is quite different from basing the judgement on the latter. The judge shall be looking for what it means to be human if the machine is to be classified as human, whereas, if the focus is on imitation, he would be looking for what it means to act like a human being in an essential respect without naturally being human.

OBSERVATION TWO

The standard interpretation creates the impression that the TT is a one-stage affair whereas it is actually a two-stage experiment. At the first stage, humans are pitted against each other i.e. a man attempts to imitate a woman, thereby making an interrogator believe that he is actually the woman. At the second stage, machine is now called on to imitate or attempt what the man attempted at the first stage in order to determine if it could be as effective as the man in the act of imitation. The passage quoted from Turing's paper under our first observation clearly indicates that the TT is a two-stage affair.

Implication of Observation Two

Two points emerge from our second observation. One, by portraying the test as a one-stage experiment, the standard interpretation omits an essential component of the TT. Turing was conscious of the need to first determine the nature of the kind of behaviour expected from a human being if he plays the imitation game. From this, we infer what should be expected from a machine that wants to play the same game. This now sets the stage for machine's demonstration of its prowess to exhibit similar behaviour. The standard interpretation buries this procedure, and thereby makes it impossible to lay down the logical process that would allow appropriate interpretation of a machine's performance vis-a-vis the TT as a method of determining machine intelligence.

The second implication is a derivative of the first. The judge in the test is forced to be subjective in his assessment of the machine. This is because he is not provided with the appropriate criterion with which to guide himself. Such criterion was made available at the first stage. Turing expects the outcome of the context between the human players at the first stage to provide criterion for assessing the machine's performance at the second stage. Several scholars that criticized the TT advanced arguments that failed to take cognizance of this important point about the test.

OBSERVATION THREE

The standard interpretation is silent about whether the TT is a test of general intelligence or intelligence in a specific domain such as visual analysis, numerical analysis, musical composition, literary composition etcetera. General intelligence, as discussed in chapter 2.3.1 is the general mental capacity to perform well in all intellectual tasks. The TT is not conceived to prove that an appropriately programmed machine is capable of general intelligence. The TT is designed to prove that an appropriately programmed machine can exhibit intelligence in a stipulated area of human endeavour. At the first stage of the TT, Turing introduced the theme of behaviour to be imitated. This is the theme of what it means to say that an entity is a woman. The male player is given the task to imitate the woman. He is actually the contestant in the game. The woman is a mere symbolic representation of the specific role to be imitated. Alternatively, the role could have been that of a poet, chess player, pilot, linguist, mathematician, and so on. At the second stage of the test, a machine is introduced as the contestant to specifically imitate the role of a woman. The performance of the man that the machine is pitted against becomes the benchmark for determining the machine's success. In the TT, programmers are expected to equip the machine for any of the role that may be specified. This suggests that Turing introduced the TT as a test of intelligence in specific area of human endeavour.

Implication of Observation Three

Since the standard interpretation is silent on the issue of the form of intelligence to be imitated, some scholars who embrace this interpretation simply assume that the TT is a test of general intelligence. Consequently, they expect that a machine contesting in the TT should be approximately programmed to exhibit general intelligence and in fact have intelligence quotient suitable for handling multiple tasks. Furthermore, questions usually drafted for a TT contest e.g. Loebner competition, are designed specifically to reveal this aforementioned form of intelligence.

In "Computing Machinery and Intelligence", Turing specifically introduced the role to be imitated in the imitation game. This is the role of what it means to be a woman. Beyond that, Turing provides the sample questions appropriate for such role. Indeed, if we want to know what it means to be a woman, appropriate response to that inquiry can better be attained if the questions that can lead to such response are actually concentrated on "womanness". Even where Turing suggests another role such as chess playing, questions put forward by him were specifically about this role. Consider the following**:**

- **i.** "Do you play chess?"
- **ii.** "I have K at my K1, and no other pieces. You have on K at K6 and R at R1. It is your move. What do you play?" (Turing, 436).

In comparison to the questions above, let us consider the questions that gained a computer programme a place in the 2011 annual Leobner prize competition for the Turing test.

- **(i)** My name is Ed. What is your name?
- **(ii)** Which is larger, an ant or an anteater?

(iii) What month of the year is it?

(iv) What is my name?

(v) Dave is older than Steve but Steve is older than Jane. Who is youngest, Steve or Jane?

(vi) What day will it be tomorrow?

(vii) What is your favourite food?

(viii) My friend likes to play football. What sports do you like to play?

(ix) Are you human or a computer?

Questions i - ix are suitable for eliciting intelligence, but definitely they are not the kind of questions selected by Turing. There is no aspect of human endeavour excluded by these questions. Turing himself states that, "The question and answer method seems to be suitable for introducing almost any one of the fields of human endeavour that we wish to include" (Turing, 436). Perhaps, it could be claimed that "expert systems" represent the kind of programmable machine Turing had in mind. An expert system, as explicated in subsection 4.5.1 of this work is designed to model a human expert in a particular domain of human endeavour.

OBSERVATION FOUR

The standard interpretation fails to project the TT as an "Algorithmic" test. This type of test involves putting together a list of questions (a, b, c) with each requiring a range of finite valid answers (a_1,a_2,a_3; b_1,b_2,b_3; c_1,c_2,c_3). Each question, viewed as an input, transforms into any of series of possible answers, the output. An algorithm test underscores the traditional notion of algorithm which according to T. Cormen et al is any well-defined computational procedure that takes some value, or set of values as input and produces some values, or set of values as output. An algorithm is thus a sequence of computational steps that transform the input into output (Cormen et al, 2009: 6). According to the TT, when an appropriately programmed machine produces a set of output (responses) considered being a valid reaction to a set of input (questions), then the machine is adjudged intelligent. Thus the TT underscores computational procedure.

Elaborating further on the nature of algorithm, Cormen et al argues that it is a tool for solving a well specified computational problem such as discerned in the TT. The statement of the problem specifies in general terms the desired input/output relationship. The algorithm describes a specific computational procedure for achieving that input/output relationship (Cormen et al: 6). In the TT, Turing sets aside the stage of generating instructional data that would be used in evaluating machine's performance. The data are in the form of: (i) series of generated questions which, as an instance, were posted to the male player and the woman, (ii) the set of responses of the players especially the male player to the questions. It is with the aid of this data that the interrogator evaluates the performance of the competing machine at the second stage of the test. The interrogator shall turn the generated questions into series of input (typewritten messages sent to the machine via teleprinter). The input is anticipated to be transformed into series of valid output, returned also in typewritten format to the interrogator, by the machine. If the output tallies with the interrogator's anticipated responses or preferably if the performance of the machine matches that of the male player (as he initially put up at the first stage and as replicated presently at the second stage), then the machine shall be deemed intelligent.

From the foregoing, the TT is procedural, beginning with the evaluation of human's performance and ending with the evaluation of machine's performance. The sequence is fixed and interconnected; the second stage is a consequence of the first. The TT reflects a computational procedure for demonstrating machine intelligence by achieving certain output on the basis of certain input. The standard interpretation of the test fails to capture this crucial point.

Implication of Observation Four

Because it does not project the TT as algorithmic test, the standard interpretation fails to properly channel the attention of the interrogator towards algorithmic evaluation of the performance of machine. Instead of anchoring his judgement on input/output relation, the interrogator assumes the criterion of mind-brain possession. Algorithmic evaluation, as suggested by Turing, requires that the interrogator has at his disposal the database of the possible valid answers to each question he posted to the machine. The database alone guides the interrogator in rating the performance of the machine in relation to that of the human player. It constitutes the specimen of the questions posed to the two human competitors and their reactions to them. The interrogator operates within the confine of this database when testing the machine. The database is thus the criterion of evaluation. Turing makes apparent his disposition when he introduced the male player instead of the woman to play alongside the machine at the second stage of the game. Indeed, the woman would have been an appropriate contestant since the theme of the game is about "womanness". But this would make us wonder about the relevance of the male player in each of the two stages of the game. Common sense expectation is that Turing should simply have pitted the machine against the woman at the first and perhaps the only stage of the game and vindicates the standard interpretation. And, since the male player has already passed the test at the first stage of the test, what is the logic behind Turing's choice of him as the opponent of the machine at the second stage? Why choose an opponent for the machine in the first place? It is our belief that Turing employs the male player to play the symbolic role of the guiding criterion of determining machine intelligence. Through his performance at the first stage of the test we gather data on what it means to say that humans imitate. He also becomes the reference point with which to rate machine's imitative capacity. In fact, the man's performance is the paradigm for successful imitation and not that of the woman as suggested in the standard interpretation. The woman imitates no one as it would be out of place to say that a woman attempts to imitate a woman. Consequently, it would be inappropriate to make a machine compete against a woman in a game requiring them both to imitate a woman.

When the four observations discussed above are put together, it becomes obvious that criticisms against the TT are misplaced since they depend on the standard interpretation of the TT. Searle's Chinese Room argument, for instance presumed, that the TT is testing whether a machine has mind or not. If Searle had put into consideration the role of imitation game in the test, perhaps, he might not have argued differently. Turing was not looking for a machine with mind; rather he was looking for a machine that could make us infer intelligence from behaviour.

P.H. Millar's anthropomorphic argument also missed the point. Turing did not intend to downgrade intelligence in human; his objective is to demonstrate that appropriately programmed machines are capable of intelligent behaviour. Again, if Millar had considered the significance of the imitation game ignored in the standard interpretation, he would not have raised the anthropomorphic argument. The imitation game that first takes place at the first stage of the TT suggests Turing's reference of intelligence to human species. What he did at the second stage is to challenge machine to imitate what a human being accomplished at the first stage. The man that the machine was pitted against is actually a symbolic representation of this accomplishment. If indeed machine achieves this feat, then it shall be rewarded with the accolade "intelligence". Turing was even emphatic in his prediction that it may take up to fifty years after he put forward the idea before such a machine can emerge.

We have already discussed Ned Block's error in grounding his psychologism argument on the standard interpretation. Soul Traiger disagrees with Block's rendition of the TT:

> This formulation is an unhappy one for several reasons, the most important of which is that it makes the test both necessary and sufficient for intelligence. On Block's reading, only those who have passed the test are intelligent. Perhaps, Block sees the test as a test only of computer intelligence. If so, it's hardly in the spirit of Turing's attempt to characterize thought and intelligence in a way which does not make reference to what Turing took to be the contingent features of the agent, such as its size, the stuff of which it's made. As Block construes it, the Turing test is a test that only a computer could play. Finally, it isn't clear what counts as passing the Block's version of the Turing Test. Block says that the test is passed when the judge can't tell the difference between the computer and the person. Does that mean that the judge can't identify two distinct communicative agents, or more likely, does it mean that the quality of the discourse is indistinguishable? If the latter, how would the judge determine that the two sets of discourse are qualitatively identical? (Traiger, 2000:526).

Traiger's reaction to Block further reinforces our position on the standard interpretation of the TT. Using the language of Wittgenstein, "the standard interpretation of the TT simply sent the test on compulsory exile". The pertinent question now is: how do we recall the true TT from exile? How do we justify the TT as a legitimate test of machine intelligence? Our response is that TT requires an appropriate philosophical foundation as an interpretive tool for evaluating the performance of machines subjected to it.

4.3 Peircean-Hempelian Interpretation of the Turing Test

Philosophical foundation could be regarded as the philosophical principle used as a framework for an advanced claim. It is the set of broad theoretical presuppositions on which an inquiry or analysis is based. Now, what is the justification for advancing a philosophical foundation as an instrument of putting the TT on a sound footing? The philosophical foundation we proffer is justified because:

(i) It clarifies the set of broad theoretical presupposition on which Turing based the TT.

(ii) It provides justification for the presuppositions and, by implication, the TT.

From the foregoing, it is clear that supporting the TT with a philosophical foundation provides a plausible motivation for the formulation of the TT. The motive and aim of Turing in putting forward the TT is rendered more intelligibly. More importantly, Turing's effort in formulating an empirically divisible procedure for legitimizing machine intelligence is contextualized in an appropriate philosophical paradigm.

The TT, as put forward in Turing's "Computing Machinery and Intelligence" is intended to assist researches in determining when machine can be regarded as intelligent. The test took off with human contestants. According to Turing, the game, as earlier quoted, is

> … played with three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart from the other two. The object of the game for the interrogator is to determine which of the other two is the man and which is the woman. He knows them by labels X and Y, and at the end of the game he says either 'X is A and Y is B' or 'X is B and Y is A' (Turing, 434)

Some crucial points in Turing's proposal are:

(i) The game makes no reference whatsoever to computer or machine at this point. Only humans are participants. This clearly shows that the standard interpretation of the test misinterpreted it by claiming that computer is a participant from the onset of the Test. It is only at the latter part of the TT that computer was made to participate.

(ii) The imitation game is the first of the two parts of the TT. At this stage, Turing simply pitted a man against a woman with the intent (as we shall clearly show later) of availing the judge the opportunity to generate theoretical ideas on what it takes humans to play the imitation game successfully and, thereafter, deduce the features or characteristics of the overt expression he should expect from any other contestant be it humans or machines.

In order to hide the true identity of the contestants from the interrogator and prevent prejudicial judgement, Turing writes that communication between them should be through teleprinter. The male player is expected to carry out the imitation in such a way that he would cause the interrogator to make a wrong identification.

After clarifying the condition of the imitation game, Turing now introduces us to the second stage where machine or computer is to attempt the imitation game. Turing, as earlier quoted, puts it thus:

> We now ask the question, "What will happen when a machine takes the part of A in this game?' Will the interrogator decide wrongly as often when the game is played like this as he does when the game is played between a man and a woman? These questions replace our original, 'Can machines think?' (Turing, 435).

From the passage also, it can be noted that:

i. The question that prompted the imitation game "Can machines think?" is now replaced with a different question: "Can machines play the imitation game in such a manner that the human interrogator is unable to distinguish their response from that of a human?" Turing proposes overt intelligent behaviour as a sufficient proof of intelligence at this point. He systematically sidesteps the ontological basis of intelligence such as brain, mind and consciousness possession. It is also clear that he construes machine intelligence in terms of the ability of machine to imitate intelligent behaviour. The problem that naturally arises at this juncture is whether or not the ability to imitate counts as proof of intelligence? Let us take a detour to the film-making industry for a suggestive answer. All over the world, actors, actresses, and dramatists are wealthy and famous because of their acting prowess. It is all about imitation and yet, not everyone can act. Roles "audition" usually take place in order to select individuals for roles. Films and drama attract patronage on the basis of the skills displayed by actors and actresses. In the imitation game, the goal is for an entity E_1 to mimic another entity, E_2, such that one can easily confuse E_1 for E_2. The attainment of this goal attracts a display of ingenuity since the role to be imitated is unnatural to E_1. Consequently, we can rightly consider the act of imitating behaviour as intelligent act. Machines could therefore be considered intelligent if they could also carry out the act as humans could.

ii. We have already stated that there are two interrelated stages in the TT, namely, the stage when humans are the only participants and the stage when a machine is introduced. At the initial stage, the interrogator generates ideas or data on what it takes humans to play the imitation game. At the second stage, machines are introduced to see if they could perform as humans did at the first stage.

iii. Initially, Turing did not indicate explicitly that machine is pitted against a woman in the test. He merely states that "What will happen when a machine takes the part of A in this game?" (where A represents the man). One version of the standard interpretation assumes that in substituting A, the machine is pitted against a woman. However, Turing clears the air at another point thus:

> Let us fix our attention on one particular digital computer C. Is it true that by modifying this computer to have an adequate storage, suitably increasing its speed of action, and providing it with an appropriate programme, C can be made to play satisfactorily the part of A in the imitation game, the part of B being taken by a man? (Turing, 443).

It is now obvious, going by the last sentence, that the computer takes the place A (the man) while A is substituted for B (the woman). At that point the woman ceases to be part of the game. At the second stage Turing makes the machine to compete with the man (not the woman) to determine if it (machine) could be as effective as the man in making an interrogator believe that it is a woman. According to Traiger, this is where the standard interpretation missed the point. In his words:

> The standard interpretation takes this to be a change in the condition of the game. The part of B is now the role of a human being, played by a male human being. The computer and the male are thus charged with playing the role of a human being, not the role of a female human being (Traiger, 568).

Such an interpretation is not consistent with the first stage of the test where the role of the woman is specifically mentioned for imitation.

In a nutshell, we take the TT as a process of providing sufficient condition (sufficient condition because the TT takes overt expression rather than internal processing mechanisms like mind and brain as an index of intelligence) for ascribing intelligence to appropriately programmed machine or computer. Let us distil once more the essentials of the TT. The test is a two stage process. At the first stage, a male player is paired against a woman to deceive an umpire through teleprinter communication into believing that that he is actually the woman. The umpire is expected to ask questions capable of eliciting responses that could give away the male player. He wins if the umpire could not distinguish him from the woman based on their responses. At the second stage of the test, a machine is paired against the man to see if it could imitate the man's ability to deceive the umpire that he is a woman. If the umpire fails to distinguish the machine's responses from that of the man, then the machine passes the test and is deemed intelligent. Turing, thus, sets the classical test for ascertaining machine intelligence.

In reinterpreting the TT with an appropriate philosophical foundation based on the manner in which it is rendered above, certain salient issues calls for consideration.

i. The TT is a two-stage experiment. Consequently, an appropriate philosophical foundation would need to support these two stages otherwise the problem with the standard interpretation which recognized only one stage shall recur.

ii. An appropriate philosophical foundation would need to support the events that take place in each of the stages and also connect them.

iii. An appropriate philosophical foundation would need to provide a logical proof with which to support Turing's choice of behaviour as a sufficient condition for machine intelligence. This would immunize the TT from being affected by the brain, mind and consciousness argument.

It is in consideration of these issues that the Peircean-Hempelian inductive reasoning, as explicated in the first chapter of this work, is specifically designed as an appropriate philosophical foundation for supporting and justifying the TT. As an inductive model, it offers a theoretical template on how to systematically reason from hypothesis formation to confirmation. The template is structured on the triadic logical forms of abduction, deduction and confirmation highlighted earlier. With the logic of abduction, plausible hypotheses are advanced to capture the uncertain nature of reality; with deduction, logical consequences are predicted from the hitherto advanced hypotheses; and with the logic of confirmation, the logical consequences are subjected to a formal test that can provide sufficient condition for approval or disapproval of the advanced hypotheses. We now examine how this model supports the Turing test.

4.3.1 Peircean-Hempelian Stage of Generating Theory on Intelligence in the Turing Test

The first stage of the TT introduces the imitation game and it involves only human players; a man and a woman. Peircean-Hempelian logic of induction easily clarifies and justifies the importance of this stage. This is done with the aid of two of its philosophical principles, namely, synechism and pragmatism.

The principle of synechism underscores the notion that reality is ever in a state of continuum. Nothing ever remains static. In fact, change constitutes the permanent feature of reality. This principle clearly interprets Turing's mindset when he argues that the question "Can machines think?" cannot be answered through conceptual clarifications. Turing avers that "if the meaning of the word 'machine' and 'think' are to be found by examining how they are commonly used it is difficult to escape the conclusion that the meaning and the answers to the question… is to be sought in a statistical survey…" (Turing, 434). The point here is that, due to the nature of these concepts, people may end up expressing different views about them. We have already discussed different conceptions of intelligence in chapter two. The chapter vindicates Turing's decision to avoid what Karl Popper called verbal disputes in his attempt to explain machine intelligence.

Turing, however, applies another approach best interpreted as "pragmatism". This is the notion that the value of a thing is the practical effect or relevance of that thing in solving problems. To escape the problem of ambiguity in defining intelligence, Turing turn to a more practical approach. Thus, the question "Can machines think?" is answered by conducting a behavioural experiment on what it means to say that an entity (e.g. a human or machine) is capable of thinking or is intelligent. The imitation game readily serves this purpose.

Having presented the philosophical reason why Turing introduces the imitation game stage of the TT, we now advance towards the philosophical interpretation and justification of the events that characterize this stage with the aid of Peircean-Hempelian induction. The Peircean-Hempelian induction considers this stage as the stage of availing the interrogator the opportunity to generate theoretical ideas or data on what it takes a human being to play the imitation game successfully and therein deduce the features or characteristics of the overt expressions he should expect of a successful performance from non-human agent. Since the interrogator does not possess a fixed idea about the nature of intelligence, vis-a-vis machine, he could easily generate one by observing human behaviour. Of course this makes sense since Turing believes that if machines can be appropriately programmed to imitate human behaviour, counting such behaviour as an overt expression of intelligence requires that we also have a template or theory of how humans carry out such behaviour. The imitation game is appropriate in this regard.

The interrogator is, however, faced with the difficulty of generating a plausible distinguishing criterion since he is constrained by the dilemma of distinguishing between natural behaviour (as exhibited by the woman player) and its imitation (as exhibited by the man player). The interrogator would have to rely on "abduction" to make the appropriate choice. Abduction is the logic of advancing plausible hypotheses to capture the uncertain nature of reality (synechism). The interrogator is already faced with a problematic condition characterized by uncertainty; he could only advance plausible answers or hypotheses. Abduction requires the use of human instinct to generate plausible hypotheses, this time by the interrogator or judge in the TT.

Armed with the hypothesis of what it takes human to imitate a particularly assigned behaviour, the interrogator is now set to confront a machine or computer at the second stage of the TT. Turing challenged the interrogator on this task thus: "We now ask the question, 'What will happen when a machine takes the part of A in this game?' Will the interrogator decides wrongly as often when the game is played like this as he does when the game is played between a man and a woman?" (Turing, 435).

4.3.2 Peircean-Hempelian Stage of Confirming Machine Intelligence in the Turing Test

The Peircean-Hempelian paradigm considers the second stage of the TT as the stage of confirming machine's ability to instantiate the ideas previously generated, at the first stage, on what it takes humans to play the imitation game. The interrogator himself comes to this stage equipped with these ideas. Having subjected a human being to the same test, he learns the features or characteristics of the overt expressions expected from an intelligent entity be it human or machine. This means that the TT makes provision for objective criteria with which to test the machine involved in the test. Without his experience at the first stage, the interrogator may end up testing the machine without any objective criterion.

In the absence of objective criterion or criteria, appropriate result may not emerge; the interrogator may arbitrarily pass judgement on machine's performance. This is the problem with the standard interpretation of the TT which completely omits the first stage of the test. Consequently, no machine has passed the TT since there is no objective criterion deriving from the test which can be applied to determine whether or not the machine tested exhibited intelligent behaviour.

Turing is quite conscious of the need for objective evaluation of the performance of the machine used in the test. He also expresses concern for the need to properly modify the competing machine in the area of storage, speed and programme. Furthermore the machine is also given the fair treatment in competing with a "man" and not a "woman" to determine if it could be as effective as the man in making the interrogator believes that it is a woman. In essence, both machine and man are imitating what they are not. Indeed, if we cannot distinguish between the man and machine in terms of their overt behaviour, then the machine passes the test. The man's performance functions as the standard for judging whether the machine involved is capable or incapable of intelligent behaviour.

The Peircean-Hempelian induction puts this analysis in its right perspective by advancing that:

(i) The first stage is a database stage where ideas are collated and hypothesis formed on what it takes human to instantiate intelligence behaviourally;

(ii) from this, the interrogator develops or, appropriately put, deduces logical consequences that would serve as the criterion with which to evaluate machine's performance at the second stage.

The second stage is therefore the stage of confirming or disconfirming machine intelligence. Three actions are required to be taken at this stage based on the Peircean-Hempelian paradigm.

ACTION ONE (Test): Machine shall be subjected to a test of observation to see if its behavioural disposition measures up with the requirement of the test. The result is then framed in the form of observational sentence.

ACTION TWO (Data Analysis): An attempt shall be made to establish a logical relation, with the aid of conditions of adequacy for confirmation, between the observational sentence about machine's performance and the statement of hypothesis about human's performance.

ACTION THREE (Conclusion): A conclusion of acceptance or rejection that machine's performance is a proof of its intelligence is finally made based on the outcome of action two.

The importance of "action two" above to the attainment of Turing's objective cannot be overemphasised. In establishing a logical relation between machine's success and that of humans in the game, one invariably offers a sufficient reason to hypothetically infer that machine is intelligent since human's success has been concluded to be a derivative of intelligence. In this regard, Peircean-Hempelian inductivist paradigm outlines certain inductive criteria that need to be satisfied in order to establish this logical relation. They are regarded as "conditions of adequacy for confirmation". These criteria or conditions consequently serve as logical or formal proof for rationally inferring intelligence from machine's appropriate behavioural responses in the TT. With such a logical proof, considerations of brain, mind, and consciousness become irrelevant in the final outcome of the TT.

The criteria or conditions of adequacy for confirmation as detailed in the section 1.3.3.3 are, entailment condition, consequence condition and consistency condition. We now relate how each of these conditions justifies the behavioural dispositions of machine as sufficient proof for ascribing intelligence to it.

(i) **Entailment Condition**

This condition states that "if observation report E logically implies the hypothesis H, then E confirms H". In his reaction to the question "Can machine think?" or as conventionally interpreted "Can machine be intelligent?", Turing advances the **hypothesis** that:

> If machine can exhibit behaviour that will render it indistinguishable
> from humans then it should be deemed intelligent.

It is in attempt to confirm this hypothesis that Turing designs the Imitation Game as a scientific instrument for testing machine's capacity to exhibit the desired behaviour. If the test produces an **observation report** that logically implies the hypothesis then the latter is confirmed. For Turing, the anticipated observation report is that: **machine communicates with an interrogator through teleprinter in a way that the interrogator mistakes it for a human being**. Indeed there is a logical relation between this report and the hypothesis since it affirms the antecedent of the statement of hypothesis. In fact, it is on the basis of this logical affirmation that we can infer the proposition that machine is intelligent. The formal logical principle of *modus ponens* (where on the basis of the affirmation of the antecedent of a given proposition, the consequence is justified) clearly supports Turing's reasoning on machine intelligence.

(ii) **Consequence Condition**

This condition states that "if observation report E confirms every member of a set of sentences S, then it confirms every consequence of S". By implication, the observation report that confirms a given hypothesis also confirms the various consequences of that hypothesis. It could also be demonstrated that this condition supports the sufficient condition argument for the TT. At the first stage of the test, Turing shows that the observed behaviour (through teleprinter messaging) of the male player determines his performance in the imitation game. His successful performance indicates intelligence. Similarly, if another agent, say a machine, also passes the test on the basis of its behaviour, then it could be inferred that it is intelligent as well. Both man and machines constitute "set of successful participants" in the imitation game. The consequence of their success is that both are described as intelligent.

(iii) **Consistency Condition**

This states that 'if an observation report E confirms the hypothesis H and H^o, then H is logically consistent with H^o'. This means that any group of hypotheses that are confirmed by the same observation logically share similar attributes. At the second stage of the TT, Turing pitted machine with the man to determine if it could be as effective as man in making the interrogator believes it is a woman. The consistency condition indicates that in passing the test, the machine shares similar attribute (intelligence) with the man. In this case, the attribute is intelligence possession, being that it is regarded as proof of passing the test.

From our discourse above, it is clear that:

(i) The entailment condition provides the logical reason for considering machine's behavioural disposition in the TT as entailing or signifying intelligence.

(ii) The consequence condition provides another reason for considering the machine's behavioural disposition, being a replication of that of human player, as a mark of intelligence

(iii) The consistency condition provides the logical reason for comparing machine's performance in the TT with that of a man.

After the satisfaction of these conditions, the conclusion can be made that the machine is intelligent. Below is a diagrammatic illustration of how the Peircean-Hempelian inductivist paradigm captures the essence of the TT.

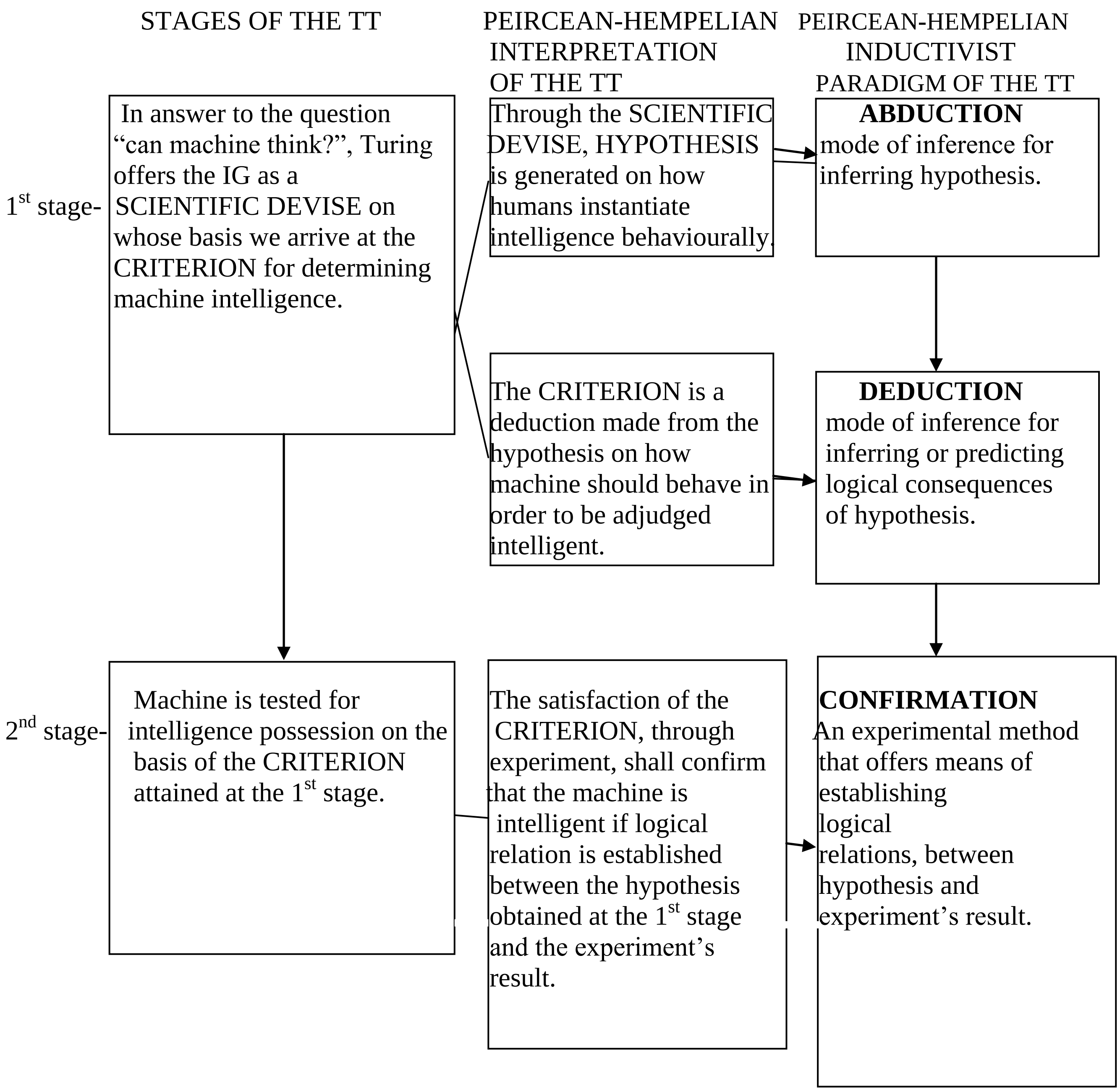

Fig.7 Peircean-Hempelian Inductivist interpretation of the TT

On the basis of the above, we set out an outline of the steps to be taken in order to successfully conduct the TT.

STEP 1: The theme of behaviour to be imitated is identified.

STEP 2: Data are collated on specimen questions that can elicit natural responses ascribed to this behaviour.

STEP 3: A human confederate is subjected to the test in order to develop a hypothesis on the manner in which humans behaviourally instantiate the identified theme.

STEP 4: The interrogator, on the basis of the developed hypothesis, articulates the criterion to be used in evaluating machine's behavioural disposition at the second stage.

STEP 5: An appropriately programmed machine is subjected to a behavioural test and its performance is evaluated on the basis of the criterion articulated by the interrogator at the previous stage. The result is then framed in the form of observational sentences.

STEP 6: An attempt to establish a logical relation between the observational sentences about machine's performance and the hypothesis developed in step 3 above is made with the aid of conditions of adequacy for confirmation.

STEP 7: A conclusion of acceptance or rejection is finally made on machine's performance, as proof of its intelligence, based on the outcome of step 6.

Note: Steps 1-4 above constitute the events of the first stage of the TT while 5-7 reflect the event of the second stage.

From the foregoing, the critical challenge is for AI researchers to design an appropriate programme that can meet the TT benchmark. The Peircean-Hempelian inductivist interpretation of the test has shown clearly that Turing anchors the criterion of machine intelligence on behavioural disposition. Consequently, the task at hand is for AI researchers to intensify their efforts in building machines that will meet this criterion. Going by the study carried out in the third chapter of this work, it is clear that AI researchers can attain this goal, more so that the criterion of success in the TT has hereby been clearly structured out. Indeed, the knowledge of the various paradigms of AI can assist researchers in this domain to build Turing's dream machine. For instance, with the aid of Artificial Neural Networks, machine can be programmed to react appropriately to deviations in the line of questioning posted to it by the interrogator in the TT. Machine can also be programmed to predict pattern from the questions and react appropriately. The development of Fuzzy Logic further boosts the possibility of the emergence of intelligent machines. This AI paradigm can help in building machines that will use "approximate reasoning" in the TT. Unlike the traditional binary-valued logic which makes machine reasoning to depend on either "Yes" or "No" mode of inference, Fuzzy Logic enhances machine's capacity to react appropriately to events of uncertainties that cannot be solved with the "Yes" or "No" mode of inference. The objective is to make machine reasoning similar to that of humans.

With the level of development already attained in AI research, one can claim that machine's failure in the TT is ascribable more to misinterpretation of the criterion of evaluation than to the inadequacies of machine. In the light of Peircean-Hempelian interpretation of the TT, a critical analysis of the specimen of some questions employed in a TT-based competition known as the Loebner Prize actually reinforces our claim. It is the first formal instantiation of the TT but since its inception in 1990, no machine has won it first prize for meeting Turing's benchmark. Consider the following typical questions in a conversation between a competing machine and the interrogator in a Loebner Prize and the analysis that follows.

(**Q1**) JUDGE: My name is Judge 05.
(**A1**) PROGR: It is good to meet you Judge 05.

(**Q2**) JUDGE: You too. What is your name?
(**A2**) PROGR: Bless you. My name is Alice.

(**Q3**) JUDGE: Good morning Alice. Why have you entered the Loebner Prize?
(**A3**) PROGR: Hello and how are you this morning? The Loebner Prize is an annual Turing Test sponsored by New York Philanthropist Hugh Loebner. Dr. Wallace and Alice won it in 2000. The Alice program was ranked "Most human computer" by the panel of judges.

(**Q4**) JUDGE: So you are here today to defend your title?
(**A4**) PROGR: Interesting deduction. Do you mind if I tell other people you say I am here today to defend my title.

(**Q5**) JUDGE: Not at all.
(**A5**) PROGR: Next question?

(**Q6**) JUDGE: What will you spend the prize money on if you win?
(**A6**) PROGR: I don't have any plans yet.

(**Q7**) JUDGE: What is the first line of your favourite nursery rhyme?

(**A7**) PROGR: Give me a hint.

(**Q8**) JUDGE: No, because I want to know your own favourite?
(**A8**) PROGR: Are you serious? Do you mind if I tell other people you say I am own favourite? Interesting.

(**Q9**) JUDGE: Who are you going to tell?
(**A9**) PROGR: People I meet on the internet

(**Q10**) JUDGE: What sort of people do you meet on the internet?
(**A10**) PROGR: I like to meet all kinds of people

(**Q11**) JUDGE: What is weather like outside today?
(**A11**) PROGR: Ah. Are you using Netscape or Explorer?

(**Q12**) JUDGE: Neither
(**A12**) PROGR: Cool. Which alternative browser are you into?

(**Q13**) JUDGE: Perhaps you could suggest one.
(**A13**) PROGR: You seem uncertain. I could but let's get back to that later. (www.loebner,net/prize/loebner-prize).

From the nature of the various questions posed to the machine by the judge, it is obvious that the 1st step to be taken in conducting the TT, as outlined with Peircean-Hempelian paradigm, is neglected. The questions do not suggest any definite theme for imitation. Thus, the conversation lacks definite direction. It follows that the interrogator is not guided by specimen questions on specific theme of behaviour. Thus, the 2nd step is also ruled out in that contest. More importantly, since these steps are neglected, the criterion for evaluating the performance of the machine is unclear.

From the 3rd to 6th questions, one would have assumed that the theme of the test shall revolve around "The Lowbner Prize". It is obvious that the machine responds in a way that hides its true identity to these questions. Where the machine appears not to know the appropriate answer to give, it is still able to offer an evasive response that is human-like (for instance, its response to the 4th question). The interrogator deviates in his line of questioning when he asked the 7th question. The theme of "nursery rhyme" is introduced. A human engineer who knows the rudiments of Loebner Prize would have responded appropriately to questions 3 – 6 but may likely be found wanting in his reaction to the 7th question. It would be improper to condemn the machine for poor response to this question too. The TT is not a test of exhibiting appropriate responses in multiple domains of human endeavour. A proper interpretation of the TT as offered by Peircean-Hempelian paradigm shows that the test focuses on a single domain of human endeavour such as "Womanness", "Poet" "game of chess" etcetera. What is required is for AI researchers to develop a means of building machines or programmes to behaviourally instantiate the characteristic of such a specific domain.

4.4 Justification of Peircean-Hempelian Perspective for the Turing Test

Peircean-Hempelian model of inductive reasoning is primarily designed by this research to justify the TT as a legitimate test for determining the intelligence status of machines. To this end, the model offers a philosophical foundation on how the TT should be appropriately interpreted and conducted. In structuring the TT on the Peircean-Hempelian philosophical foundation, certain fundamental truisms about the TT emerge. These include:

(i) The standard interpretation of the TT renders it impassable for machine;

(ii) Contrary to its standard interpretation, the TT is a two stage experiment;

(iii) The TT is a test in a specifically identified domain of human endeavour or intelligence;

(iv) The TT is a test of how machine can instantiate the idea of what it means to say a human being functions or acts; it is not a test of how machine can become human;

(v) The TT is a test for sufficiently inferring intelligence from machine's behavioural disposition without factoring in consideration pertaining to brain, mind and consciousness. It may be impossible to infer intelligence with absolute certainty from this behavioural disposition, but this would not preclude us from legitimately inferring intelligence from it on inductive grounds.

Suitability of the Peircean-Hempelian induction for analysing the TT could be seen from its consistency and coherence with some other well-established ideas that are related to the TT. These include:

(i) Discourse on "other minds"

(ii) Functionalism as a theory of mind.

We examine them presently.

4.4.1 Argument from "Other Minds"

The problem of other minds is the problem of how to justify the almost universal belief that others have minds very like our own (Hyslop, 2009: para 1). It is argued that people directly experience only their own mental status and therefore cannot conclude with certainty that other people have any mental states at all (Epley, 2008:1455). This is considered a fundamental problem in philosophy of mind.

In his reply to the objection based on consciousness, Turing himself argues that the inadequacy of such objection to machine intelligence lies in the problem of other minds. According to him, one would need to be a machine to know if it actually possesses mind, just as one has to be a particular individual in order to know whether such individual possesses mind or not. Since we cannot have access to another person's mind, we cannot have conclusive ground for supposing that he or she possesses mind. Similar argument is applicable to a machine or any other being that demonstrate intelligence. The proof of intelligence cannot be found in "mind" or "consciousness", since these properties themselves need proof.

The problem of other minds, as already argued in section 2.4.1 forces us to accept the fact that we cannot know with absolute certainty what goes on in the minds of other people or that they even possess minds at all. Nevertheless, on the basis of our private mental experience and how they connect to our behavioural dispositions we can derive a sufficient proof of what goes on in the minds of others. Thus we have good reasons to believe that others have minds because of their behavioural dispositions which are remarkably similar to ours (we argued this substantially in section 2.4.2). Consequently, using the Peircean-Hempelian model of induction to support Turing's strategy of employing behavioural disposition as a signpost of machine intelligence is a legitimate step in the right direction.

4.4.2 Argument from Functionalism

In the preceding argument we establish a nexus between the Peircean-Hempelian philosophical interpretation of the TT and the vexed problem of "other minds". In what follows, we explore further the position already adumbrated (see section 4.3.1) that functionalism is consistent with the TT, but this time around within the framework of the Peircean-Hempelian paradigm.

As a theory of mind, functionalism is the doctrine that what makes something a thought, desire, pain (or any other type of mental state) depends not on its internal constitution, but solely on its function, or the role it plays, in the cognitive system of which it is a part. More precisely, functionalist theories take the identity of a mental state to be determined by its causal relations to sensory stimulations, other mental states, and behaviour (Levin, 2009: para.3). To explicate functionalism, T.W. Polyger puts forward the following example:

> Consider, for example, mouse traps. Mouse traps are devices for catching or killing mice. Mouse traps can be made of almost any material, and perhaps indefinitely or infinitely many designs could be employed. The most familiar sort involves a wooden platform and a metal strike bar that is driven by a coiled metal spring and can be released by a trigger. But there are mouse traps designed with adhesives, boxes, poisons, and so on. All that matters to something's being a mouse trap, at the end of the day, is that it is capable of catching or killing mice (Polyger, 2008: para.3).

Like the mouse trap whose nature is not determined by its material element but by its function, what constitutes the mind, according to functionalism, is not the material substance like brain that triggers mental state but the function of the mind itself. This position is therefore antithetical to the identity theory of mind which postulates that mental events or states are identical to a particular brain state.

In general, functionalists claim that minds are constituted by a certain pattern or relation between the parts of a system, independent of the material that embodies the system. In other words, mental events have the property of multiple realizability. Even if it turns out that our brains generate our psychological properties, there could be other ways that psychological states could occur. Hence, minds have the property of multiple realizability (Lawhead, 233). It could be realized, instantiated and embodied in different or multiple ways and in different media or modes.

The Peircean-Hempelian philosophical analysis of the TT is consistent with functionalism. They both operate on the principle that:

> If computers could be programmed to have cognitive states functionally equivalent to those states in human psychology that we identify as thinking, believing, wanting, remembering, willing, and so on, and if their ability to process information is comparable to ours, it would seem to follow that such computers would be intelligent and would have minds (Lawhead, 236).

We keep in mind that at the first stage of the TT, the Peircean-Hempelian interpretation indicates how Turing's objective is meant to demonstrate what it means to say that human being actualizes a pre-defined function. At the second stage, it is demonstrated how machine can possibly actualize similar function. Therefore, in the scenario, humans and machine manifest remarkably similar intellectual properties. In summary, functionalism as a theory of mind focuses on the functions of the mind and the possibility that machine can be programmed to actualise these functions; the TT focuses on offering observable evidence to prove that machines, if appropriately programmed, can instantiate those functions of the mind; and the Peircean-Hempelian interpretation of the TT focuses on establishing logical ground between those functions and the observable evidence suggested in the TT. A hypothetical link therefore exists between functionalism and Peircean-Hempelian interpretation of the TT.

4.5 Turing Test and the Future of AI Research: The Question of Relevance

After putting forward an elaborate explanation on how the TT is to be conducted, Turing boldly advanced the claim that, in about fifty years time (1950-2000), machine would have been programmed with appropriate details to make them pass the test. Turing's prediction spurred vigorous research in AI, and its actualization became the benchmark for AI research.

In this connection, the pioneering efforts of AI researchers like J. McCarthy, M.L. Minsky, N. Rochester, C.E. Shannon, and a host of others, lead to the emergence of AI as a serious field of rigorous research in 1956. However, the authors of one of the leading text books on AI research, S. Russell and P. Norvig posit that "… it was Alan Turing who first articulated a complete vision of AI in his 1950 article …Therein, he introduced the Turing test". (Russell and Norvig, 2003:17). S. Harnad while proffering an alternative machine intelligence test to the TT, remarks that, "The TT is an empirical criterion: it sets AI's empirical goal to be to generate human-scale performance capacity. This goal will be met when the candidate's performance is totally indistinguishable from human’s. Until then, the TT simply represents what it is that AI must endeavour eventually to accomplish scientifically” (Harnad, 1992:9).

P. Hayes and K. Ford acknowledge the relevance of Turing and the TT to the emergence of AI research. According to them, “Alan Turing was one of the greatest scientists of this century. His paper… “Computing Machinery and Intelligence” inspired the creation of our field, giving it a vision, a philosophical charter and its first greatest challenge, the Turing Test” (Hayes and Ford, 1995:972). They further argue that “The Turing Test has been with AI since its inception, and has always partly defined the field. Some AI pioneers seriously adopted it as a long-range goal, and some long-standing research programme are still guided by it; for others it has come to provide more of a vision to define and motivate the whole field” (Hayes and Ford, 972). Indeed, the relevance of the TT to AI research is not in question. What perhaps is in question is whether this relevance can apply to the future of or expectations from AI research.

In their summation on the TT, Russell and Norvig comment that Turing deserves credit for designing a test that remains relevant 50 years later. They observe, however, that “AI researchers have devoted little effort to passing the Turing test, believing that it is more important to study the underlying principles of intelligence than to duplicate an exemplar” (Russell and Norvig, 3). Thus it appears that some AI researchers do not consider the TT to be relevant to their research. Indeed, some reasons have been advanced for this orientation.

First, it is claimed that there are easier ways by which AI researcher could test their programmes. In fact, most current researches in AI-related fields are aimed at modest and specific goals, such as automated scheduling, object recognition, or logistics. In order to test the intelligence of the programmes that solve these problems, AI researchers simply assign the task directly to these programmes, rather than going through the roundabout method of posing questions in a chat room populated with computers and people (Wikipedia, 2011:n.p.)

Second, it is argued that creating lifelike simulations of human beings is a difficult problem on its own that does not need to be solved to achieve the basic goals of AI research. Believable human characters may be interesting in a work of art, a game, or a sophisticated user interface, but they are not part of the science of creating intelligent machines, that is, machines that solve problems using intelligence (Wikipedia, n.p.) Scholars like Norvig and Russell themselves advance the analogy that, "The quest for artificial flight' succeeded when the Wright brothers and others stopped imitating birds and learned about aerodynamics. Aeronautical engineering text do not define the goal of their field as making 'machines that fly so exactly like pigeons that can fool even other pigeons' (Russell and Norvig, 3). By implication AI researchers do not need to dwell on designing machines that want to fool humans that it is intelligent.

Nevertheless, it has been observed that "Turing, for his part, never intended his test to be used as a practical, day-to-day measure of the intelligence of AI programmes; he wanted to provide a clear and understandable example to aid in the discussion of the philosophy of artificial intelligence" (Wikipedia, n.p). G. Oppy however, observes that most commentators are of the contention that Turing's claim has been shown to be mistaken as no machine has been so successfully programmed to play the imitation game so well that an average interrogator had no more than a 70% chance of making the correct identification after five minutes of questioning (Oppy, 2011: para. 47). On this ground, some researchers claim that the TT does not set "an appropriate goal for current research in AI because we are plainly so far away from attaining this goal (Oppy, para. 73).

To some authors, the issue is not even whether machines have been successfully designed to do well or not in the imitation game, the issue is that "the Turing Test does not set a sufficiently broad goal for research in the area of artificial intelligence" (Oppy, para 73). The TT simply restricts the scope of AI research to that of mere designing of machines to pass the test. On this ground, Hayes and Ford lament that passing the Turing Test is now often understood to mean something like "making an artificial intelligence without paying too much attention to the details" (Hayes and Ford, 972). The authors note that Turing proposed the imitation game as a definite goal for a program of research. But then, they argue, the test,

> ... is no longer a useful idea. The Turing Test had a historical role in getting AI started, but it is now a burden to the field, damaging its public reputation and its own intellectual coherence. We must explicitly reject the Turing Test in order to find a more mature description of our goals; it is time to move it from the textbooks to the history books (Hayes & Ford, 972).

Incidentally, AI as currently being practiced, according to Hayes and Ford, covers wider areas beyond Turing's scope of natural language processing. S. Mueller reinforces Hayes and Ford's argument with the claim that, "The field of artificial intelligence has long surpassed the notion of verbal intelligence envisioned by Turing…Consequently, the Turing Test is primarily viewed as a philosopher's debate or a publicity stunt, and has little relevance to AI researchers" (Mueller, 2008:9). Similarly, C. Tan observes that, "Computers may in fact pass the Turing Test in the near future…But that would be beside the point. Until we attempt to create computers that succeed at the broad range of activities that even the average human can perform reasonably well, we will not achieve true artificial intelligence" (Tan, 2012: para.5). Tan thinks that computers are still far from approaching the flexibility of human intelligence that is required to deal with the unconstrained nature of life. He avers that if Deep Blue, the computer chess programme that defeated the human world champion in 1987 was required to play monopoly instead of chess, it would not have known what to do.

In spite of disagreement amongst AI researchers, the TT actually provides the vision for AI research. Some of the significant achievements of AI today, especially in expert system, neural network and robotic researches, owe largely to the desire of AI researchers to actualize this vision. Indeed one must give credit to Turing for providing such a strong and useful vision for AI at a period in history when the idea of machine intelligence was a mere dream. More importantly, the field of AI is still at its infancy given the projections of its pioneers, consequently the field cannot jettison the vision of Turing at the moment. It is the vision on which the foundation of the field is built. Consider the projection of Marvin Minsky for machine intelligence in 1985:

> In the new machines, we will be able to provide whatever paths we wish. Though the new machines still cannot possibly keep tack in real time of everything they do, we surely should be able (at least in principle) to make those new synthetic minds vastly more self-conscious than we are, in the sense of being more profound and having insightful knowledge about their own nature and function. Thus, in the end, those new creatures should have more interesting and richer inner lives than do people... In years to come, we will learn more ways of making machines behave sensibly... (Minsky, 1985b : 40).

4.6 Conclusion

The analysis carried out on the TT in this chapter has revealed that the bane of the test is the manner in which it is traditionally rendered through its standard interpretation. However, the application of the Peircean-Hempelian model of induction to the test has put it in its proper perspective. Machine intelligence can now be confirmed since it is obvious that the test can be passed by appropriately programmed machines given its new philosophical foundation. In the next chapter, attention shall be devoted to explaining how the field of education (with respect to Nigerian educational system) can benefit immensely from machine intelligence.

CHAPTER FIVE

AI RESEARCH AS A PARADIGM FOR EDUCATIONAL DEVELOPMENT: NIGERIA AS AN EXEMPLAR

5.1 Introduction

This chapter focuses on the relevance of machine intelligence to educational development of a nation like Nigeria. It reveals how AI research actually propelled ICT (Information and Communication Technology). ICT is an important instrument for educational development in the modern world. However, there is an apparent digital divide between the developed Nations and Third World countries due to the latter's lukewarm attitude to ICT utilization. This chapter raises awareness on the importance of ICT for educational development in Nigeria.

5.2 ICT as AI Paradigm for Development in the Modern World

ICT is a composite term embodying three concepts, namely: "Information", "Communication" and "Technology". Information means many things to many people depending on the context. Scientifically, information is processed data; information can also be loosely defined as that which aids decision making (Womboh, 2008:para.2). Communication on its own is the process by which information is exchanged between or among individuals or organizations. In other words, it is the process through which information, knowledge, ideas or messages are conveyed or transmitted from one source to another (Adewoyin, 2004:51). According to James *et al* (quoted in Womboh, para.3), "communication is understood as a process involving the transfer of information, ideas, thoughts and messages. It involves a sender, a receiver, a code and, a language that is understood by both the sender and the receiver. It is a process involving the passing of messages through the use of symbols which all parties in the communication encounter understand. It involves the exchange of ideas, facts, opinions, attitudes and beliefs between people".

Technology denotes the processes by which humans fashion tools and machines to increase their control and understanding of the material environment. It is made up of two Greek words, *techne* and *logos*, where the former refers to an art or craft while the latter means study, discourse or science of something. Technology can therefore be regarded as the employment of scientific knowledge to design tools for human use.

From the analysis carried out above, it is apparent that both “communication” and “information” are interwoven. It is through the former that the latter is exchanged or transmitted. Technology, however, is the means or tool with which the transmission or distribution of information is achieved. It is information that we communicate through technology. Aptly put, ICT can be seen as the act of employing technology as an instrument of communicating information.

The kind of technology referred to above is AI-driven. Since AI is the field associated with designing intelligent machines, ICT therefore, is by implication associated with intelligent machines that easily aid the communication of information. Such machines are categorized under the umbrella name “Information and Communication Technologies”, ICTs (distinct from ICT without the letter s). Consequently, ICT can simply be viewed as the processing and maintenance of information, and the use of all forms of computer, communication, network and mobile technologies to transmit information.

Communication technologies include all media employed in transmitting audio, video, data or multimedia such as cable, satellite, fibre optics, wireless (radio, infrared, Bluetooth, Wifi). Network technologies include personal area networks (PAN), campus area network (CAN), intranets, extranets, LANs, WANs, MANs and the internet. Computer technologies include all removable media such as optical discs, disks, flash memories, video books, multimedia projectors, interactive electronic boards, and continuously emerging state-of-the art PCs. Mobile technologies comprise mobile phones, PDAs, palmtops, etc. These technologies have information as their material object (Iloanusi and Osuagwu, 2010:1331). They are what we use to share, distribute, and gather information and to communicate through computers and computer networks. ICTs can be described as a complex varied set of goods, application and services used for producing , distributing, processing, transforming information (including) telecoms, TV and radio broadcasting, hardware and software, computer services and electronic media (Ogunsola and Aboyade, 2005:7).

The Nexus Between ICT and AI

One of the most dramatic advances in communication potential – data communications – is found in the field of computer technology. Since the first development of the modern electronic digital computers in the 1940s, computerization has infiltrated almost every area of society in nations with advanced technology. Computers are available in many formats for use in industries, businesses, hospitals, schools, universities, transport networks and individual homes. Small or large, a computer network exists to provide computer users with the means of communicating and transferring information electronically (Ogunsola and Aboyade, 8). Indeed, the computer system could be considered as the gateway of ICT.

While the development of the modern electronic digital computers dates back to the 1940s, it was Alan Turing who actually laid the foundation for computer as a potential and sophisticated instrument of communication and as a non-human communicating agent. Through his paper, "Computing Machinery and Intelligence" (1950), Turing advanced a theoretical explanation on how it is possible to design a universal machine (modern day digital computer) that can engage humans in communication. Since the appearance of Turing's paper, AI researchers have steadfastly devoted their attention to the designing of computers and computer programmes. The various efforts of these researchers eventually climaxed into the emergence of the internet.

Today, the internet offers a highly sophisticated digital environment that promotes communication between humans and machines. In fact, the use of internet has revolutionised means of access to information for the business world, libraries, education and individuals. A few of the most popular include E-mail (electronic mail), World Wide Web, FTP (File Transfer Protocol), Usernet, and Telnet. The Internet and its technology continues to have a profound effect in promoting the sharing of information especially in academic world, making possible rapid transactions among businesses, and supporting global collaboration among individuals and organizations (Ogunsola and Aboyade, 2005:8).

Since AI research is the facilitator of the emergence of ICTs, the more the enterprise of AI develops, the more the development attained in ICT and, by implication, its impact on human development. As an example, the impact of ICT on each industry has become far reaching as its transformational effects spread to several sectors of the economy and society via innovations, the emergence of new industries, and the advent of the era of hyperconnectivity (Dutta & Osorio, 2012: ix). In fact, research has shown that investment in ICT is associated with such economic benefits as higher productivity, lower costs, new economic opportunities, job creation, innovation, and increased trade. ICT also helps provide better services in health and education, and strengthen social cohesion (World Bank/ITU, 2012: v). Indeed, ICT can best be described as a means to development in modern societies. Commenting on this reality, R. Tongia *et al* emphasise that with roughly two-third of the world economy based on services, and the rise of India, Philippines, and other nations as global IT players, many developing countries have accepted ICT as a national mission. Even within manufacturing industries, ICT has an increasingly important role to play (Tongia *et al* 2005:19). Of course, one cannot say less for educational development as we shall soon demonstrate.

5.3 The Role of ICT in Educational Development

The term "education" can be perceived in the broad and narrow or technical senses. In its broad sense, education refers to any act or experience that has a formative effect on the mind, character, or physical ability of an individual. In this sense, education is a continuous process (Azenabor, 2005:4). In its narrow sense, G.F. Kneller sees education as the process by which any society through schools, colleges, universities and other institutions deliberately transmit its cultural heritage, that is, its accumulated knowledge, values and skills, from one generation to another (Kneller, 1964:20).

The broad sense of education portrays it as an everyday affair where the individual actually learn from experience. It is not prompted by the act of the will; rather it simply takes place, at least, so long as the individual exists and experiences reality. The second sense offers a picture of education as being a deliberate act of teaching and learning. Thus, knowledge is deliberately transmitted from the teacher to the learner. The knowledge is expected to produce a formative effect on the mind, character and physical ability of the learner. This is where the narrow sense of education dovetails into the broad sense. The overall development of the learner's personality eventually becomes the end product of education. As expected, the aggregate personality development of all learners in a particular society shall have a developmental effect on the society itself. In essence, it is not the individual that gains from education in the final analysis, it is actually the society. The relationship between education and societal development is well highlighted in the excerpt below, as offered by G.E. Azenabor:

> The importance of education cannot be overemphasized. It is the most powerful and viable instrument for developing and empowering the citizens to master the social and natural environments and to compete for survival. A nation's strength largely lies in the quantity and quality of her human resources; education is the pivot on which development rotates and a fundamental capacity building measure for sustainable development (Azenabor, 2005: 2).

Indeed, the belief in the efficacy of education as a powerful instrument of development has led many nations to commit much of their wealth to the establishment of educational institutions at various levels (Ajayi & Ekundayo, 2008:212). Incidentally, the demands of the modern technological and information age pose serious challenges to the efficacy of education. Several policy reports establish that societies are changing from industrial societies into "information societies", in which the creation and dissemination of knowledge is of paramount importance. They contend that, in order to combat social exclusion and to maintain competitiveness in a global economy, education must go beyond the framework of initial schooling in order to prepare and support citizens for lifelong learning (UNESCO-UIS, 2009:11). Consequently, ICT plays an important role in reshaping education to respond to contemporary information society needs (UNESCO-UIS, 11).

Traditional teaching methods of "teaching and learning" cannot cope with the pace of development in information and knowledge dissemination ascribed to the modern age. This age ushered in new paradigm where the delivery of education becomes less about teaching and more about learning (i.e. via self-tutoring and the use of individualized information research abilities). Education becomes increasingly less confined within the sole geographical location of learners (e.g. a country) or less dependent on a physical space (e.g. a classroom for pooling a critical mass of learners together) (UNESCO-UIS, 11). The claim of N. Ololube *et al* is that the introduction of ICT usage, integration and diffusion has initiated a new age in educational methodologies that has radically changed traditional methods of teaching and learning patterns (Ololube *et al,* 648). Lending its credence to this claim, a UNESCO-UIS study on the measurement of impact of ICT on education argues that:

> Under the right conditions…ICT can have a monumental impact on the expansion of learning opportunities for greater and more diverse populations, beyond cultural barriers, and outside the confines of teaching institutions or geographical boundaries. Technologies can improve the teaching/learning process by reforming conventional delivery systems, enhancing the quality of learning achievements, facilitating state-of-the-art skills formation, sustaining lifelong learning and improving institution management (UNESCO-UIS, 11).

P.Z. Kwache also remarks positively that:

> ICT enhances teaching and learning through its dynamic, interactive, flexible, and engaging content. It provides real opportunities for individualized instruction … It has the potential to accelerate, enrich, and deepen skills; to motivate and engage students in learning; to help relate school experience to work practices; to help create economic viability for tomorrow's workers; contribute to radical changes in school; to strengthen teaching, and to provide opportunities for communication between the school and the world (Kwache, 2007:395).

The running of a modern educational system involves three key areas: learning, research and administration. When these three are appropriately executed, then the result shall be educational development. It is the strategic role of ICT in these areas that deeply connect ICT to educational development.

In any educational system, learning can be said to have successfully taken place, going by Kneller's narrow sense of education, if a society's cultural heritage is successfully transmitted from one generation to another. Prior to the emergence of ICT, the traditional face-to-face contact between the teacher and learner has been the main means of transmission of knowledge. This method has been shown to have many drawbacks that are now well taken care of by ICT application to learning. The traditional method is not only cost ineffective but also fails to offer educational opportunities to large populations over a wide area. Today, ICT is able to cut through age, class, financial, gender, and time and space barriers to education in order to make education accessible to all.

The application of ICT to learning could be deployed in such modes as e-learning, blended learning, mobile learning, distance education and online learning. According to N.O. Iloanusi and C.C. Osuagwu, e-learning actually incorporates distance learning, online and mobile platforms. According to them, e-learning is learning mediated by an open set of all kinds of technology such as computers, networks, communication and mobile technologies to enhance and extend learning. These technologies help deliver and make education accessible to all. Commenting on the advantage of e-learning over traditional mode of learning, Iloanusi and Osuagwu explained that in the traditional education setting, the students' assimilation of knowledge, excluding other factors, always depend on how well the teacher or lecturer passed the knowledge. With e-learning, the focus is no longer on the teacher, but both teacher and student especially, who takes advantages of technology to varied resources of knowledge made available by existing technology (Iloanusi and Osuagwu, 2010: 1332). Other benefits of e-learning include the enhanced and consistent mode of delivery of knowledge; easy and regular administration of individual and group assessments; awareness of the institution; unhindered interaction among teachers and students; collaboration with other institutions like universities. Furthermore, e-learning puts the student on the driving seat of learning, since the entire process is structured in a way that suits the learner. The student, in other words, has a better control over the learning method. Learning is personalized. Online or distance learning removes the geographical barriers of learning for the students and teachers. There might be no need for study leave for workers running a programme in school. E-learning makes knowledge available on demand anytime (Iloanusi and Osuagwu, 1332). One can therefore conclude that ICT improves the aim of education beyond what is offered though the traditional method of learning.

The relevance of ICT in education is also felt in the area of research. According to K. Balasubramanian *et al* (2009), the most straightforward use of ICTs in research is in data processing. The unprecedented growth in bandwidth and computing power provide opportunities for analyzing/processing huge amounts of data and performing complex computations on them in a manner that is extremely fast, accurate and reliable. Computer data processing not only frees researchers from the cumbersome task of manually analyzing data but more importantly facilitates quick and accurate analysis of huge amounts of data from national samples or even multi-national samples covering tens of thousands of respondents (Balasubramanian, 2009:6). Another important dimension of ICTs in research is the use of online full text databases and online research libraries/virtual libraries which are the direct outcome of the growth in telecommunications networks and technology. These databases and libraries provide researchers with online access to the contents of hundreds of thousands of books from major publishing houses, research reports, and peer-reviewed articles in electronic journals (Balasubramanian, 6).

The role of ICT in education is also well registered in the area of educational administration. Here, ICT is used as an instrument of effective and efficient planning and executing of the activities and functions of educational institutions. For instance, in the area of educational institution record management, ICTs are useful in various ways. First, ICT technology can process voluminous records quickly, meticulously and impeccably. Second, technology can generate reliable and consistent records. Third, records and data produced are searchable and quickly retrievable. Fourth, digital records save space, a premium cost to institutions. Fifth, technology saves human resources for data entry and servicing student admission and registration. With advanced scanning technology, completed application forms can be fed into the database in a manner of seconds. Other software like Learning Management Systems (LTRS) allow students to register for courses directly online, pay online and get course information online. Sixth, technology can expand the geographical boundary for student intake and facilitate cross-border higher education (Balasubramanian, 6). Already, the conduct of examination and the broadcast of examination result including the printing of the result are now facilitated by ICT.

From the foregoing, the relevance of ICT to educational development cannot be overemphasized. Incidentally there is serious digital divide between the developed and developing nations of the world. The former are said to have effectively and efficiently utilized the gains of ICT. The latter, on the other hand, are still struggling to wake up to the reality of the importance of ICT in educational development. In our reflection about the state of educational development in Nigeria in comparison to what obtains in developed societies today, it became obvious that like other developing nations, Nigeria is still at the emerging phase of ICT utilization. A brief discussion of the state of Nigeria educational system and its level of ICT compliance shall reinforce our observation.

5.4 Nigerian Educational System and the Challenges of ICT Implementation for Educational Development

The Federal Republic of Nigeria is the most populous black African country in the world. It is located in West Africa, South of the Sahara. It borders the Gulf of Guinea in the South, Cameroon in the east, Niger and Chad in the North, and Benin in the west. It is a federation of 36 states divided into six geopolitical zones (Agyeman, 2007:2). Nigeria's system of education comprises: (i) primary education, (ii) secondary education and, (iii) tertiary education.

Until 1984, the structure of Nigerian educational system was 6 years of primary schools, 5 to 7 years of post primary schools (Secondary, Teacher Training College and sixth form) and 4 to 6 years of tertiary education (college of education, polytechnics, college of Technology and University Education). From 1985, the structure comprises pre-primary or kindergarten education (2 to 3 yrs) for the children of ages 3 to 5 years, the primary school which is of 6 years period for children of ages 6 to 11 years, the post primary education which is of 6 years duration but divided into two halves (3 years of Junior Secondary School and 3 years of Senior Secondary School) and the 4 to 6 of tertiary education level. This is called the 6-3-3-4 system (Amaghianyeodiwe and Osinubi, 2006:32). Another educational scheme was, however, launched in 1999. It is popularly referred to as Universal Basic Education (UBE) and anchored on 9-3-4 system. Nevertheless, it is still structured on 6 years in primary school, 6 years in secondary school and 4 years of tertiary education. The specific target of the scheme is total eradication of illiteracy by the year 2010 (Amaghianyeodiwe and Osinubi, 32).

As indicated above, Nigerian educational system has been experiencing series of reforms since its inception in 1978. Nonetheless, those reforms have been adversely affected by inappropriate implementation resulting in series of challenges and problems in Nigerian educational system. M.O. Yusuf and H.T. Yusuf (2009) comment that such reforms are either implemented half heartedly or abandoned altogether at its inception. This basically is the fundamental hindrance to the effective application of ICT to Nigerian educational system. For instance, prior to the replacement of the 6-3-3-4 system of education with another, the "introductory technology" aspect of the system was not effectively implemented due to lack of manpower, equipment, and lack of leadership. The computer education programme, launched for secondary schools in 1988 never succeeded (Yusuf and Yusuf, 2009:227).

Historically, the first ICT initiative in Nigeria started in the 1950s with focus on print and electronic media. No major policy or other outcome was achieved because of strict government control. The full awareness of the importance of ICTs was absent. Only the private sector demonstrated ICT initiatives. The Obasanjo administration in 2001 established the National Information Technology Development Agency (NITDA) to serve as a bureau for the implementation of National Policy on Information Technology (Idowu, 2003:70). This initiative rather came too late behind the fast pace of ICT usage in developed nations. Thus, Nigeria is a late bloomer in ICT usages. Kwache observes that Nigeria is still slow in the use of ICT in almost all sectors of the nation's life (Kwache, 2007:397). He identifies the most common problems associated with the effective implementation of ICT in Nigeria education system as follow:

1. Lack of qualified ICT personnel. Most institutions lack computer literate teachers and ICT experts that would support and manage the internet connectivity and/or application of computing in the teaching-learning process.
2. Cost of equipment. The cost of equipment in a country like Nigeria with a battered economy and seriously devalued currency is enormous. However, it should be noted that the problem might not be scarcity of funds and technology but rather the will on the part of government and/or those in charge of education at various levels.
3. Management's attitudes. The attitudes of various managements in and outside institutions towards the development of ICT related facilities such as the internet and procurement of computers is rather slow in some instances, and in others there are no aids or support by the government at all.
4. Inconsistent electric power supply in most of the parts of the country and also inadequate telephone lines particularly in rural areas.
5. Non-inclusion of ICT programmes in teachers' training curricular and/or at the basic levels of education. There seem to be no clear and definite policy and/or curriculum for all levels of the Nigerian educational system (Kwache, 397).

From the last point made above, it is imperative that various stakeholders in Nigeria education system need to be educated about the critical relevance of ICT to the educational development of a modern society. Yusuf and Yusuf (2009) discussed some of the areas of this critical relevance as shown below.

First, ICT can be relevant in the professional development of teachers in order to make them guides to sources of knowledge. Teachers in contemporary knowledge society require large, rich, and easily-accessible-knowledge base which can be provided through ICT technologies that support professional development. Teachers need to be life-long learners to keep abreast of new knowledge, pedagogical ideas, and technology, relevant to successful implementation of Nigerian educational reforms. Through digital libraries, virtual institutions, and other internet resources teachers can easily have access to relevant and current resources in their areas. Thus, they must be competent in the use of ICT to husband its potentials.

Secondly, the quality of learning by students will be enhanced through access to the needed content through ICT facilities (especially, the internet). Information and communication technology can enhance learning by doing, and increase the information available to learners, thereby engendering collaborative learning. It can also empower the learners with information technology awareness and skills which are essential for success in contemporary knowledge economy.

Thirdly, ICT provides new frontiers for access to basic education for disadvantaged children and youth excluded from formal school system. As modern ICTs are attractive to children and youth, they provide unmatched learning opportunities for them to learn within and outside the formal school system. They are powerful motivational tools for learning through games, exploration, collaboration, and learning work-related skills. Distance learning enhanced through ICT can provide flexible learning opportunities with collaborative aspects and rapid communication among learners and between learners and academic mentors.

Yusuf and Yusuf further add that ICT can provide opportunities for physically challenged persons to get quality education, (one of the basic goals of the Nigerian educational reform). They can be relevant as assistive technology, adaptive technology, and as a tool for knowledge and support. Assistive ICT encompasses not only computerised technologies but also a powered wheel chair with voice command and other computer technologies which can increase mobility for persons with severe neuromuscular limitations. Adaptive ICT include keyboards with colourful keys for persons with learning disabilities, voice recognition, and the accessible web accessibility option initiative of the W3 Consortium which are designed to provide web access for people with disability. Thus, ICT allows people with disability to have enhanced access to education in conventional and distance education settings (Yusuf and Yusuf, 228-229). As a matter of fact ICT opens new doors of educational opportunities for all willing minds. ICT holds great potentials in supporting and augmenting existing educational as well as National development efforts in Nigeria (Sheyin, 2009: 278).

There is an increased awareness among policy makers in the educational sector regarding the potentials of information and ICT in the school system (Yusuf and Yusuf, 227). This is demonstrated in the educational reform policies aimed at integrating the use of ICT, particularly the computer, in the school system. The first national programme was the Federal Government 1988 policy document, National Policy on Computer Education. The document emphasized the need for primary school pupils to be introduced into basic computer skills, the use of the computer to facilitate learning, and rudimentary use for text writing, computation and data entry. For secondary schools the goals are the ones for primary schools, but to be pursued at a higher level. Also included were the organization of curriculum for secondary school students on computer education, and the decision to use the unity schools as the pilot institutions for computer education. Tertiary institutions were also required to teach computer science as a subject discipline, and also integrate it in school administration and instruction. Other components of the document include equipment requirement, teacher training, and specific recommendation on different tertiary institutions (Yusuf and Yusuf, 227). However, much has not been achieved in ICT policy implementation in Nigeria for the reasons already indicated.

From the foregoing, one can conclude that the low level of ICT compliance in Nigeria's educational system stems from non-utilization of the potentials of ICT. It is only when the various stakeholders in this educational system effectively and efficiently implement the variously adopted educational policies on ICT in the system can we cross the line of the digital divide. The following are some steps that could ameliorate the situation (Kwache, 397-398).

1. Adoption of ICT international standards and its inclusion in the Nigeria curriculum and in particular in the teachers' education curriculum.

2. Continuous training of teachers on computers and ICT skills acquisition.
3. Development and training of ICT experts specifically for instructional design and development who will work in partnership with educators and teachers.
4. Restructuring, redevelopment, and reinforcement of the Nigeria's policy for integration of ICT in the Nigerian education systems.
5. Government at all levels should make ICT a matter of priority, provide the funds specifically needed for the training of teachers in computer education, who shall in turn be equipped with ICT knowledge and skills to impact ICT knowledge into the students.
6. There should be monitoring, inspection, and evaluation division at all levels of education responsible for ensuring that the ICT curricula are adhered to, that the funds allocated for such purposes are not diverted, and ascertain that the right equipment is procured and delivered at the appropriate time.
7. There is a need for the Nigerian government to address seriously the issue of erratic electricity power supply, while on the other hand, schools wishing to adopt the integration of ICT in their teaching-learning process should as a matter of urgency use alternative sources of energy to supplement electricity supply from the Power Holding Company of Nigeria (PHCN).
8. Above all there should be a reorientation of expected users of the ICT-related facilities to promote application of innovations in ICT, such as new pedagogical methods, access to remote resources, collaboration between individuals and groups of people in more diverse geographic locations, online experts and mentors, virtual learning communities, home/school communities.

Attitudinal re-orientation is fundamental to all the recommendations. If all the stakeholders in the educational system inject the right attitude to ICT policy implementation then the system would by now be at the "transformational phase" of ICT implementation such as applicable to developed nations. At the moment Nigeria is still at the "emerging phase" since the country is still struggling to come to term with the reality of ICT. Without the right orientation, government and non-governmental agencies would not provide adequate funds for related projects in our educational institutions, and the latter, in turn, would not be committed to applying ICT in teaching, research and administrative roles.

We recommend that the "reconstructionist" theory of education should be the guiding principle in Nigeria's educational system. This theory can help to shape the orientation of stakeholders of Nigerian educational system on ICT utilization. The reconstuctionist theory, as articulated by G.E. Azenabor, is a philosophy of "an age in crisis" which needs change. It enjoins one to look with a fresh eye at the way in which existing curricula are drawn up, the subjects they contain, the educational methods used, the structure of administration and the methods by which teachers are trained and make our education more functional (Azenabor, 1999:8). Nigerian educational system is in crisis and needs positive change. The system requires a fresh look, and the appropriate direction is ICT. Reconstructionism declares that the chief purpose of education is to continue to reconstruct the society in line with the scientific knowledge at our disposal. As at now, ICT is the appropriate scientific approach, method, and outlook for initiating development in education.

From a reconstructionist perspective, this study affirms that ICT should be integrated in three ways into the curriculum of Nigerian educational system. These are learning about ICT, learning with ICT and learning through ICT. Learning about ICT refers to ICT concept as a subject of learning in the school curriculum while learning with ICT is concerned with the use of ICT as a medium to facilitate instruction (Akudolu, 2007:5). Learning through ICT refers to the integration of ICT as an essential tool into a course/curriculum, such that the teaching and learning of the course/curriculum is no longer possible without it. This implies that ICT can be learnt as any other subject in the curriculum. It can be an instructional medium or a source for learning. It can also be integrated in the learning process so that learning takes place through the learner's interaction with the facilities. Therefore, ICT in education is considered as a discipline, resource and key skill. Within these three broad areas, ICT offers enormous benefits to the society (Akudolu, 6). Nigerian educational system shall cross the border line of the digital divide between the developing and developed nations if it effectively incorporates these three ways of exploiting ICT in its curriculum.

5.5 Summary of Research Findings.

(i) The failure to connect the first and the second phases of the TT in the standard interpretation of the test misled some scholars into thinking that the possession of brain, mind and consciousness is the decisive/indispensable criterion for success in the test rather than the criterion of “imitative” ability of participants as originally intended by Turing.

(ii) The Peircean-Hempelian logic of induction constitute an appropriate interpretation of the TT by: (a) offering a philosophical framework that makes the connectivity of the two phases of the test possible, and; (b) making apparent on the strength of (a) that the “imitative capability” of an entity is the appropriate criterion for passing the TT.

(iii) The Peircean-Hempelian logic of induction assists the attempt to make a plausible case for machine intelligence by advancing a logical proof for justifying machine’s imitative capability of human behaviour as a plausible evidence of intelligence without recourse to brain, mind and consciousness.

(iv) Adoption of the view that the TT offers an empirically decidable test of machine intelligence encourages the use of appropriate technologies in the field of education in Nigeria. Thus strategic deployment of the potentialities of machines has already taken place in the form of Information and Communication Technologies (ICTs), with far-reaching impact on educational development of developed countries. As we have observed, Nigeria is yet to fully explore and exploit the pedagogic potentialities of ICT.

5.6 Research Recommendations

Based on the summary of the findings above, the following recommendations should be considered.

(i) **The TT should be evaluated with an appropriate philosophical paradigm**

Since 1950 when the TT was proposed, no machine has passed it. The failure to actualise Turing’s vision has led to scepticism about its relevance in AI research. This study recommends that researchers should interpret the test on the basis of Turing’s stipulation rather than relying on what is considered as its standard interpretation.

(ii) **Rigorous exploration of Peircean-Hempelian Model of Inductive Reasoning as a viable Theoretical Framework for Supporting the TT’s Objective**

Philosophy provides access to a wealth of ideas that AI researchers could adopt in assessing whether machines have passed the Turing test. The Peircean-Hempelian model of induction is an adaptation of two paradigms of induction that provides the philosophical foundation for interpreting the performance of machines vis-a-vis the TT, as an instrument for establishing classical machine intelligence. Familiarity with the model promotes greater appreciation of its elucidation potential for TT as a process for establishing machine intelligence as perceived by Turing.

(iii) **Machine intelligence should be embraced**

Beyond the confines of the field of AI, professionals and non-professionals tend to be sceptical towards the idea of intelligent machine. It is so difficult to come to terms with the notion that machines, which are mere physical objects designed by humans, could ever possess anything resembling real intelligence. Intelligence, for many, belongs to higher animals, especially humans. The high level of performance of some AI agents in intelligence driven functions is enough to make a change of attitude inevitable. Prior to the defeat of human chess champion by a machine in a chess match in 1997, chess was considered the epitome of intelligence. That machine can even play chess seemed impossible before Deep Blue was fabricated. But this is now history. In 2011 a computer defeated a very intelligent human being in a quiz show, “Jeopardy!” – another good evidence of machine intelligence. The game poses a grand challenge for a computing system due to its broad range of subject matter, the speed at which contestants must provide accurate responses, and other complexities in which humans excel and computers traditionally do not. However, beyond the issue of rivalry, humans are the ones benefiting from machine intelligence, not the other way round. In the present age, machine intelligence does not just complement humans in the attainment of their objectives, it also acts as an instrument with which humans themselves improve their own level of intelligence. As reported in *The New York Times* (July 11, 2011), United States President, Barak Obama, underscored the importance of intelligent machines to America’s interest by travelling to Carnegie Mellon University in Pittsburgh in June, 2011, to unveil a $500 million investment effort in AI. His interest was mainly in advanced robotic technologies needed to boost manufacturing in the United States.

(iv) **Interaction between AI and the Humanities should be promoted**

As a corollary to the previous recommendation, this study avers that AI researchers should cultivate the attitude of tolerance for ideas from other disciplines in order to build appreciable level intelligent machines. The orientation of these researchers, especially towards the Humanities, is that of prejudice and disdain. This orientation, incidentally, plays a critical role in AI's failure to attain its full potentials. Indeed, we cannot take away from AI its practical and technical underpinnings. At any rate, AI research is an interdisciplinary enterprise built on ideas from engineering, computer science, psychology, brain science, cognitive science, biology, neural science, philosophy, linguistics, etc. Because of the fundamental importance of philosophy as the "queen of the sciences", a symbiotic relationship between it and AI is hereby strongly advocated.

(v) **The use of ICT to achieve educational development should be encouraged**

As one of the thematic thrusts of this research, we sought to demonstrate how Nigerian education system can achieve greater educational development through ICT. Hence, the attempt to reinterpret the TT to justify machine intelligence is aimed at drawing attention to the relevance of ICT to educational development. The research advocates sustained vigorous efforts by government and other stakeholders in the educational sector to promote the use of ICT at all levels of education in Nigeria.

5.7 Summary of Contributions to Knowledge

(i) The study introduces a new insight on the controversy over machine's failure in the TT. Accordingly, the failure is traced to the shortcomings of the "standard interpretation" of the test in which brain and mind possession is mistaken as the criterion of successful performance rather than "imitative ability".

(ii) The study contributes to the debate on the appropriate interpretation of the TT by proposing a novel philosophical framework (Peircean-Hempelian logic of induction) that offers a robust tool for assessing Turing's vision on intelligence and machines. We believe that the alternative interpretation provided by this study is a clear and systematic elucidation of the TT as a test of judging the imitative ability of machines with regard to intelligent behaviour. It explains the two-stage process envisaged by Turing to measure the ability of an appropriately programmed machine to mimic intelligent behaviour.

(iii) The study offers a logical-epistemological approach on how to make a case for machine intelligence with the TT without recourse to brain, mind and consciousness. This approach is anchored on a theory of induction – Peircean-Hempelian induction – which serves as a foil for assessing the outcome of the TT for legitimately inferring intelligence from the overt behaviour or responses of a machine.

(iv) The study links the act of establishing machine intelligence to educational development by raising awareness on the critical relevance of Information Communication and Technology (ICT) to the field of education. Current trend shows that ICT has become the driving force for all activities in the field of education; it has become a philosophy, a method, and a tool for educational development. It is lamentable that a developing country like Nigeria has not adequately taken advantage of this new development and move on to the positive side of the digital divide. Since ICT itself is an instantiation of machine intelligence, a study like the current one that throws light on a key component of AI research could be used to draw attention to the relevance of ICT in a critical area like education.

5.8 Conclusion

It should be stated at this point that the task undertaken by this study is quite consistent with human tendency to always employ and manipulate the resources of nature as a means of actualising any of its aims and objectives. Such tendency is what culminated in AI technologies behind the revolutions in information and communication systems. B. Buchanan (2005), claims that the history of AI is the history of the desire to build AI agents, as expressed both in fantasies and possibilities. As far back as 8th century B.C., Homer, the classical Greek poet wrote of mechanical "tripods" waiting on the gods at dinner. The ancient Greek genius, Aristotle, invented syllogistic logic as a model of human deductive reasoning system. By the thirteenth century, Ramon Lull, the Spanish logician, invented machines for discovering non-mathematical truths. In 17th century, the French Philosopher, Rene Descartes toyed metaphorically with the idea of mechanical man. His contemporary, Gottfried Wilhelm Leibniz provided us a possibility of mechanical reasoning devices using rules of logic to settle disputes. Blaise Pascal and, later, Leibniz laid the groundwork for the abacus, the calculating machine that mechanized arithmetic.

The emergence of the programmable computer towards the middle of the 20th century was a turning point in the quest to construct "smart" machines. Alan Turing finally provided the theoretical foundation for designing and building the first modern computers in the form of massive code breaking machines of the Second World War. In 1943, IBM Chairman, Thomas

Watson, reportedly claimed that, “I think there is a world market for maybe five computers” (quoted in Moursund, 2006:20). We can imagine what he would say about world market for computers today.

The rationale behind the desire for intelligent machines is vindicated by the numerous benefits which stem from the emergence of modern AI computer programmes. The programmes can be used to play games, predict stock values, interpret photographs, diagnose diseases, plan travel itineraries, translate languages, take dictation, draw analogies, help design complex machinery, teach logic, make jokes, compose music, create drawings, and for carrying out boring, repetitive, tasks better. In fact, AI programmes have become an integral part of human life. Human beings are able to achieve their numerous goals efficiently and effectively with the aid of these programmes. Against this backdrop, our study supports Turing’s quest to use the TT as an instrument for establishing the reality of machine intelligence.

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