

Learning, Intelligence and Consciousness: Objective Science and Subjective Spirituality are Complementary

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Trying to understand yourself is like trying to bite your own teeth.

— Alan Watts

In this paper we define learning and discuss its relation to intelligence and artificial intelligence. We relate learning and intelligence to consciousness and discuss the relation between science and spirituality.

1 WHAT IS LEARNING

Learning denotes changes in the system that are adaptive in the sense that they enable the system to do the same task or tasks drawn from the same population more efficiently and more effectively the next time.

— Herbert A. Simon

1.1 Definition of learning

Learning can be defined with the following general situation: we have a system – the learner – that has (wishes) to perform a certain task. At the beginning the performance is poor. With practice, by imitating the teacher or by trial and error, the performance gradually becomes better. “Better” may mean faster, more accurate, cheaper etc., depending on the task. Practising, imitating the teacher, and repeated trial and error is called *learning*.

The learner has *learned* to perform the task, if he or she can repeat the task equally well without relearning. To be able to repeat the task equally well the system – learner – has to transform. The process of transformation due to learning is called *knowledge acquisition*.

Knowledge is defined as an interpretation of the information contained in data. Knowledge can be either given in advance (for example inherited or pre-coded), or is the result of learning. It can be correct or wrong, correct but useless, incomplete, etc. Any data with a given interpretation can be considered as knowledge. However, in practice only useful knowledge is interesting, i.e. knowledge that enables the system better performance when solving tasks from the given problem domain.

1.2 Artificial intelligence research

Learning takes place in almost all living beings, the most obvious in humans. Learning by a living system is called *natural learning*; if, however, the learner is a machine – a computer, it is called *machine learning*. The purpose of developing machine learning methods is, besides better understanding of natural learning and intelligence, to enable the algorithmic problem solving that requires specific knowledge. Often such a knowledge is unknown or is used by a limited number of human experts. Under certain preconditions, by using machine learning algorithms we can efficiently generate such a knowledge which can be used to solve new problems.

Even the whole natural evolution can be regarded as learning: with genetic crossover, mutation and natural selection it creates better and better systems, capable to adapt to different environments. For our purpose, only learning in a single system is interesting. However, the principle of evolution can also be used in machine learning to guide the search in the hypothesis space through so called *genetic algorithms*.

1.2 Artificial intelligence research

When we exclude consciousness the reasoning is transformed into mathematically predictable activity based on information, available in advance.

— Mortimer Taube

Learning, knowledge and intelligence are closely related. Although there is no universally accepted definition of intelligence, it can be roughly defined as follows:

Intelligence is the ability to adapt to the environment and to solve problems.

In definition itself we have learning – adaptation. In order to solve problems one obviously needs knowledge and the ability to use it.

A long term goal of machine learning research, which currently seems unreachable, is to create an artificial system that could through learning achieve or even surpass the human intelligence. A wider research area with the same ultimate goal is called *artificial intelligence*. Artificial intelligence (AI) research deals with the development of systems that act more or less intelligently and are able to solve relatively hard problems. These methods are often based on imitation of human problem solving. AI areas, besides machine learning, are knowledge representation, natural language understanding, automatic reasoning and theorem proving, logic programming, qualitative modeling, expert systems, game playing, heuristic problem solving, artificial senses, robotics and cognitive modeling.

In all AI areas machine learning algorithms play an essential role. Practically everywhere one has to include learning. By using learning techniques, the systems can learn and improve in perception, language understanding, reasoning and theorem proving, heuristic problem solving, and game playing. The area of logic programming is also highly related to inductive logic programming that aims to develop logic programs from examples of the target relation. Also in qualitative modeling the machine learning algorithms are used to generate descriptions of complex models from

examples of the target system behavior. For the development of an expert system one can use machine learning to generate the knowledge base from training examples of solved problems. Intelligent robots inevitably have to improve their procedures for problem solving through learning. Finally, cognitive modeling is practically impossible without taking into account learning algorithms.

1.3 Natural learning

Unknowing is either wisdom or the lack of knowledge.

— Osho

Humans learn throughout whole life. We learn practically every day, which means that our knowledge is changing, broadening and improving all the time. Besides humans, also animals learn. The ability to learn depends on the evolutive stage of species. Some researchers succeeded even to train worms.

Investigation and interpretation of natural learning is the domain of *the psychology of learning* and *the educational psychology*. The former investigates and analyses the principles and abilities of learning. On the other hand, the latter investigates the methods of human learning and education and aims at improving the results of educational process. Educational psychology considers attention, tiredness, forgetfulness, and motivation to be of crucial importance for a successful educational process and carefully takes into account the relation between teacher and learner, and suggests various motivation and rewarding strategies. All those are of great importance for human learning, however, much less important for the (contemporary) machine learning.

1.4 Types of natural learning

Memorizing is something else than learning.

— Peter Russell

Many researchers were trying to define types of natural learning and were searching for a basic type, from which all types originate. Most frequently, the types of learning are classified according to the learning complexity, the learning material, and the learning strategy.

With respect to the **complexity of the learning process** we differentiate the following learning types: imprinting, conditioning and associating, probabilistic learning, memorizing, learning by trial and error, imitation, and learning by understanding and insight. As regards **the learning material** we differentiate the following learning types: sensorial learning, learning of motor skills, and semantic (textual) learning.

2 LEARNING, INTELLIGENCE, CONSCIOUSNESS

Identity between human and machine is not achieved by transferring the human characteristics to the machine but rather by transferring the mechanical limitations to the human.

— *Mortimer Taube*

As we already stated, intelligence is defined as *the ability to adapt to the environment and to solve problems*. Nowadays, most of the researchers agree that there is no intelligence without learning. Learning alone, however, is not enough. In order to be able to learn, a system has to have some capacities, such as sufficient memory capacity, ability to reason (processor), ability to perceive (input and output) etc. These abilities per se do not suffice if they are not appropriately integrated or if they lack an appropriate learning algorithms. Besides, for efficient learning one needs also some initial knowledge – background knowledge, which is inherited in living systems. By learning the abilities of the system increase, therefore intelligence also increases. An oversimplification gives the following equality:

intelligence = hardware + background knowledge + learning + ?

Opinions of various scientists and philosophers are not united whether hardware, background knowledge, and learning suffice for (artificial) intelligence. Defenders of the opinion that natural intelligence is the only possible intelligence disagree with their opponents who claim that it is possible to create the intelligent machine.

2.1 The amount of intelligence

Knowledge is important, however, much more important is its beneficial use. This depends on human mind and heart.

— *Dalai Lama*

The systems cannot be strictly ordered with respect to the amount of intelligence because we have to consider various types of intelligence (abilities): numerical, textual, semantical, pictorial, spatial, motor, memorial, perceptive, inductive, deductive etc. Lately, even emotional intelligence became widely recognized. Some authors describe more than one hundred types of human intelligence. A system (a human or a machine) can be better in some types of intelligence and worse in others and vice versa. When speaking about artificial intelligence we do not expect from an intelligent system to be extremely capable in only one narrow aspect of intelligence, such as for example the speed and the amount of memory, the speed of computation or the speed of searching the space or (almost optimal) game playing – nowadays computers in each of these aspects already have very advanced capabilities. We expect from an intelligent system to be (at least to some extent) intelligent in all areas which are characteristic of

human problem solving. It seems that we need an integration of all different types of intelligence into a single sensible whole (a kind of supervisory system) so that during problem solving it is possible to switch appropriately between different types of intelligence. Anyway, most of the speculations about artificial intelligence do not take into account yet another level: consciousness (which seems to be a good candidate for the supervisory system).

2.2 Consciousness

When you remove all thoughts, what remains is pure consciousness.

— *Ramana Maharishi*

Self awareness, differentiation of self from others, awareness of your own problems, tasks and your own (ethical and moral) responsibilities – all these are related with consciousness, however, what consciousness is by itself is much harder to define. Nowadays scientists from various fields study various aspects of consciousness: psychologists, psychiatrists, neurophysiologists, physicists, biologists, chemists and biochemists, computer scientists, philosophers etc. On annual international scientific conference in Tucson, Arizona hundreds of scientists all over the world each year try to clarify at least some aspects of consciousness. Through years it became clear that no one really knows how to define consciousness. In recent years they invite to the conference also people that study and practice various spiritual techniques and meditation. It seems that consciousness is highly subjective while science by definition is struggling to be objective. The relation between science and spirituality is described in more detail below in Section 3.

Some quantum physicists relate consciousness with the collapse of the wave-function which is used to describe the probability distribution of all possible states of the observed system (for example a set of particles). When the measurement takes place the wave function collapses and from all possible states one particular state appears as real - the result of the measurement. The great mathematician John von Neumann, who provided a rigorous mathematical foundation of quantum mechanics, believed that only the human consciousness can collapse the wave function. The eminent Nobel prize-winning physicist Eugene Wigner writes: “It follows that the quantum description of objects is influenced by impressions entering my consciousness ... It follows that the conscious being must have a different role in quantum mechanics than the inanimate measuring device.” The famous physicist John Wheeler has taken this one step further. According to him the entire universe can emerge into true physical existence only via observation of the consciousness!

Therefore, the quantum principle of non-determinism of state “until the measurement” could actually mean “until the measurement, performed by a conscious being”. By this principle the reality is not determined until a conscious observer measures it. If confirmed, this hypothesis could clarify many currently unexplained phenomena, such as telepathy, precognition, tele-kinetics and clairvoyance. Most of researchers still assume the materialistic explanation of consciousness – they assume (note that this is

2.3 Limits of symbolic computability

mental content	self awareness	
	YES	NO
YES	wakefulness	dreaming
NO	meditation	dreamless sleep

Table 1: States of consciousness

only an assumption), that consciousness appeared in a certain stage of evolution and is a result of complex (hard-wired) system such as human brain.

With humans we differentiate several states of consciousness. One possible classification is provided in Table 1. Note that the boundaries between the waking state, dreaming and dreamless sleep are fuzzy. For example, while dreaming one can be self-aware (lucid dreaming). Besides, we do not know if a dreamless sleep exists at all, because when we do not remember any dreams we cannot be sure that in fact there was no dream.

Functions of the human consciousness can be further divided into several levels: pure consciousness (without mental content, which in Table 1 corresponds to meditation), super-consciousness or altered state of consciousness (corresponds to special abilities, such as clairvoyance, telepathy etc.), normal consciousness (waking state – mental content depends on our attention), subconsciousness (corresponds to all mental processes, which we are not aware of, but in principle we could become aware of them with the appropriate focus of attention), and unconsciousness (which most probably corresponds only to the dead body).

2.3 Limits of symbolic computability

It is impossible to teach the truth.

— Osho

Theory of computability reveals that only a tiny (one could say a negligible) part of all problems, which can be formally described, can be algorithmically solved. The number of all different algorithms is countable infinity \aleph_0 which is equal to the power of the set of all natural numbers: $|\mathcal{N}| = \aleph_0$. However, the number of all problems is uncountable infinity \aleph_1 which is equal to the power of the set of real numbers $|\mathcal{R}| = \aleph_1$ (in fact, the uncountable infinity corresponds to the power of the powerset of a countably infinite set: $2^{\aleph_0} = \aleph_1$). Therefore, the number of all problems is so huge, that almost none of them is algorithmically solvable.

Nowadays the science uses the following formal symbolic languages for describing (modeling) reality:

- mathematical logic,
- programming languages,
- recursive functions, and
- formal grammars.

All these formalisms have equivalent expressive power and they all have equivalent

2.4 Possibility of artificial intelligence

limitations: they can partially describe the phenomena in the discrete world (discrete functions), and practically a negligible part of the continuous world (continuous functions). Therefore, if the world is indeed continuous, then most probably it is undescrivable by any of formalisms which we are able to use with our (rational) mind. This would implicate that any knowledge that can be reached by science, described in books or by teachers, cannot be ultimate, as it is always only an approximation of the reality.

Note that the number of all rational numbers (fractions) is the same as the number of all natural numbers: $|\mathcal{N}| = |\mathcal{Q}| = \aleph_0$ (we can assign to each rational number a unique natural number and vice versa). The set of rational numbers corresponds to the *discrete world*, while the set of all real numbers corresponds to *continuous world*. The names here are suggestive: rational numbers correspond to the world, reachable by our rational mind, while real numbers correspond to the reality which is much more rich and is *in principle unreachable to rational mind!*

In all years from the very beginning of electronic computers we cannot notice any crucial progress towards the ultimate goal of creating an intelligent machine by using machine learning algorithms. Anyway, we can mention some important steps:

- Lenat's Automatic Mathematician - an interesting system for discovering new concepts in mathematics,
- great successes of computers in complex games, such as checkers, backgammon, and chess,
- artificial neural networks for modeling the cognitive processes in the brain,
- several successes in generating new and beneficial knowledge from data.

But the principal limitations for programming languages and other formalisms, described above, that stem from the computability theory, hold also for any ML algorithm, no matter how advanced and complex it is. Very strict limitations are posed by the theory of learnability. The latter is derived from the computability theory - the machine learner is necessarily an algorithm. As it may be expected, all the limitations for computability hold also for learnability.

2.4 Possibility of artificial intelligence

Morality and intelligence are learnable.

— Anton Trstenjak

Practically all research of artificial intelligence methods try to develop systems that behave intelligently and are able to solve relatively hard problems. The developed methods are often based on imitating the human problem solving. As a long-term goal we are interested whether computer intelligence (capability) can indeed achieve or even exceed the human intelligence. Important aspects for understanding the abilities of artificial intelligence are the impact of learning on intelligence, the speed of problem solving, the principal limitations of algorithms, and the imitation of intelligent behavior:

Impact of learning on intelligence: By learning the capability of the system in-

2.5 (Im)possibility of artificial consciousness

creases, therefore also its intelligence increases. Human intelligence is dynamic and is changing throughout the whole life, mostly increasing. However, when determining the amount of intelligence one has to take into account numerous different types of intelligences, mentioned in Subsection 2.1.

Faster is more intelligent: Adaptation to the environment and problem solving are better (more efficient) if they are faster. Therefore, intelligence is highly related to speed and time. All tests of intelligence are timed as are also all examinations. Therefore, we can conclude, in that sense, that faster computers are more intelligent than slower ones, that parallel processing is more intelligent than serial one, etc.

Limitations of intelligence: If humans were equivalent (degradable) to a computer algorithm then all the limitations posed by the computability theory would hold also for humans - this would have strong impact on the abilities of human intelligence. If, however, we assume that humans are stronger “machines” than (digital) computers (for example continuous and not discrete machines) then the human activity is undescrivable. The consequence of this assumption is that it is impossible to algorithmically derive an artificial intelligent system which would completely reproduce the human behavior.

Imitating intelligent behavior: Nowadays the technology of movies, multimedia, computers, robots, and virtual reality is very convincing and suggests that it is possible to imitate just everything and induce the sensation of reality.

Therefore, if we omit the consciousness, a machine can in principle be intelligent enough (for example by huge amount of memory, containing the solutions to all possible situations) to induce the sensation of artificial intelligence. If we add also extraordinary processing abilities (super parallelism with super-fast processors), algorithms for efficient search of huge spaces and machine learning algorithms that would enable online improvements of algorithms and heuristics, then such a machine could rightly be named “intelligent” - it could outperform the humans in many if not in all “practical” tasks. Of course, such a machine still lacks consciousness.

2.5 (Im)possibility of artificial consciousness

If you understand others you are intelligent. If you understand yourself you are enlightened.

— Lao Tse

In principle, we are able to determine (detect or objectively measure) any system that has certain learning capabilities and that has a certain level of intelligence. Opposed to learning and intelligence, consciousness is much different. It is necessarily related to subjective experience and any objective observer has no means to verify it. Although nontrivial, it is objectively possible to determine the ability to learn, the amount of acquired knowledge, the ability to (intelligently) adapt to the environment and solve

2.5 (Im)possibility of artificial consciousness

problems. Various tests of intelligence are able to measure only specific types of intelligence and the results are typically only partially reliable. On the other hand, in principle it is not possible to verify the consciousness of the system. Whether a (biological or artificial) system is conscious or not is known only to the system itself - in the case that it is conscious. An observer from outside has no way to verify it. You can speak about consciousness only if you yourself are conscious and if you assume that systems, similar to you, are also conscious. Any conscious system can be imitated with an unconscious system to arbitrary (but always incomplete) resemblance, therefore any objective observer can be fooled.

In the following we speculate about some interesting viewpoints. A system can be more or less intelligent but without consciousness (such as robot or in an extreme case a human zombie) or a system can be conscious but much less intelligent (such as less intelligent people, animals etc.). Consciousness seems to be fundamentally related to the following notions: life, intelligence, and free will.

Consciousness = life? Humans are conscious, dogs and cats are conscious (typical claims of pet owners), and even ameba may be conscious to some extent. Nowadays science is still not able to explain the origin of life. By materialistic assumption life appeared by chance (which is highly improbable) or it is a result of the complexity and selforganization of the matter. Another theory states that life came out of the space (aminoacids on the meteors), but then we have to ask, where and how were those aminoacids created. By vitalistic assumption, on the other hand, the life was created by a higher force - a universal consciousness.

More intelligence enables higher level of consciousness? Although consciousness is not objectively verifiable nor measurable we can speculate that with greater capabilities, i.e. greater intelligence, the higher level of consciousness can be achieved - we can assume that less developed species are less intelligent than more developed ones. Of course, you can have obvious counterexamples: have a super intelligent system (for example a highly intelligent man) and remove consciousness (such as brain washing or simple blindness with his or her own ego), you can obtain a highly intelligent system (for example a fanatic or an extremely avaricious man for money or power) that is not conscious of his or her actions. If we paraphrase: a child (in the sense of lack of consciousness) is playing with a nuclear bomb. The consequences can be catastrophic.

Consciousness implicates free will? If a system only reacts to outside stimuli then its responses are determined and unconscious. A conscious system can by itself, without any outside cause or stimulus, decide for an action (and not reaction) which means that it has free will. Various researchers and philosophers still argue whether free will exists at all, however, it seems sensible to assume that if consciousness exists then exists also free will.

SCIENCE	SPIRITUALITY
scientists	mystics
logical, rational mind	intuitive mind, inner sense, heart
objectivity measurable, describable	subjectivity nonmeasurable, undescribable
describing reality	conscious sensing, awareness of reality
how?	why?
studies matter	studies consciousness
life appeared by chance	life is a chance
doubt, verification	faith
logic, experiments, statistics	relaxation, meditation, ceremonials
analysis, differentiates, parts	synthesis, joins, whole
discrete, rational world (\mathcal{D})	continuous, real (\mathcal{R}), irrational world
objective, indirect experience	subjective, direct experience
active, violent free will	passive, harmonious free will
subordination, control	cooperation
taking, profit, ego	giving, all is one
knowledge	wisdom
Scientific theories: quantum, relativity, thermodynamics, evolution ...	Spiritual virtues: love, humility, compassion, patience, courage, sincerity ...
Scientific branches: mathematics, physics, chemistry, biology ...	Spiritual movements: yoga, tao, zen, sufism, institutional religions, new age ...

Table 2: Relation between science and spirituality

3 SCIENCE AND SPIRITUALITY

Science without faith is lame, religion without science is blind.

— Albert Einstein

This section outlines the relation between science, which tends to be objective and therefore limited to rational (logical) mind, and spirituality, which tends to be subjective and primarily uses intuitive mind (heart). Both science and spirituality search for the truth, but use completely different tools and interpret their results on completely different grounds. We follow the above statement of Albert Einstein (1940) and argue that science (objectivity) and spirituality (subjectivity) are complementary to each other and that we need both. Table 2 presents main contrasts between science and spirituality.

Science models empirical data: derives a model (hypothesis, theory) which

describes measurements and, if the model describes the data accurately, reliably and repeatedly, it is eventually accepted to be a (natural) law. If new measurements (which can be more accurate or measured under different conditions) deviate from the current knowledge, the laws are changed/widened in order to correspond also to new measurements. Science limits itself with objective principles and admits only the rational mind, which is limited, as described in Subsection 2.3, with symbolic representation/computability/learnability (although, of course, scientists during creative research use also, most probably undescrivable, intuition). Science is interested in HOW the nature operates and is not concerned in WHY the universe exists and what is the purpose of life. Due to ignorance of the latter two questions many scientists (unfoundedly) assume that the universe and the life appeared by chance and that there is no deeper purpose of existence.

On the other hand, spirituality is mainly concerned with the purpose of life. In all traditions, spiritual movements and all religions, from the east and the west, we can find the same basic issues:

- the purpose of life goes beyond the materialistic world;
- everything that exists is one, originates from the same source and serves the same purpose;
- the truth is undescrivable and unreachable to logical mind, it is necessary that everyone tries to feel it by him or herself by subjective experience;
- the purpose of life is learning, the goal is to overcome the limitations of ego, to subjectively recognize the truth and to attain the wisdom;
- spiritual life is based on cultivation of spiritual virtues, such as unconditional love, compassion, faith, humility, patience, tolerance, simplicity, spontaneity, modesty, courage, sincerity, forgiveness etc.

Spirituality is necessarily subjective and uses intuitive mind, inner sense - heart. Various relaxation methods, meditation and spiritual ceremonials tend to calm down the rational mind, to eliminate thoughts, in order to enable the direct sense of reality and to widen one's consciousness.

Philosophy (in the original sense of the word) uses both science and spirituality, objective and subjective experience, in order to achieve the balance and harmony between rational and intuitive mind, between head and heart. True philosophy deals with both questions, how the universe operates and why universe exists and what is the purpose of life. Great philosophers and sages from all cultures remind us that we need both, rational and intuitive mind. As Dalai Lama has stated: "We need education and the sense of moral ethics - these two have to go together."

Intelligence is the capability that artificial systems are gaining and in the future they will continue to gain more and more capabilities. However, consciousness has deeper meaning and purpose, it is necessarily connected with ethics of life. Intelligence without heart is unconscious intelligence, able to demolish and destroy the environment

Further reading

and itself. Artificial (and natural) intelligence is a tool which can be beneficially used or abused, the responsibility remains on your consciousness and conscience.

4 FURTHER READING

*Intellect separates, locates and compares details by searching mutual contrasts;
Wisdom unites and joins apparent opposites into one uniform harmony.*

— *Sri Aurobindo*

A classic introductory book on the psychology of learning is (Borger and Seaborne, 1966). Thorough overview of human learning and memory is given by Anderson (1995) The classic philosophical books by opponents of the possibility of artificial intelligence are (Dreyfus, 1972; Taube, 1961). More recent discussion on this topic is by Penrose (1989), Searle (1992), and Sloman (1992). Another collection of papers is edited by Gams et al. (1997). The theory of computability is thoroughly described in excellent books by Hopcroft and Ullman (1979) and Manna (1974). Einstein (1940) discusses the relation between science and religion. An excellent classic book on relation between quantum physics and spirituality is (Capra, 1983). Some aspects are further discussed by Wallace (2000), Kononenko (2002), and in a collection of papers edited by Lorimer (1998). Annual International Conference on Consciousness Studies takes place at the University of Arizona in Tucson: <http://www.consciousness.arizona.edu>. A huge amount of experimental work has been done by the Institute of Noetic Studies, <http://www.noetic.org> and published by *Journal of Scientific Exploration*.

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