US-China Education Review A, May 2024, Vol. 14, No. 5, 288-298
doi: 10.17265/2161-623X/2024.05.002

Towards a Natural Learning Process?

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Many different methods and teaching tools have been developed to teach different subjects, but the enormous consumption of resources has not resulted in tangible improvements in the quality of teaching. For a long time, and still today, the prevailing idea is that someone teaches someone something, not that someone helps someone learn. There could be tangible progress if there was a notion of cognition, memory, and thinking. Then both the methods and the means could be adapted. Everything up to now has been mostly based on experiments, observation, and statistics (psychology, pedagogy, etc.). To find out what can be done to improve and accelerate learning, an empirical model of cognition, memory, and thinking, which are necessary conditions for the ability to learn about the world around us, has been developed. There is a natural learning process that most people go through early in life, learning about nature and society. It has been observed that this process has been and is largely based on similarity, which is also an essential part of the empirical model. This suggests that similarity is one of the main tools for learning. The aim of this paper is to show that it is possible to approximate the natural learning process using insights from an empirical model and to give practical examples based on this model.

Keywords: similarity, comprehension, models, learning, recognition

Introduction

In 1977, at a conference on “A Common Language for Information Retrieval”, it became clear that things were “somehow not right”, for example, because more and more resources were being invested, yet the quality of natural speech text recognition was not improving.

I realised that it cannot go on like this because the problem is that we perceive everything approximately and at the same time precisely enough to be able to exist fully. The key was to make sure that we could empirically construct a model that would be convincing enough to demonstrate recognition and memory. This could help to explain the effect of these approximations and, at the same time, of sufficient precision, as well as to improve the efficiency of the learning process.

The author’s most convenient tools for building an empirical recognition model were recursive function theory (Rogers, 1987) and inductive synthesis theory (Gold, 1967; Bārzdiņš, 1974).

The black box approach principles (Gold, 1967) were used as the basis, where a black box has one input and one output. Depending on what is input, we get a result at the exit and, looking at both, the observer (generally recursive function) outputs a result—a hypothesis about what is in the black box. This is repeated an infinite number of times, and each hypothesis is written on a single-sided tape (infinite tape divided into cells with a fixed

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start). A hypothesis is accepted as valid if, given the same inputs to the hypothesis and the black box, the same results are obtained at the output. If the results are different, then a new hypothesis is taken and so on. Mathematician E. M. Gold argued that, if from a place we did not know before, we begin to write the same hypothesis over and over on the tape to infinity, then we have guessed what lives in the black box. It seems simple but there is a significant drawback—if we knew the world like that, we would need infinite time to distinguish a chair from a cup of coffee.

Does anyone at all need the whole truth sometime, not now? There is no need, and so the idea of replacing theoretical, absolute truth with a usable candidate for truth was born. Intuitively, it feels that we really do perceive and remember everything approximately and with time more and more accurately, rather than absolutely precisely. Then comes the need to reflect on why the established recognition programmes could not answer the old lady's question to the librarian—dear, please give me something about love. We can analyse text word by word or by phrases but there is such a thing as a concept that can be termed in different words, languages or described in different words without even naming it and still—everyone will understand. Everyone understands what a chair is, if you say that it is a thing you can sit on and support your back. Each particular chair is a separate example of the concept of chairs—a definite representative of the concept.

What then may be happening in people's heads? As already mentioned, there is no need for absolute truth, but we use candidates that are close to it—hypotheses. What do we remember and how do we recognise it? We seem to remember things as if they were specific, but we know things in general and therefore specific things. For example, we recognise a car in general and we recognise the car of a neighbour. Many things seem to be true but they are not. Many image recognition algorithms and programs were originally built on the basis of their writers' apparent ability to describe the thing being recognised—four legs, straight, or curved downwards from a flat platform, etc. I do not think that such descriptions live in our heads. Algorithms and techniques have now emerged that are able to modify their descriptions (program text) from intermediate results of long-running, pre-programmed prescriptions, to reread large numbers of different data files of different sizes, comparing them at different angles and levels of detail, which naturally gives significant results with a rather low error rate, but at the same time it is and remains like rereading a pile of data, like working with a phone book. Neural networks are somewhere closer, but there are problems with them too—they don't yet reach human concepts.

Basic Comprehension—Agreements

In general, we all live in a world of agreements where the word "word" in the particular language itself is an agreement made a long time before; we agree on the time and place of a meeting, we negotiate relations, etc. Therefore, we cannot continue this time without an agreement either.

Let's agree—let's make a deal that programmes are the Turing machine programmes. The theory of recursive functions deals with program capabilities, groupings, runtimes, lengths, properties, and much more. It has been shown that a non-trivial program can be improved to work faster (Bloom's speedup theorem), and it has been shown that there are programs that can write other programs, etc. It is important to know that there are general-purpose programs that can, for example, reproduce an image of any cup from a set of cups, or another program can reproduce an image of any comb. These proven facts can be verified by reading the relevant scientific literature.

Let's agree that the things in the black box in the introduction will be images/objects, and the hypothesis will be a program (a Turing machine program with a specific recursive function that corresponds to it). Let's agree that the program will reproduce the images. Let's agree that an image is a concept (in the intuitive sense) that includes visual, fixed image, motion image, sound image, tactile image, process image, etc. Let's agree to call the image we observe in the black box the image/object, and what is reproduced—the image. Assuming that all hypotheses about the contents of the black box will be programs, in theory we write all hypotheses on single-sided tape divided into equal sections, with each section containing a hypothesis corresponding to the current experiment/activity (input/output) with the black box. We are looking for a candidate for configuration that meets the described agreements and produces a usable result rather than the exact truth. Such a candidate can be obtained by requiring hypotheses to be written on tape, with a usability criterion such as the number of matches between the output and the output of the black box, of course with the same input for both. At each step one hypothesis is written on the tape, at each step there is a good enough candidate for the truth (a hypothesis) and as we work to infinity we will get more (not less) matches between the output of the hypotheses and the output of the black box. The process described in this way (a modification of E. M. Gold's approach in 1977) is called candidate truth synthesis (CTS).

CTS can be enhanced with memory and reproducibility, i.e., to run hypotheses to retrieve their reproduced images. In CTS, all processes are deterministic, where probability is introduced by external factors that determine the images/objects to be observed and their sequence. CTS operates with the smallest possible number of steps using the number of similarities as the selection criterion. Let us stipulate that the empirical model will be built using a modification of E. M. Gold's boundary synthesis framework (Gold, 1967) mentioned in the introduction—candidate truth synthesis (CTS).

It is a known fact that the source code of computer programs consists of "0" and "1", where this number, in the program, can be converted in a binary counting system into a natural number, which we will call the program number (Gödel number (GN) of the recursive function).

Suppose that the usability criteria are defined as follows: for a hypothesis to be eligible to be written on the current section of the tape, at the *n*-th step at the same reception input, the output of the hypothesis must match the output of the black box at least $S(n)$ times, where $0 < S(n) < n$, and $S(n) < S(n+1) < n$. Suppose if the last hypothesis on the tape in step n is not changed for another in at least $S(n)$ steps (other criteria can also be introduced), then we say that there is a stabilisation of the hypothesis, and let's also call it a concept. We will call the process of concept generation implemented by the CTS described above the Natural Learning Hypothesis (NLH).

Recognition

Suppose we have CTS (in the physical world probably genetically inspired and born in the head, but here, a program that can and does write/generate other programs). There were studies and practical experiments for the synthesis of programmes by examples, studies by J. Bārzdiņš, I. Etmane (1990), which starts to "get to know"/learn the current image/object, i.e., write hypotheses on the tape. We agree that the CTS is a finite-size, finite-time programme and gives a finite-time answer. The new image/object can be considered as the one in the black box. In the first section of the tape, the CTS records a hypothesis (its number) that claims to reproduce images of the totality of things as represented, for example, by a particular image/object in the black box (images are not only of tangible things, but also of sensations, movements, etc.—everything that can be observed). The process shall take place in no less than one step, and the result shall be stored by the CTS. After some time (steps), the same image/object or some other image/object unknown to CTS is again in the black box, runs the last written hypotheses on different tapes, and sees if their reproduction has any matches with the reproduction in the black box, and takes the hypothesis with the highest number of matches. The saved synthesis process is continued. If there are no matches, the CTS starts a new synthesis process as described above. Criteria can be established at which the CTS, even with a match but subsequently insufficient, starts a new synthesis process. If the CTS takes a saved CTS process tape to continue the process, we say that the image/object is known. If the CTS takes a stabilised hypothesis, or concept, and a tape of its further synthesis process, we say that recognition takes place at the level of the concept.

The existence of CTS in the form of a program executable on a computer is confirmed by the research carried out by postgraduate student Ilona Etmane on the synthesis of programs based on examples at the Computing Centre of the University of Latvia in the 1970s. The set for which the CTS writes the series of image-reproducing hypotheses (programs) that will be written in the sections of the tape arises from what comes out without any precondition. Of course, CTS does not work in the way we think we can build images of cars and other things, but only in terms of its own performance, which depends on the speed and resource consumption of the CTS on different groups of images (visual, colour, sound, motion, or other), as well as on probabilistic ambient processes—the presence of different images/objects or sequences of them in the black box.

We assume that the CTS does all the accumulating, searching, and hypothesis-running of what it synthesises. The natural conclusion is that the CTS should remember the hypotheses recorded in the last section of all the tapes, which are candidates for reproducing images of all cases in the field. The CTS, when receiving the next image/object, first looks in its last hypothesis if there is a similar hypothesis to take the next hypothesis (continue the hypothesis synthesis process with the next image/object). This is why at the beginning the cars looked like carriages. There are a number of other examples, which show that many times the new has been created by analogy with the old.

Of course, acquiring each concept requires looking at many images/objects, i.e., observations—CTS black box operations that take time—steps. If there is a concept, then when you look at an image/object, it is operated on and reproduces that image, which can be compared with the image/object being looked at and thus, as a result of comparing the images, the thing is known at the level of the concept. We all know cases when we have mistaken and identified something completely different from the thing actually seen. This naturally occurs when the memory and recognition are created as described.

We assume that the CTS can leave itself a set of images to be used as a single image/object in the black box. It follows from this assumption that the CTS can also synthesise concepts of abstract things. Of course, this is all at the level of what we consider to be abstract concepts.

Individuality of Recognition and Memory

Each of us had different encounters with images/objects and their combinations, so for each of us the hypothesis that has stabilised and become a concept is different from another person's hypothesis/concept. No one can put their own eyes in another person's and live their life exactly step by step, which shows that each concept is developed individually and trying to remember a cup of coffee will give everyone their own original reproduction of the concept.

Each has its own CTS, its own order in which the images/objects are viewed, and its own time—the number of beats, e.g., time sections of 12 seconds or whatever other duration, that are allocated to the different stages of viewing the images/objects. We can assume that the hypothesis at a given value of scale reproduces the image/object observed at that particular scale. For example, if I saw the coffee cup I drank from at 18:12 yesterday, the term “cup” on date + 18:12 in the input will reproduce the exact image of yesterday’s cup.

Full Picture—Frame

Previously, it was about how individual concepts/hypotheses are formed for some sets of images/objects that are formed individually. We are aware that our view captures not isolated single things, but a group of different images/objects in each moment. We actually see movement, something straight, something crooked, rough, smelling, smelling, loud, etc. We see the board as an image/objects, as well as the “curvature” of the images/objects, and we notice that it is hooked together. This is our real daily life.

So all this different group of images/objects, let’s call it a frame like in a film, that we see, hear, feel every moment. Why can we remember a room we have seen before, the people in it, and certain characters, as well as other things such as furniture?

Each frame that we observe is reproduced by a group of concepts that participate in the reproduction of the images/objects included and observed in that frame, which are compared with what they observe all the time. Similarly, how cinema is made—the activity of each actor, the speech, and the space are fixed on the film, and at any moment we can compare the film with the position of the respective actor, the speech, and the space where they operate. If we go beat by beat, the result of each beat is verifiable. So again, the picture of the frame is built by concepts/hypotheses that repeat (reproduce) what is seen, heard, felt, etc. at every moment. Also, testing is done every moment, comparing a special internal image to the observed one.

For the memory, this is not enough, because it is necessary to remember the sequence of frames and the specific things in it. To solve this problem, we bring in two things: the relationship between all the concepts and the specific images they reproduce, and the sequencing, because we remember what came after what.

Let’s assume that it is necessary to start a biological clock, which starts to work at least from birth and counts beats throughout the life. To establish the association of the images reproduced by the concepts, for each specific image reproduced by a concept in a given frame, we write in references, all the other images/objects in the frame in the given beat. The introduction of a beat creates a specific beat number (BN) for the situation/frame that we observe. This is a fundamental assumption of the memory model. Hypotheses typically have an input and output or the data that must be processed at the input and generated at the output. So by this logic, giving, for example, the concept (hypothesis) of a human face to the BN of a frame should result in the faces of exactly those people who have participated in that particular frame in that particular take. The same should happen with all the concepts involved in the frame. So, if we assume that the concept of a particular BN issues an image attributed to a particular item that matches this BN, then remembering the beat number can provide the image of the particular thing that was in the frame at that particular time. For each frame, a list of BNs is remembered (kept), with all the concepts of the frame with references to all the other concepts written down for each of them. It’s a long list, but it guarantees that for any particular image in any frame, we can build images of all the other participants and even restore the whole frame. Overall, it seems to describe the effect—why we can walk down a street in a strange city and see a familiar corner and find our way back.

Association Chains

If we have to remember a certain frame from before then we have to try to remember what it was related to—a particular person, thing, time, place, etc. If one of these mentioned things is more common, then using its BN we reach the goal. This is usually called associative memory—to remember John, you have to remember the table where we celebrated Johns birthday, and then John will come to mind. The BNs of concepts/hypotheses reproduced in specific images and references to neighbours, which we encounter more often, float to the top of the recall list and so you can get everything quickly and effortlessly from the most frequently used ones, but if things have sunk far, you can only remember if someone in the frame is related to someone at the top of the list. It is what happens in reality because we often cannot remember a particular surname but it takes time and it just floats up because we have seen a specific vase, which can lead directly to the image of the person you are looking for by referencing them.

The natural consequence of this model is that CTS does not forget anything but does not have time to reread the whole database, because new incoming information has to be processed all the time—a duplicate of the observed image/object has to be reproduced and compared with the observed one. It is known that CTS and hypotheses that produce images or sequences of frames for a particular domain can work faster or slower. If the hypotheses work faster in a certain field, it can be said that there is talent in this area. The same is true of CTS, which builds hypotheses faster in some areas and slower in others.

Step of Thinking

The thinking step is a matter of opinion because it looks simple but nature works on the principle of the least energy consumption. This principle leads us to the need to use similarity, as it can significantly reduce the number of steps required in the CTS. We actually observe the series of frames that make up the film of our lives.

CTS can reproduce any frame or sequence of frames with recorded beat numbers. If there is a need—a discomfort to get something—to search for an image/object, the CTS searches for a series of frames that lead to a result similar to the image/object being searched for. In addition, a series of frames can also be the image/object to be observed in order to synthesise a new hypothesis/concept. CTS can present the reproduced images of several hypotheses to itself as a new image/object for the synthesis of a new hypothesis. Alternatively, the CTS can split the reproduced image of a hypothesis into several images and present them separately to itself as images/objects for the synthesis of new hypotheses. This leads to abstract concepts. Once the CTS has found a similar sequence of frames, it starts to synthesise the sequence of frames, which leads to the search. The CTS can handle multiple framesets at the same time. The CTS synthesises a sequence of future frames all the time, based on the similarity of the previous frames. This explains why there is no free will (Hawkins, 2021)—the CTS has built everything in advance. The CTS can be "forced" by similarity to use "instructions" for pre-tested frame series which are guaranteed to reduce the number of CTS steps, are at the top of memory, and can be found quickly by CTS.

There is one important aspect—the speed of the CTS, where a large number of steps can often lead to the termination of a process because another process has to be started. We assume that what is done in fewer steps is attributable to "liking", which can accordingly be a motive for thinking.

One assumption is safe to make: discomfort is the motivation for CTS thinking. Motivation can be purely physiological feelings, such as not counting the fewest steps, satisfaction, fear, pain, etc.

Teaching

A look at the description of the CTS shows that one CTS cannot teach another CTS any concepts, nor can it teach memory, nor can it teach thinking, and if the brain works in a similar way, one of the most important helps to recognise new things—images/objects—is the use of similarities. If we arrive at recognition at the level of the concept, we can say that recognition also takes place at the intuitive level (through the ability to reproduce a similar image or series of frames with the participation of other concepts, to verify recognition in practice). The empirical model described in this paper can claim to be an approximation to brain activity and in no way contradicts the use of similarities/models in natural learning. The fact that current teaching methods do not lead to tangible improvements at high resource consumption makes it necessary to use parables/models that stimulate familiarity and concept formation in parallel to the teaching method used. This helps the individual to learn for him/herself, rather than just trying to teach (train) him/her.

To begin the conversation on the step of thinking one has to return to memory and recognition once again and only then moves on to the step of thinking. If we put a CTS that has acquired the surroundings in Africa into another environment, such as the Arctic, it will be a long time before it starts to arrive at concepts that are on average appropriate for the Arctic. Over the course of many hundreds of thousands of years, people have approximately learnt to guess what to show their children and how, so that they become roughly alike the preferences of the parents. No parent has been able to accurately guess or confirm how it happens, so we can assume it is a kind of axiom. The teaching method meets great approximation and approximate usable results and problems that are already associated with the exponential growth in the amount of information. The CTS described above can be trained according to the pyramidal scheme used in recursive function theory (Rogers, 1987), but this is counterproductive because it takes an inadequate amount of time, and the student would die before learning anything. This approach only shows that a constructive/feasible training method is possible and that the best one cannot be found in the end. In fact, we can conclude that for a few hundred thousand years we have been looking for the best method of teaching and have not found it.

How can CTS be trained to deliver roughly what we expect? The biggest problem is that experimentally it has been happening for several hundreds of thousands of years and now it collides with very difficult problems. All the time, people followed practice as they thought best to teach.

The Greek academies were based on disputation and the ability to prove one's point with logic, parables, observation, and whatever else was available at the time. They were the closest to a natural learning process. Then monotheistic religions introduced canons and there was only one version—learn and repeat, which prevailed for two thousand years and are still felt today. Of course, there were experiments, new insights, new theories based on them, but the old formula—learn and repeat—is still used in education by inertia. While there are attempts to raise comprehension, there is virtually no system specifically for raising or stimulating comprehension. Today there are attempts to replace it with role-play in similar situations, so that the student can relate to them. It is not bad but this also leads to the inspection of different examples where the student does not have a concept about the thing under consideration and the examples. Practically, comprehension is left to the learner itself—saving the drowning is the task of drowning itself. The most talented can and could do it but everyone else could not and cannot even today.

Still today, the teaching and learning of STEM subjects is a major issue that is being addressed with great attention. I do not want to throw a stone in the garden of teachers and psychologists because they work in good faith using experiments, assumptions, history, and other things that they think can improve the situation, believing they can give or teach someone something. They work with the students on feedback, mainly using statistics and trying to guess what the students need and how to show them in order to achieve the desired result. It has been happening for many years, and very large resources are spent with very low success rates. Many methods and techniques are created but the results are minimal. This effect is because these attempts to change methods and techniques are uniform. Of course, there are also many talented students who are more capable than others with any teaching method.

Spending large resources at low levels of growth suggests that something in general is wrong. The similarities in the CTS speed up the synthesis of a new concept and it is reasonable to suspect that the same happens to humans. Using similarities can help you learn new things faster and improve your memory.

It seems that the ability of the CTS to synthesise a new hypothesis/concept using similar hypotheses and sequences of frames previously used by itself should be exploited, which reduces the use of CTS resources, and the number of steps. If we accept this, then training should be structured in such a way that everything new is learnt through similarities to the old (has long it has been learnt, what is familiar, which has the concept, the series of frames involving it). The old is not meant to be the specific material of the subject, but everything that the student has come to know intuitively in their life. So a series of new observations will not be needed, as these will be replaced by those made previously and already used in the CTS synthesis process. So in many cases, the CTS simply continues synthesis processes already underway.

In practice, this can be achieved by deliberately giving the student an image or series of frames similar to what they already know, thereby stimulating them to remember and use what they know in their own synthesis process. In this way, the teacher hopes to have found something that the student is familiar with, to find something similar in their memory, to be able to check in dialogue with them whether the memory is really similar, and at the same time to hope that the student will form their own hypothesis about what they have been given, which can be tested again. The fact that the teacher's and the student's concept sets may overlap only slightly makes it necessary to accumulate similarities from different domains for the image/object to be learnt in order to increase the chances of coincidence. Let's call these similarities that stimulate memory retrieval patterns.

Language, Pictures, and Other Forms of Information Transfer

For a freshly synthesised concept, the CTS attaches a code—a linguistic word. As each individual develops an individual concept, the word can convey a different image to each person. A grammar is a new image/object with a series of other images/objects constituting it, about which the CTS has to synthesise appropriate hypotheses, preferably already concepts. Science tries to introduce definitions and other techniques to make the language it uses (formalisation) unambiguous, but not always successfully, because even at big conferences, high-level scientists use patterns—similarities—to show what sense a particular word or term is used in. Very often one word describes a variety of concepts, and, in the same way, different terms indicate the same concept. The linguistic word, according to the empirical model, is the reproduced image (visual, sound, tactile, etc.), but each has its own, though perhaps not very different from the reproduced images of others. This is usually the case, but not always, as the reproduced image initiated by the word can also be quite different. We can say that every verbally pronounced sentence is subconsciously transformed into a sequence of frames, in which concepts induced through words are involved. We cannot say that there are only word-initiated concepts, but there may be something else—meaningful or unsubstantial, which is extracted from each individual memory according to the concepts that took place in some actions. That is why when speaking about one thing, things that are irrelevant come to our mind.

Verbal thinking—executing "instructions" is about 60 × slower (while taking many more steps) than thinking in images—the CTS builds a sequence of frames not from memory, but as few steps as possible, and this has been experimentally proven.

Verbal expression is an option to roughly pass the information at the level of perception we have imagined but without chances of any precision; it is approximate because each recipient of information will recycle it at the level of his/her experience.

So, with the language we can transfer the information to another but it is very approximate and even within specific, closed theories it will be quite heterogeneous without explanatory models, which also does not guarantee full accuracy, but iteratively, this accuracy can be significantly improved, and even achieve "absolute" accuracy for many man-made objects. You can ask the creator of the object what exactly he has created and for non-trivial objects with similarities, patterns, final iteration is possible. We all communicate very approximately but still functionally, if we use all the means to specify the compatibility of the information provided and received. Since language creates a sequence of frames, words (terms) are used in training to create a sequence of appropriate frames for the student, but if they are presented with words (terms) for which they have no concepts, then a situation arises—known & known & unknown & known & ... & known is unknown. In this situation, the student will not be able to reproduce an image for themselves that they are familiar with. This is one of the basic mistakes in teaching. If the unknown word is replaced by an image, a series of frames similar to an image, a series of frames in another domain familiar to the student, then there is a high probability that the student will synthesise a new, usable hypothesis in a small number of steps and maybe even a concept in the future, otherwise it will be deleted/forgotten, because all the time in the CTS will be taken up with the next frames. This method, the "model method", claims to significantly improve human training, as everything else was tried long ago with no apparent success.

Conclusions

This paper shows that an empirical model can be constructed for CTS recognition, memory, and that it learns sufficiently similarly (based on interpretation of observations in history and today) to a natural learning process. The empirical model of the CTS can be used to demonstrate a process of neighbourhood acquisition/learning in which no absolute truth is required, all processes are deterministic, and each moment uses what is present at that moment, as well as the concepts of synthesis, recognition, memory, and elements of thought. The CTS makes significant use of similarity to another hypothesis already in CTS memory to speed up the synthesis process for each hypothetical new image/object hypothesis, a concept to continue the synthesis process. The number of matches at the output given the same input can be used as similarity criteria, as already mentioned in the paper. The model/similarity is a good candidate for the requirement to find a method that is easiest for the brain to adapt to.

A process can be demonstrated in which the CTS synthesises hypotheses that reproduce a given set of images. The images/objects in this set can also be processes and, in our case, series of memory frames—peculiar series of frames—films, which can themselves become observable images/objects. These many different films can be glued together by the CTS using similarities to produce a hypothetical sequel to one of the films, or various other similarities—matching activities. This is how we perceive many things, play them out faster than they will happen, but only by a few tenths of a second. The PCS, like the brain, is constantly building a future with similarities known to it. This is evidenced by the experimental detection of the absence of "free will" in brain activity (Hawkins, 2021). This shows that the empirical model developed can also be used to explain thinking effects. Naturalness is also a concept of mathematics and is largely in line with the intuitive perception of naturalness—it does or does not happen because it is natural. In the case of CTS, what happens naturally is exactly what happens as in a CTS-synthesised future.

The work of the CTS is not affected, for example, by the complexity or inability to build the object-functions on the higher floors of the Clini-Mostowski hierarchy (Rogers, 1987) in finite time and in one dimension, because the CTS synthesises what it can and further uses what it can and to some extent corresponds to the results of a natural learning process at its different stages.

An important consequence of the given empirical description of the recognition-memory model of the CTS is the ability of CTS to rapidly synthesise new image/object hypotheses only given a large enough list of concepts in memory and sufficiently long, viewed, or synthesised groups of frames to make it possible to find something similar across that list and across those groups. This is called experience in the language of conversation, and the consequence is an independent, efficient search for patterns in memory in order to learn about a new object starting at an age when a sufficient number of concepts and hypotheses have been accumulated.

It can be hypothesised that in a natural learning process, both the individual and the CTS are likely to act in a fundamentally similar way, and that "similarity" is one of the basic concepts on which the learning process is based. Comprehension is closely related to knowing at an intuitive level, which means being able to find or construct at a conceptual level one's own similar internal model or several models (the same for sequences of frames). Once comprehension is achieved, the teaching methods and tools used so far become training grounds for spotting similarities, building similar patterns, and practising skills.

In the learning process, communication with the student might be most successful in the model-similarity option, as this seems to be a natural learning process according to the described CTS.

A method that has been used from antiquity by the most talented teachers in the learning process in a fragmentary way—to make use of similarity, a system that can be used consistently by all—is of great importance. Based on the empirical model described above, in 2009, the author, together with several teachers and students, practically implemented the accumulation of similarities/models on the freely accessible website www.goerudio.com[1] (Vitkovskis, Heidingers, Jakubova, Rikmane, & Krišmane, 2012; Vitkovskis & Heidingers, 2018) for STEM subjects in a secondary school course. It demonstrated the feasibility of creating such a database of similarities/models in a very short time (from zero to populated database in six months) and the effectiveness of using it for more than 10 years. This method was used in the European Union education project "GoScience Project", which won the European Commission Prize for Innovative Teaching[2] in 2022.

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[1] Goerudio Project, http://goerudio.pixel-online.org/.

[2] GoScience Project, https://www.goscience.eu/.

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