# Towards an Adequate Theory of Cognizing

Edward Pogossian
Institute for Informatics and
Automation Problems of NAS RA,
Yerevan, Armenia
e-mail: epogossi@aua.am

***Abstract*— Humans succeed in overall cognizing, including cognizing itself. Nevertheless, the questions on how cognizing was originated, developed, and what its limits are that remain so far open.**

**Thus, inevitably, human cognizing entails the necessity of reliable prognostication of solutions, particularly, of the problems of the most effective human cognizers and conditions to meet them constructively, the origination of cognizing and conditions necessary for it, the limits of human cognizing of the Universe and ways to overcome them, and the frontiers of human-AI relationships.**

**Such prognostication, expectedly, can provide the theory of cognizing we aim to advance.**

**In the paper, we argue the transition of human cognizing of the Universe to one of combinatorial games, then specify cognizers, followed by providing premises on their adequacy to cognizers by Piaget, listing ongoing advances of the theory, and conclude with plans for further research.**

***Keywords*— Theories, questioning cognizing, adequate modeling, combinatorial games, Piaget, cognizers.**

## I. Introduction

**1.1. Why the theory?** Humans cognize the Universe to support the promotion of their utilities. Nevertheless, acknowledging that cognizing is essentially ensuring being of humans, the ultimate frontiers of human ways of cognizing the Universe so far remain to be challenged.

1.1.2. Let's also admit a burst of concern on tremendous progress and intervention of AI into human societies. Known futurists Kurzweil and Goertzel argue that AI is currently entering the period of exponential growth. The critical question arises: whether *the coexistence of humans is possibl with AI e, i.e., with non-cellular cognizers.* But, AI, in fact, is a synonym of the attempts to construct adequate, effective models of human cognizing that can also clarify the critical problem of human-AI relationships.

1.1.3. Thus, inevitably, human cognizing entails the necessity of reliable prognostication of solutions, particularly, of the problems on

1. *The most effective human cognizers and conditions to meet them constructively*
2. *Origination of cognizing and conditions necessary for it*
3. *The limits on human cognizing of the Universe and ways to overcome them*
4. *The frontiers of human-AI relationships.*

Such prognostication, expectedly, can provide the theory of cognizing we aim to advance as follows.

1.2. **Targeting the type of the theory of cognizing**, let's preliminarily remind that theories, in general, comprise means of inferring reliable classifiers of new utilities from the basic reliable ones.

Hence, logical theories by rules like *modus ponens* infer new reliable classifiers, theorems, from reliable basic axioms.

1.2.1 Physical theories by some rules/relationships (say by *cause-effect* one or its *modus ponens* abstraction in logics), infer reliable classifiers from already massively experienced ones, *postulates*, combined, possibly, with earlier inferred classifiers and some not inferred ones, *hypotheses.*

1.2.2. Let's acknowledge also that the development of successful theories can be grounded on adequate constructive models already *communalized* classifiers, which along with identifying human utilities and, as a rule, having communalized IDs allow to rise the concreteness of theories up to degrees of their applications.

Hence it is worth to remind [1,2] that *regularized* classifiers Cl, i.e., communalized ones able by some means regularly provide positives r of Cl, and Cl themselves, are interpreted as *models* of classifiers Cl' if r are classified as positives of Cl`, while Cl are interpreted as *adequate models* of Cl' if positives r meet certain additional requirements focused on positives r' of Cl', for example, any r' is also positive of Cl.

And classifiers Cl are *constructively regularized* if Cl are regularized, and samples sps or their models are assembled from cellular independent units of matter.

For example, *algorithms* are such adequate constructive models of classifiers of methods, procedures, computability, and ground corresponding theory.

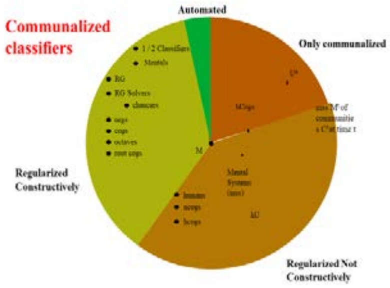


**Fig.1.1.** Attributing communalized classifiers

1.2.3. Analogously, the theory of cognizing is worth to ground on adequate constructive models of acknowledged classifiers of *human cognizers* hcogs and interactions of hcogsU with the Universe U.

1.3. In what follows, we, at first, argue the transition of human cognizing of U to one of combinatorial games, then specify cognizers, followed by providing premises on their adequacy to those by Piaget, then listing ongoing advances of the theory, concluding with plans for research.

Let's acknowledge that models in [1, 2, 8, 11, 23, 24] already were incrementally enhancing the constructiveness and adequacy of constituents of the theory. Nevertheless, they vary in their accentuations, which unavoidably fluctuate in presentations.

Hence, to make these models the base of the theory of cognizing, we are going to center their presentations on the theory, as well as enrich their arguments and consequences with up-to-date findings.

## II. Specifying Cognizing as Games

2.1. The entire Universe and new target **problems appear to humans *combinatorically*** because they need to be analyzed not in the frame of absolutely reliable conceptual frameworks, but with involvement of the entire ad hoc knowledge and means of its enrichment.

2.1.2. Such problems, if lucky, can be completely resolved. For example, in our practice [1], such complete solution was found for Schroder's combinatorial problem on specifying the systems of sets with min number of subsets, where the proof followed from the proofs of the chain of 36 lemmas (reminding also the proof of Nadareshvily's chess etude required the analysis of chess tree in the about 39 depth [3]).

Unfortunately, combinatorial problems appear as intractable and are resolved for sub-problems and only fragmentarily, which, as a rule, are too local and do not enlighten the solution of the original problem.

2.2. To resolve problems **humans represent all over,** including themselves, **by** systems of symbolic doers, classifiers, and relationships between them, or ***mental structures (mss).***

**Functionality of mss**

-**grounds on** *imprints*, i.e., the outputs of *sensors* and other ad hoc classifiers, which by their IDs symbolically represent the causers of imprints, the *realities*

- **incrementally develops** over imprints from

=nuclear 1place classifiers to

=time-space, cause- effect and other 2-place classifiers, *relationships* (rels), between ad hoc classifiers, then

=regularly comprise incremental systems from ad hoc mss and relationships

-**includes** direct or induced **classifying**.

For example, *Markov algorithms* providing if->then cause-effect rels between if- /then- classifiers , ordered and controlled again by certain rels.

Thus, any mss induce classifiers, the *systemic* ones, comprising with regularized and estrange-able ones, the *attributes*.

The outputs of attributes, *situations*, operably, and communicably represent the peculiarities and relationships of "*things in themselves*" of the observable Universe, which allows mss to be effective in supporting decisions.

2.3. Thus, the problems and dynamicity of the entire Universe U appear to humans by situations changed by a variety of bundles of known doers b, including, as a rule, hcogs, and possibly some unknown doers.

2.3.1. Ideally, the situations of U appear to humans h at times t as the outputs of all classifiers and cause-effect rules so far gained by h afore t. Thus, the possibilities of humans to reason on the Universe U and prognosticate decisions at time t are bounded by these ad hoc cognized classifiers and rules, ***ad hoc cognizable universe*** (ahcU). This model seemingly addresses to issues rooted in Platoon's plate and Vernadsky's noosphere comprehensions of the cognized and cognizable, as well as to Herbrand's model [29] of possible propositional inferences and Wolfram's ruliard "…the abstract object corresponding to the entangled limit of all possible computational processes: the result of following all possible computational rules in all possible ways" [27].

2.3.2. Really, hU interactions and cognizing of U, as a rule, are local. People, professionals, experts are goal-oriented and working with local sets of relevant attributes, thus, situations and corresponding local problems, and try to resolve them by so far gained mss, otherwise coincide this resolving with further cognizing the problems to enrich mss and become more successful. Eventually, the union of successful interactions and cognizing of such local problems comprises the global ones for the entire U.

2.4. Thus, given situations p, certain utilities, bundles b of doers/actors and their possible doings in corresponding problems P, thus, changes/transformations of p at times t caused by b, the experts, in agree with mss gained before t, can prognosticate possible trajectories/branches of changes of p in time t by local *trees Ts of situations* allowing them to examine Ts for the most perspective trajectories of decisions in p and do correspondingly to solve the problems P.

2.4.1. Moreover, when experts in situations p' of Ts aim to prognosticate strategies of actions for particular doers d and utilities, they for each action a of d consider all expected responses of the rest b\d doers of b in p' with corresponding possible changes of p' allowing to transform the trees Ts of situations into games on Ts, which comprise all possible strategies of d in interactions of d with b\d, thus, to search the best strategies for d to solve P.

2.4.2. Such games allow experts to process preliminarily the expected versions of strategies of solutions in the framework of the models of problems, i.e., in frame of gained experience on peculiarities of situations of the problems, compare the strategies, choose the most promising of them and apply, instead of riskier immediate elaboration of strategies induced by widespread reasoning common for any situation. And because mss have IDs, experts can communicate mss, i.e., explain and understand mss of each other, thus, collaborate for more effective solutions.

2.4.2.1. For example, in oligopoly competitions producers, say A, B, C, D ones, influence the market situations by bundles of 4P - price, product, promotion and proliferation, actions. Such competitions can be modeled by trees of situations, which focus on the benefits and strategies, for example, for A, can be transformed into game trees, where for each action of A in p', all possible responses of B, C, D will be branched along with corresponding changes of p' [9].

2.5. Resuming, we state

**St.2.1.** *Humans hcogs cognizing of the Universe U can be modeled by hcogs cognizing of global combinatorial games gG on global gTs trees of situations, which, in turn, consist of hcogs cognizing of local sub-games lg of gG on the corresponding local sub-trees lTs of situations of gTs altogether covering the global gTs ones*.

**Cl.2.1.1**. *Expectedly, as closely local combinatorial games cover the global ones, so higher are the chances of their proper modeling the hcogsU games.*

**Cl.2.1.2.** *Properties common for hcogs cognizing of local sub-games lg of gG expectedly take place, and for hcogs cognizing of gG, thus, the relevant of them take place also for hcogs cognizing of the Universe U.*

Distinguishing these common properties as ones related to the ***means*** *of cognizing* lcm and ones related to the ***outputs*** *of cognizing lco* (i.e., the gained knowledge lco), the Cl.2.1.2. actually states that lcm and lco can also properly approximate the corresponding means mcU and outputs ocU of cognizing U.

2.5.1. This reasoning is similar, for example, to revealing properties of a mosaic by analysis of its differently colored glass units, then concluding that the mosaic is also glass-made.

2.5.2. Thus, addressing to the theory of cognizing, it follows that

**Cl.2.1.3.** *The theory of cognizing of combinatorial games by adequate constructive models of hcogs can, in principle, be adequate constructive models for the entire theory of cognizing,* and

**Cl.2.1.4.** *The theory of hcogs cognizing of local sub games lg of global gG ones based on common properties of the means lcm and outputs lco of local cognizing can approximate adequate models of hcogs cognizing of U*

2.5.3. Consequently, the above statement St.1. and corollaries Cl.2.1.1.-2.1.4. argue the necessity of revealing proper **coverages of global games gG by local lg ones**, followed by revealing lcm and lco properties common for all representatives of such coverages.

2.6. Studies of knowledge-based solutions of various explicitly or not identified combinatorial games rooted in Theory of Games and Shannon's works in chess [10], are presented, particularly, in [4-7,30].

In [1,8], analogically to games with perfect information, a **class rg of *reproducible* ones** is identified by the following requirements:

- there are (a) interacting actors (doers, players, competitors, etc.) performing (b) identified types of actions at (c) specified moments of time and (d) specified types of situations,
- there are identified benefits for each of the actors,
- the situations perceived by actors of the games and ones after their acting have to be specifiable by if-then rules allowing experimenting with them regularly.

2.6.1 It appears that Rg class among chess-like games, covers massive application problems in competition, defense, and dialogue, including intrusion protection, marketing, craft defense, tutoring, testing of programs, and, as a rule, there were no intractable difficulties in their proper rg representation [1]. Even more, the class can be properly extended, allowing for the appearance of situations, for example, that are not only strongly deterministic, but also have some proximity and likelihood.

2.6.2. Hence, we can assume

**Ass.2.1.** *Games of rg class and their extensions properly approximate the coverage of local lg sub-games of the global gG games.*

2.6.3. Then, following St.2.1. and Ass.2.1.2., it is reasonable to expect that properties common in rg cognizing, at least, approximate hcogs cognizing of the Universe U, allowing the corollary Cl.1.4. to transfer to the following assumption

**Ass.2.2.** *The theory of hcogs cognizing of games of rg class based on common properties of the means and outputs of rg cognizing can approximate adequate models hcogsU of hcogs cognizing of U.*

2.7. On the way of Ass.2.1.2, let's emphasize that such a theory arguably can be based on common rg properties, while any rg member assumingly possesses them.

Hence, for convenience of researching it is reasonable to develop the theory for rg representatives, ***rg-kernels***, followed by dissemination of the results to the theory of the entire rg class, and then, moreover, to approximate adequate models of hcogs cognizing of U (hcogsU).

Acknowledging that chess historically was pretending for such a rg-kernel, referring to studies of chess rooted in Zermelo's one [26] and continued by others including [1,4-6,8,10], we extend the properties expectedly rg common from those argued for chess.

2.8. As a result of comprising properties so far gained in cognizing chess, the applications of and experimenting with competition, defense, and dialogue of rg problems rooted in cognizing chess and summarized in [1], let us state

**St.2.2.** *Properties revealed in cognizing chess are arguably extendable to the entire rg class with proper replacement of chess terms in them by targeted rg representatives and chess values by corresponding utilities.*

Correspondingly, the corollaries of St.2.2. follow

**Cl.2.2.1.** *Humans hchcogs cognizers of chess can properly approximate hcogs rg cognizing, thus, also approximate the adequate models of hcogsU.*

**Cl.2.2.2**. *The theory of chess cognizing, based on the models hchcogs, can approximate the entire constructive theory of cognizing.*

2.9. Resuming, let's list some **of** the **ongoing and intended studies of cognizing of chess arguably relevant to the theory of cognizing by cogs the Universe U:**

- *measurability of progress of cogsU by local tournaments*
- *learnability of meanings by cogsU: by examples provided by experts, by acquisition of meanings of both the experts and members of communities (swarms)*
- *progression of cogsU from octaves to the highest Cogs, at least, comparable with hCogs*
- *comprehensive outputs of cognizing of global games on ad hoc trees of situations by analogy with comprehensive outputs of cognizing of chess*
- *origin ability of cogsU by providing examples in the earliest learning of chess.*

## III. SPECIFYING HUMAN COGNIZING

3.1. Questioning constructive models cogs of human cognizing hcogs, let's concede that cogs definitely have to be grounded on the most acknowledged contemporary views on cognizing.

Then, it is desirable that cogs are consistent with effective at present constructive algorithms of cognizing and cover them.

And it will only add to the reliability of the theory if arguing the adequacy of cogs to hcogs was consistent with great experience of arguing the algorithms – the models of computability and ground for developing the theory of solvability of problems.

3.1.2. Correspondingly, our specification of cogs

- constructively regularizes descriptive psychological models pcogs of hcogs by the outstanding psychologist Jean Piaget [12].

- ***enriches*** object–oriented approach to modeling realities by allowing both arbitrary additional input classifiers, say NN ones, and any relationships, say ones in English

- follows the methodology of arguing the adequacy o algorithms.

3.2. **Jean Piaget** (1896-1980) revealed and experimentally argued that human cognizing

- *is governed throughout the entire life by universal and inherited laws,*
- *develops by acquisition (assimilation) and revelation (accommodation) of mental structures, followed by their organization and equilibrium,*
- *necessarily transits from sensor-motoric to operational stages, then to the abstractt one that can develop unlimitedly.*

3.2.1**. Interpreting Piaget** *generalized constructive cognizers* cogs are defined as realities with energizers, sensors, effectors, controllers, and certain utilities, which throughout their lifetime regularly and unlimitedly learn and organize certain constructions, *mentals,* to support the promotion of utilities [1, 2].

The definition of ***mentals*** (generally exempted from cellular and computer dependency) is incremental and is based on those of doers, sensors, classifiers, relationships, attributes, imprints, identifiers, nominals, doins, systems over nominals, and others.

3.2.2. Analogously with cognizers pcogs by Piaget, generalized cogs **learn mentals** motivated by utilities of cogs, **reveal** them, but mainly **acquire** mentals from experts and communities of cogs.

*Revelation /discovery/* of mentals, in essence, is *inductive classifying,* which developmentally is enriched by *deductive, imaginary, and intuitive inferring of mss, enhancement of effectiveness of mss, processing mss to search or prognosticate classifiers and strategies.*

Enhancement of the effectiveness of mss we refine, particularly as their *constructive regularizing* and *adequate modeling. Acquisition* assumes gaining mss straightly from teachers or throw *representations of mss.*

3.2.3. Focusing cognitive doing of mental ones, we need, first of all, to confirm that they are unavoidable for cognizing, then, have to reveal whether they are denotative, and if the answers are positive, look for their models, so far varying in their degrees of constructiveness and adequacy.

Cognitive doings with acknowledged acceptability of degrees of adequacy of their models along with the above ones include utilization of realities by acquisition, matching to classifiers, communications, compound classification, as well as motivation, will, imagination, intuition, regularization and modeling of classifiers, development and origination of cognizing, *and meta cognition.*

At the same time, *emotions, self-awareness, consciousness, and meta-consciousness* so far are questioned for being cognitive, before attempting to develop their constructive adequate models.

3.3. Note, that following the above reasoning, we can state that cogsU -> rgcogs rg, since rg->U, thus, cogs U interaction is reducing to rgcogs rg,

Then one can state that rgcogs rg is equal to its computer model since both of them are constructive and the model is validly implementing rg cogs.

## IV. ADEQUACY OF MODELS OF COGNIZING

4.1. We tend to make the adequacy of models completely explainable and carry it out by analogy with the justification of algorithms by Church [13], i.e., to assure, at first, the coverage of constituents of Piaget's declarative models pscogs by constructive ones scogs. to argue cognizing. Let's also remind that this arguing we tend

4.1.1. Then, following the models pcogs of cognizing by Piaget, we distinguish sub-models pcogs, classifying mostly stabilized in their development constituents of pcogs and ones dpcogs, classifying the engines of development of pcogs.

Consequently, the arguing of adequacy of cogs to pcogs we branch to those of scogs to spcogs and of dcogs to dpcogs, correspondingly, thus, questioning the adequacy of (rgcogsrg = srgcogsrg + drgcogsrg) to (prgcogs rg = sprgcogsrg + dprgcogsrg).

4.2. **Arguing the adequacy of scogs to pscogs so far holds** premises **that scogs**

- preserve the majority of known statements and algorithms of cognizing, including

  =inductive learning algorithms, particularly in the NN (Neuron Nets) mode,

  =Personalized Planning/Integrative Testing algorithms, elaborating strategies in target situations dependent on the learned classifiers, thus, elaborating "if then" relationships - the base for formation algorithms, say, by A. Markov or E. Post [13],

  =algorithms of acquisition of strategy meanings by experts and those from the texts conceptually close to the study in Stanford by [14],
- provide expert-like explanations/interpretations of mentals,
- can be based on any classifiers, say on NN, thus, constituting functional and connectivity models of cognizing,
- are supportive of the revelation of the origination of cognizing functionally, which can essentially extend the variety of solutions.

4.2.1. This arguing, similar to those for algorithms by Church, is **continuing** and assumes **further coverage of functional constituents of cognizing** and its outcomes unavoidable for cognizing.

These constituents include imagination, an ability to modeling both quantitative and qualitative in physical, biological, and social systems, common sense and spatial reasoning, diagnosis and design, as well as those enlighten by Piaget and his colleagues, namely, development of language, thought and causality, judgments including moral one, the studies of realities such as quantity, logic, number, time, movement and velocity, space, measurement, chance, adolescent reasoning and perception.

4.3. The next step of arguing of cogs focuses on **arguing of adequacy of dcogs to developmental models pdcogs by Piaget.**

Thus, it has to be argued that dcogs is able adequately develop in agree with fundamental hypotheses by Piaget [12] stating that cognitive doings are learned stage by stage from certain root doings of newborns to the highest ones by means of only a few rules, namely, acquisition (assimilation), revelation (accommodation) of mss, followed by their organization and equilibrium.

4.4. For these aims, we have defined *octaves* as cognizers with means of learning and organizing mentals, while being sufficient for unlimited development of the power of cognizing in any dimensions, however, so far limited in the time of this development [1,2].

Therefore, the question arises, whether, given octaves and their basic classifiers, it is possible to construct models of stage-by-stage development of human cognizing based on *the inductors* of revelation of classifiers and mss of increasing abstractness, *the acquirers* of mss from communities and *the comprisers* altogether towards the highest pCogs U.

4.4.1. The progress in answering these questions is partly argued so far using their chess interpretations following the Corollaries Cl.2.3. and Cl.2.4.

Recall that Cl.2.3. and Cl.2.4. are consequent to the chain of reductions starting from reducing common sense cognizing of U to cognizing of games by Piaget and finalizing by stating that hcogs U <-> prgcogs rg.

In turn, this equality follows from assumptions that rg can approach U, the projection of hcogs to rg is hrgcogs rg, hcogs = pcogs, and inferences that hcogs U -> hcogs rg -> hrgcogs rg -> prgcogs rg.

Remind that for generalized cognizers cogs, we have inferred that cogsU -> rgcogs rg⇔ (computer models of rgcogs rg), assuming that rg->U and rgcogs is the projection of cogs to rg.

Consequently, the aforementioned allows to reduce the adequacy of cogsU to hcogsU to the adequacy of rgcogs rg to prgcogs rg.

And, eventually, the adequacy of rgcogs rg to prgcogs rg following the Corollary Cl.2.3. can be sufficiently approximated by chess representative of rg., thus, reducing it to the adequacy of chcogs ch to pchcogs ch.

4.4.2. Correspondingly, it is questioned, whether given octaves and their basic classifiers in chess interpretation, it is possible to construct models of stage-by-stage development of chess cognizing based on the inductors of revelation of classifiers and mss of increasing abstractness, the acquirers of mss from communities and comprise altogether towards the highest chCogs U.

4.5. For these aims, we are going to advance in learning expert meaning processing (LEMP), and because the problem is too complex, we approach the problem in the following stages: 1. reducing general LEMP to one for rg problems, 2. advancing in LEMP for a kernel rg problem, chess, 3. extending successful chess LEMP results to the entire rg, followed by attempts of generalizing them to NL processing [1, 8, 15-18].

4.5.1. For chess LEMP, we have collected about 300 units of communicative chess-specific words, phrases, idioms, names, etc., with interpretations comprising the chess repository (Rps) [1, 8].

The units of Rps are ordered by 5 levels by complexity of their acquisition by chess experts, as well as including their algorithmic representation and interdependency.

Thus, while the 1st level comprises, for example, classifiers of the types and colors of figures, coordinates, lines, etc., classifiers of the 5th one, for example, King is Compressed, Breakthrough, etc., can be ambiguous, fuzzy, etc., and carry all complexities of NL representations.

Advancing in chess LEMP so far rg solver analogously with chess players have learned meanings of four levels of Rps and can automatically transform them into texts of equal sets of clauses [1, 18]. The basic classifiers of the 1st layer were learned inductively by NN [19], while the rest of them was acquired by layer-to-layer formation of mentals of cogs correspondingly with the growing complexity of the layers of Rps [1, 15-18, 22,25].

4.5.2. Ongoing chess LEMP research focuses on learning of units of the 5th level of Rps with preliminary representation of NL units of Rps by ontology graphs, followed by involvement of both the ontology graphs and teaching for learning these NL units [15, 22].

4.5.3. Recalling that children become able to play chess usually about more than four years of development, which is associated primarily with sensor-motoric and operational by Piaget stages of their development, our research also tends to reveal by modeling their necessity for LEMP [19, 20].

4.6. Let's also note that along with the above premises on adequacy of models dcogs to dpcogs ones by Piaget and based on stage-by-stage development of meanings, additional premises provide successful experimentation on arguing the ability of cogs to *learn rg problems and their solutions in* security, competition, and dialogue [9, 21].

## V. State of the Art of the Theory

5.1. Ongoing advances in constructing an adequate theory of cognizing we presented as follows.

5.1.1. *Human cognizers hcogs of U can be modeled by descriptive pcogs Piaget's ones.*

5.1.2. *The constructions mentals adequately model mental systems (mss).*

5.1.3. *Humans cognizing of U can be modeled by cognizing of combinatorial games, particularly, of rg reproducible subsets of such games by corresponding rgcogs models of cogs.*

5.1.4. *There are premises that constructions cogs can adequately model pcogs.*

5.1.5. *Progressing of cognizers to the most effective ones of given classes can be measured algorithmically.*

5.1.6. *Mentals and means of their formation are decomposable to symbolic 1-place atomic classifiers.*

5.1.7. *There are premises that cogs are decomposable to not necessarily symbolic 1-place atomic classifiers.*

5.1.8. *There are premises of origination of symbolic and not necessarily symbolic atomic 1-place classifiers in nature, followed by their development to generalized cognizers cogs (Pogossian, 2024).*

5.1.9. *The theory constructively questions the power and limits of cognizing the entire U* and observable U universes.*

## VI. Conclusions

Forthcoming development of the theory of cognizing, along with already mentioned questions, we plan to focus on

- premises that cogs are decomposable to not necessarily symbolic 1-place atomic classifiers
- the origination of symbolic and not necessarily symbolic atomic 1-place classifiers in nature and their development to generalized cognizers cogs, as well as
- to advance in revealing the power and limits of cognizing the entire and observable Universes.


## Acknowledgments

The author expresses his gratitude to colleagues of Cognitive Modeling for productive discussions and Anahit Janazyan for corrections.


## References


[1] E. Pogossian, *Constructing Models of Being by Cognizing*, Academy of Sci. of Armenia, Yerevan, 496 p., 2020.

[2] E. Pogossian, "Specifying Adequate Models of Cognizers*", AIP Conference Proceedings 2757*, 010001, 2023, https://doi.org/10.1063/12.0015299. [Online]. Available: https://pubs.aip.org/aip/acp/article/2757/1/020003/2891620/Specifying-adequate-models-of-cognizers

[3] E. Pogossian, V. Vahradyan, and A. Grigoryan, *On competing agents consistent with expert knowledge*, Lecture Notes in Computer Science, AIS-ADM-07: St. Petersburg, Russia, pp. 229-241, June 6-7, 2007.

[4] Ch. Brutyan, I. Zaslavski, L. Mkrtchyan, "On methods of automated synthesis of positional strategies in games", *Problemi Kibernetiki*, Moscow, vol. 19, pp. 41-75, 1967.

[5] M. Botvinnik, *About solving approximate problems*, S. Radio, Moscow, (in Russian), 1979.

[6] R. Benergi, *Theory of Problem Solving*, Mir, Moscow, 1972.

[7] J. Laird, *The Soar Cognitive Architecture*, MIT Press, England, 2012.

[8] E. Pogossian, *Adaptation of Combinatorial Algorithm*, Academy of Sci. of Armenia, Yerevan, 280 p., 1983.

[9] E. Pogossian, *Effectiveness enhancing knowledge-based strategies for SSRGT class of defense problems*, NATO ASI 2011, *Prediction and Recognition of Piracy Efforts Using Collaborative Human-Centric Information Systems*, Salamanca, Spain, pp. 16, 2011.

[10] C. Shannon, "Programming a computer for playing chess", *Philosophical Magazine*, Ser.7, vol. 41, 1950.

[11] E. Pogossian, "On Explanatory Definition of English Clause", *5th International Cognitive Linguistics Conference*, Vrije Universiteit Amsterdam, Transactions of IPIA NAS RA, pp. 46-55, 1997.

[12] J. Flavell, *The Developmental Psychology of Jean Piaget*, D. VanNostrand Comp. Inc., Princeton, N.J., 1962.

[13] A. Markov, N. Nagorni, *Theory of Algorifms*, Nauka, Moscow, 1984.

[14] P. Langley, H. Shrobe, B. Katz, "Cognitive task analysis of rapid procedure acquisition from written instructions", *Annual Conference on Advances in Cognitive Systems,* pp. 19, 2020.

[15] S. Grigoryan, T.Shahinyan, E. Pogossian, "An Ontology-Driven Approach to Learning Expert Meaning", *Processing. International conference "AI : Opportunities and Challenges"*, European University of Armenia, pp. 10, 2024.

[16] M. Hambartsumyan, Y. Harutunyan, E. Pogossian, *A Repository of Units of Chess Vocabulary Ordered by Complexity of their Interpretations*, National Academy of Sciences of Armenia, IIAP, research reports (in Russian), 1974-1980.

[17] K. Khachatryan, S. Grigoryan, "Java programs for presentation and acquisition of meanings in SSRGT games", *SEUA Annual Conference*, Yerevan, Armenia, pp. 135-141, 2013.

[18] S. Grigoryan, "Automating Acquisition and Explanation of Strategy Knowledge", *Proceedings of CSIT conference*, pp.21-23, 2021.

[19] B. Karapetyan, "Instrumental Environment for Supporting Sensorimotor Development", *Proceedings of CSIT conference*, Yerevan, pp. 32-34, 2025.

[20] B. Karapetyan, E. Pogossian, "Modeling and Handwriting Examination of Sensorimotor Intelligence", *XV Annual International Conference of the Georgian Mathematical Union*, Batumi, Georgia, 2025.

[21] S. V. Grigoryan and Z. H. Naghashyan, "Adequacy and Application of Models of Cognizing by Combinatorial Games", *MPCS*, vol. 62, pp. 25–42, Dec. 2024.

[22] S. Grigoryan, T. Shahinyan, E. Pogossian, "On the Way to Learning Expert Meaning Processing", *International Conference of Artificial Intelligence: Opportunities and Challenges*, Yerevan, Armenia, pp. 10, 2024.

[23] E. Pogossian, "A Model of Cognizing Supporting the Origination of Cognizing in Nature", *AAAI Symposium on Human-Like Learning*, Stanford, USA, pp.3, 2024. https://doi.org/10.1609/aaaiss.v3i1.31282,

[24] E. Pogossian, "Promoting origination of non-cellular cognizers", ISSN 1054-6618, *Pattern Recognition and Image Analysis*, vol. 34, no. 1, pp. 158–168. © Pleiades Publishing, Ltd., 2024, doi: 10.1134/S1054661824010164

[25] B. Karapetyan, "A High-Level Language for Chess Concepts", *Mathematical Problems of Computer Sciences*, 1986.

[26] E. Zermelo, "Uber eine Anwendung der Mengenlehre auf die theorie des Shachspiels", *Proceedings of the fifth International Conference of Mathematicians*, Cambridge, Cambridge University Press, pp. 501-504, 1912.

[27] https://writings.stephenwolfram.com/2024/12/foundations-of-biological-evolution-more-results-more-surprises/

[28] E. Pogossian, "Specifying personalized expertise", *CELDA*, Barcelona, Spain, pp. 151-159, 2006.

[29] Chang, Chin-Liang, Lee, Richard Char-Tung, "Symbolic logic and mechanical theorem proving", *Academic Press*, San Diego, 1987.

[30] A. Newell, J.C. Shaw, H.A. Simon, "Report on a general problem-solving program", *Proceedings of the International Conference on Information Processing,* pp. 256–264, 1959.