A Bridge to Cognition Through Intelligent Games

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Abstract. Computational neuropedagogy applies neuroscience to the problem of learning, whilst learning is intrinsic to the process of understanding. An intelligent game is a neuropedagogical ludic instrument constructed through a scientific process to achieve introspection into cognitive aspects of human reasoning.

The postulate of universal access presupposes a universal cognition apparatus, and fortunately this is the case. Contrariwise, what is not the case is a presupposed uniformly developed apparatus, equally available in each individual. Understanding and accounting for the distinct configuration of each individual is a requirement of universal knowledge access. Intelligent games can cleverly access a non mediated view of the cognition machine.

This work presents an intelligent game calibrated to three developmental dimensions to collect vestiges from the internal cognition engine, revealing the innards of EICA. EICA is the Engine of Internal Cognitive Acquisition, universally installed in every human brain which is responsible for the main course of cognition process. Learning is accomplished by the EICA machine, consisting of eight recognized hierarchical states ranging from simple to high complexity.

The inference that cognition machinery is equally available to every person is the principle behind the proposition of an effective universal access to knowledge. Monitoring the EICA machine performance is a mean to assess and even adapt the process of learning. Under the universal access principle, this means that beyond all the differences that uniquely identify each individual, everyone can have access to knowledge through intelligent systems.

Keywords: Neuroscience · Neuropedagogy · Cognition · Games · Accessibility · Knowledge · Learning.

1 Introduction

Computational neuropedagogy applies neuroscience to the problem of learning. In the intent to achieve this it produces instruments to assess and intervene in human learning. Intelligent games are examples of such instruments, being computer games developed through a elaborated scientific process. These games purport to achieve intro-

spection into cognitive aspects of learning. They can tap into the unconscious process of learning and interchange information between computer and human cognition.

An intelligent game is piece of software designed to provide a direct interface to the human cognitive engine. The scientific process preceding the conception of such a game takes several steps to convey the theoretical statements into programmable code features. The construction of a dimensional model is the principle of a intelligent game fit to explore a given cognitive space. A cognition domain so defined is bound to activate the corresponding cognitive functions in the brain learning mechanism.

This model uses phylogenetic, ontogenetic and microgenetic dimensions [3] to synchronize with the internal cognitive machine and collect details about its functionality. Those dimensions constrain cognitive operations to the realm of learning procedures, together with the respective probing reactions. Amidst the many signals obtained from those reactions, some can be investigated in search of telltale vestiges of internal gears behind its performance. Those vestiges are detected and discriminated to correspond to what theory predicts about leaning. The aforementioned discriminating machine provides an unmediated channel into the mind, capable of monitoring the cognition innards.

Such direct interface into human cognition is useful in assessing individual competences and levels of understanding of episodic frames. Effective access to knowledge implies in a formal understanding and interconnection of the whole set of information acquired by sensory channels. Follows that, in this sense, universal access requires scaffolding beyond just viso-motor and audio-phonetic senses and interfaces. Evaluating the coalescence of cognition processes into terminal forms can provide assessment to the level of true understanding.

2 The observability of cognition

Cognition is an internal process mostly unaccessible from the conscious mind. As Penrose [1] remarks, consciousness is a process occurring as deep as quantum events in microtubules inside brains cells. Down below in brain functionality is the cognition process, even deeper away from consciousness, mostly pertaining to subconscious thought. The hermetic quality of those processes poses an apparent insurmountable obstacle to direct observation with available technology for years to come. At psychogenesis level, some testing can assess intellectual development, since it is a process taking place is a span of years. Microgenesis, evolving in the short span of minutes, leaves scarce traces of is whatabouts.

In the microgenetic dimension, several microprocesses concatenate to complete a chain of understanding that embodies the human reasoning. If any of these processes is broken, there is no real access to the information, since it has no meaning. There are several theories on how microgenetics works. Inhelder [6] draws the most acknowledged theory, solidly drawing from the extensive works of her colleague, Jean Piaget . Kienits [4] extends Inhelder view to more recent experiments.

Microgenetics defines a set of states and a procedure to walk through these states using an internal encoding and processing befit to brain innards. Microgenetic theory

affirms that those states and processes must exist, notwithstanding the lack of access to the actual states or transactions of mind. In principle, all brains should feature the same structure and the same learning machine original installation. However, individual brain formation process and cultural interactions tend to reconfigure some areas to be prevalent and detrimental to others. Therefore, microgenesis theories implies in a sort of machine existing in each and every brain, capable of stepping through all these states to complete the cognitive process.

On the empirical side, waywardly to theory expectations, instead of a consistently staging of learning performances, what comes about is a large diversity of cognition abilities scattered among human population. Such diversity sources from the psychogenic formation and matching predisposition of brain abilities from phenotypical DNA expression.

3 Universal access and cognition paradigms.

Universal access presupposes a universal cognition apparatus. The universality of learning capabilities is a recurring theory in many fields, being Chomsky [2] one of its most regarded and influential scientist. Assuring universal access to information from the cognitive side requires monitoring the effectiveness of learning. The prevailing trend on the effort towards knowledge access is standardize the education system. The purpose is the implantation of a homogeneous cognition apparatus in each and very individual. Although seemingly a noble, even utopic errand, might not be totally beneficial or even attainable to the human race.

Acknowledging and accounting for the distinct installment of each individual cognition is a better proposal for universal knowledge accessibility. Preserving the natural variations on the individual cognitive machinery is a less intrusive approach. Diversity is a defensive asset for any species, catering for fluctuations of environmental conditions. Instead of attempting the elimination of differences, they must be accounted for and harmonized to bring about the required level of understanding acknowledgeable as universal access to cognition.

The utmost perspective of cognition assertion should consist of tapping into the brain machinery and observe the completion of the knowledge acquisition process. Yet, issuing from the complexity and encapsulation of its innards, cognition internal gears remains mostly unobservable whatsoever. Nevertheless, inspection of cognition machinery is still a feasible undertaking taking into consideration its products, particularly to its byproducts. Follows that cognition is the driving force behind most volitive reactions. Operating behind the scenes, cognition merges into its responses apparently unintentional artifacts. Considering those artifacts as inherent outcomes of cognition operations, they elicit as subtle clues of its mechanism.

Inferably, most volitive responses that encompass a motor activity originate ultimately from transitions inside the cognitive machinery. Transitions are convulsive physical events incurring in telltale evidence, namely high order harmonics, that may propagate unintentionally through the whole system and end up as an elusive signature of cognitive state shifting.

A cognition tracking machine can then log the acquisition process and mark the level of understanding attained. Postulating on the existence of a cognition machine, more precisely an automaton, cognitive processes evolves propositionally in a cascade of entangled and coordinated automata operations. More plainly stated, the full process of understanding develops inside the cognitive machinery as continuous flow of intercommunicating languages across the several automata engaged in the reasoning effort. Thereafter, the whole process of accessing and acquiring a knowledge transcribes to a collection of scripts in a language circumscribed to the mental realm, unrelated to any other human language. Capturing and interpreting the internal cognition language is the key to assess the score of understanding.

4 An instrument to investigate the cognition engine

Theory suggests cognition as a pipeline of languages (Seminerio [5]), cascading the refinement of understanding up to the higher levels of abstraction. A suitable model of language processing exerting the computation of meaning comprises of a collection of automata. Investigation of automata can be procured by exercising input states that steps the machine across a conspicuous walkthrough of its operation.

4.1 Development of a research mode

Given a theoretical model of the analyzed machine, ensues the protocol required to reverse engineer the language processing mechanism. Figure 1 depicts the original theoretical machine model, based in studies of human linguistics. Named states and proposed transitions presuppose a linear progression in the interpretation of meaning.

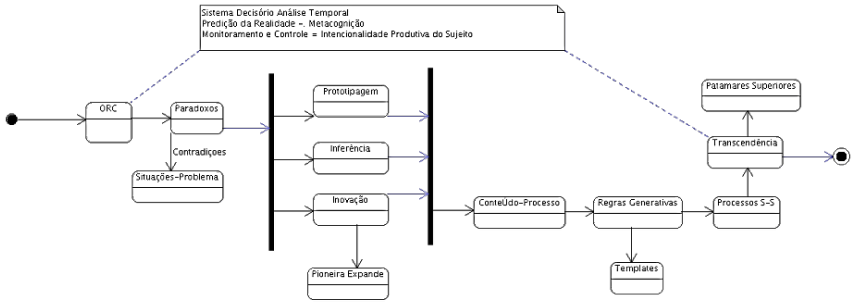

Figure 1: Theoretical model of cognitive learning finite state machine

Since the study purposes the investigation of the learning process, a suitable dimensional space involves three views of temporal development spans. Those dimensions recur in the learning procedures and represent evolution in three scalar ranges, namely phylogenetic, ontogenetic and microgenetic. Figure 2 represents a fragment of

the phylogenetic dimension. Learning is represented by the human achievements in mathematics, language and science in prehistoric periods.

Scenario	Historical Context	Technological Artifact	Description	Linguistic Artifact	Description	Mathematical Concept	Description
	2000000 B.C. – Lower Paleolithic	Staff 	It could be any piece of wood used for personal defense and exploitation.	Color differentiation 	Part of the understanding of visual languages	Groups 	Used for food group differentiation
	200000 B.C. – Middle Paleolithic	Fire 	Essential for protection from cold and predators and for feeding	Signs 	Used before the development of spoken languages	Food Counting 	Necessary to ensure the feeding of the whole group
	30000 B.C. – Upper Paleolithic	Ink 	In the cave paintings, blood, clay, latex, fat, egg white, iron oxide, etc. were used.	Cave paintings 	Predecessors of any organized writing system	Cave paintings 	Essential in a time when there were no numbering systems

Figure 2: Phylogenetic dimension with historic marker of cognitive evolution

A complete dimensional model was developed to infuse the required stimuli into the learning apparatus in order to capture the full transactional profile inherent to cognitive language processing. An intelligent game was designed and calibrated to three developmental dimensions to collect vestiges from the internal cognition engine and unveil the minutia of the language processing automata.

The game (figure 3) takes the form of a scene where a paleolithic character try to make his way into the observation of the world in which he lives. Carefully designed assets conducts the caveman actions into the prospective realm of cognition, forcing advances an retrogresses in the reasoning process, coupled with the respective volitionary investigative reactions determined by the internal automata.

Figure 3: The intelligent game for EICA

This automata, entitled to compile the incoming sensory information into cognitive knowledge have being identified in Marques [7] as the Engine of Internal Cognition Acquisition (EICA). EICA is a neurobiological computing apparatus installed ubiquitously in human brains which endows any individual with the cognition proceedings characteristic to the Homo Sapiens species. This machine is the evolutionary solution to achieve the high level of abstraction responsible for the outstanding human cognitive abilities.

4.2 Anatomy of the cognitive machinery

The instrumentation and observation of EICA requires a complex study and development process capable of exposing the subtle telltale traces of internal cognition machinery. The basis to the aforementioned intelligent game is the exertion of the learning process. Learning is accomplished by the EICA machine, consisting of eight recognized hierarchical states, ranging from simple to high complexity.

EICA is the essence of human learning machinery, consisting of a finite state machine in which each subsequent state correspond to a more complex cognitive achievement. Observed in EICA tracking experiments, eight recognizable states are the hallmark of the cognition automata, shown in figure 4.

Colored sections represent the states and colored arcs indicate the transitions between states. Cognitive acquisition cycles follows sensory information with volitive prospectives responses emanating from evolving or involving transitions in EICA states. The ideogram demonstrates that beyond the linear perspective of the theoretical

model, transitions occurs to non adjacent states and in both forward an backward directions.

Figure 4: Ideogram representing EICA states and transitions

Ensuing transitive streams develop into concatenated expressions of meaning, imprinting the effectuated access to the given information as new linguistic nodes in the epistemic knowledge network. Although restrained to internal communication interchange among the internal cognitive structures those linguistic nodes can be observed to be the same across non related individuals. The reverse engineering necessary for that consists of inducing the volitionary response through the retrace of phylogenetic, ontogenetic and microgenetic path development. The prospecting instrument for cognitive unveillance guides the acquisition machinery into retracing the three dimensional ranges of thought development, namely the evolution of reasoning within the species, within the development of an individual and within the coalescence of an idea.

4.3 The microgenetic-paleopathic resonance

The foremost feature of this intelligent game resides in exploiting the microgenetic-paleopathic resonance to expose the innards of the learning cognitive apparatus. Encompassing the whole stream of prospective reactions, emerges a common pattern, recognizable for every and each individual. The pattern features a rhythmical response interwoven with seemingly chaotic jitter, apparently disconnected of the given information. The microgenetic-paleopathic resonance or Resonance of Marques [7] consisting of coupling between the high energy nervous motricity impulses and the faint and undetectable occurrence of transitions within the cognition machinery. A precisely calibrated analog-digital discriminator can recognize and trace (figure 5) the disturbance in the output signal caused by the originating cognitive computation of meaning orchestrated by the EICA machinery. EICA state set is evenly distributed among even the smallest and heterogeneous population, notwithstanding the fact that it differs for each an every person, difference which must be circumvented to convey equality of understanding and universal access to information and learning.

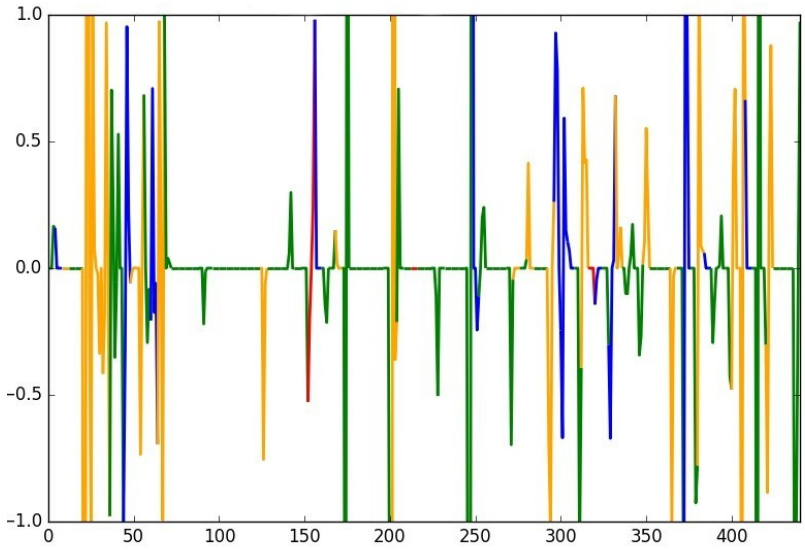

Figure 5: Emerging pattern already marked in colors by the discriminator

4.4 Depicting the cognitive landscape

The EICA machine operation complies with a rather strict deterministic behavior which is the same in every individual observed in the available experiments. The temporal distribution of states and transitions are rather logic and regular across the sampled population (figure 6).

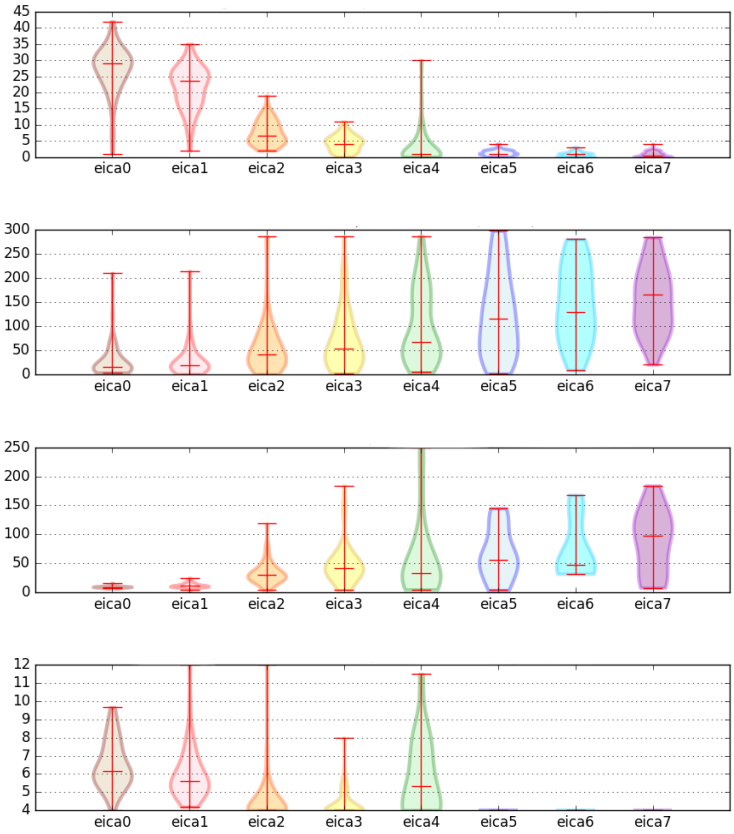

Figure 6: Violin distribution of EICA state characterization

Equity in EICA machine configuration among the human population implies, from the cognitive point of view, that all individuals have the same aptitude to learn, therefore deserving equal and universal access to knowledge and understanding. Uniqueness in individual experience and education results in a idiosyncratic usage of EICA machinery, departing each person from the expected EICA behavior. Those unique usage patterns are kindred to personality formation and may not imply in a better or worse cognition performance (figure 7).

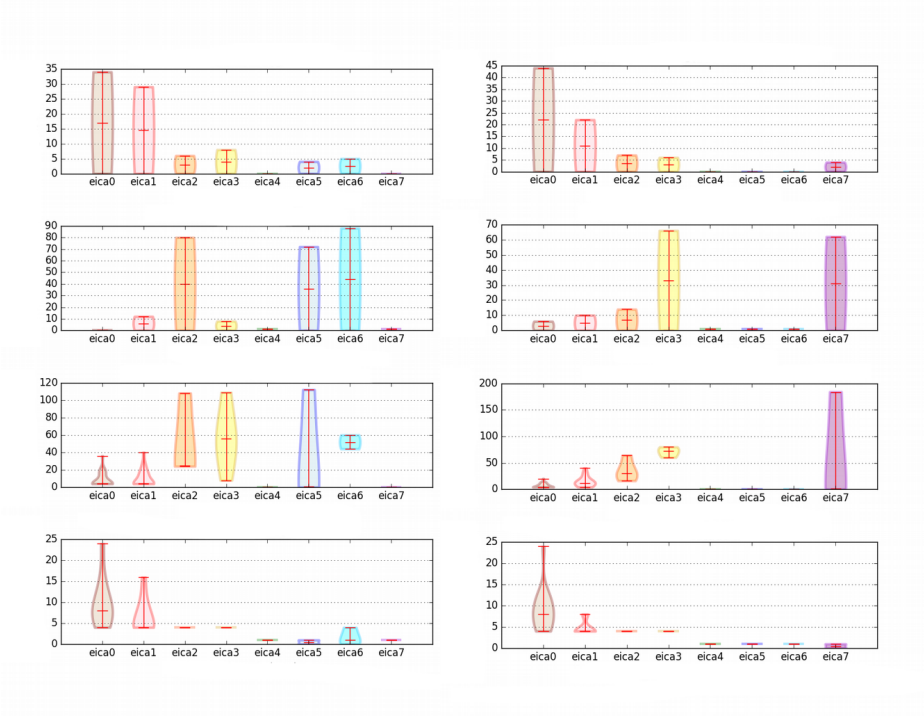

Figure 7: Comparison side by side of two individual EICA signatures

Universality and individuality are both inherent to EICA machine manifestation in human population. Universality express itself as a recognizable consonance of operation and as well as commonalities in the reasoning stream development.

Individuality concerns to variations in states and transitional sequences defining a peculiar traversal of cognitive acquisition landscape singularizing a personality driven behavior. Similarities in the diverse meaning construction narratives demonstrates that all cognition processes converge to a prototypical epistemic subject quiescent in every person whilst particularities alert to an adaptive conformance requirement for accessible knowledge outspreading. The personal idiomatic nature of cognition inflow requires the assessment and compensation of those differences hitherto taken for granted in education, eventually hindering the establishment of a universal access to knowledge.

4.5 Learning process and effective accessibility

Understanding both the universality and nonuniversality of cognition process assures that learning is accessible to any human being at any level. The inference that cognition machinery is equally available to every person is the principle sustaining the proposition for an effective universal access. However, unique and personalized use

case profile of EICA states provides both for essential diversity and complexity for effective and efficient learning. Monitoring EICA machine performance is a mean to assess and even adapt the process of learning.

5 References

1. Stuart Hameroff, Roger Penrose, Consciousness in the universe: A review of the 'Orch OR' theory, Physics of Life Reviews, Volume 11, Issue 1, March 2014, Pages 39-78, ISSN 1571-0645, http://dx.doi.org/10.1016/j.plrev.2013.08.002.
2. Chomsky, Noam. *Aspects of the Theory of Syntax*. Vol. 11. MIT press, 2014.
3. LANGER, J. Phylogenetic and ontogenetic origins of cognition: Classification. *Piaget, evolution, and development* (1998): 33-54.
4. KIENITZ LEMOS, MYRIAM ; L.R. MOTTA, Claudia ; M. MARQUES, CARLA VERÔNICA ; T. OLIVEIRA, CARLO EMMANOEL ; FRÓES, MAIRA ; POMPEU E SILVA, JOSÉ OTÁVIO . Fio Condutor Microgenético: uma metodologia para a mediação metacognitiva em jogos computacionais. Revista Brasileira de Informática na Educação, v. 22, p. 1-17, 2014.
5. SEMINÉRIO, F. L. P. *Infra-estrutura da cognição: fatores ou linguagens?* Rio de Janeiro : FGV; ISOP, 1984.
6. Inhelder, B. Le cheminement des découvertes de lénfant. Recherche sur les microgenèses cognitives. Paris: Delachaux et Niestlé, 1992.
7. Marques, C. V. M. Eica - Estruturas Internas Cognitivas Aprendentes: Um Modelo Neuro-Computacional Aplicado À Instância Psíquica Do Sistema Pessoa Em Espaços Dimensionais. [doctorate thesis]. Rio de Janeiro (RJ - Brazil): Universidade Federal do Rio de Janeiro; 2017. 195 p.