Emotional Theory of Rationality

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Abstract

This article proposes a new functional theoretic framework that provides a better understanding of emotion-cognition duality. Based on an evolutional argumentation, this paper pretends to go further into the knowledge about emotions, justifying their existence, explaining how they work and linking them to superior cognitive processes, mainly attention, intelligence, decision making and consciousness. This theory tries to make sense of many different problems, partial theories, experiments and observations in several brain and behavioural studies. It also could have important implications on fields such as Psychology, Economy, Social Sciences, Education, Marketing, Management, and Justice among others.

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Human brain is by large, the most advanced and complex biological system that we know. With more than a hundred thousand millions of neurons (10^{11}) and thousands of billions of synapses (10^{15}), it is the physical substrate for our mind, a great unknown that allow us to perceive colours and sounds, move, think and feel intense emotions like love, analyze, ideate, remember, plan and dream. Our mind is responsible for finding solutions and, sometimes, for creating the problems. It's what makes reality real and the one that must make sense of everything that happens to us, either inside or outside.

It's that large structural complexity what greatly complicates our understanding of its design and operation. Our current technical limitations in the field of brain scan, don't allow us to observe the neural processes that occur inside it with the necessary detail to achieve full understanding yet. Indeed, the very intrinsic characteristics that define growth and brain development, based on the individual's own life experiences as a modeller, make each individual unique, forcing us to focus on the search for general models, which allow us to understand human behaviour from a statistical standpoint.

There are many sciences that have addressed the different areas and capabilities that nervous system exhibit, providing partial theories, experiments and observations that shed light on many facets of its operation. All that data set still suffers from enormous knowledge gaps that must be completed in the coming years but, above all and most importantly, all these results are still partial pictures and should be integrated into broader theoretical models that explain them and make predictions. These new theories will serve as a link between low-level observations (molecular, neural, etc ...) and their psychological, cognitive and behavioural manifestations.

Therefore, this article presents a new theoretical framework for trying to definitely resolve the emotional-rational duality.

Evolution

Evolutionary Principles

Every living organism need to interact with its environment to carry out its life cycle, either to feed, reproduce or defend. The evolutionary process (Darwin, 1859; Dawkins, 2004) has generated many different species, and provided each with specific subsystems to allow them to detect environmental conditions in which they lived, as a first step to adapt to. But would be useless to detect hostile conditions if you can not act on them to modify, evade or take advantage of them. The emergence and maintenance of the different adaptive response mechanisms follows some basic principles that are outlined below:

First, if an organism needs a specific subsystem to be able to front some special environment conditions and it doesn't have it, it won't be able to resolve the situation. Also, any change that evolution generates by chance, will certainly not last for long, if it is not really necessary for survival. A new evolutionary advantage is immediately tested by natural selection. There is no middle ground; or it is enhanced and preserved as being necessary, or it slowly disappears. We call this the *Necessity Principle*. A simple example of this principle may be the disappearance of the tail in humans, as it was no longer needed for balanced movement through the branches of trees.

Secondly, we can assume that over evolutionary periods of time (thousands to hundreds of millions of years), environmental conditions to which organisms are exposed change dramatically, testing the effectiveness of the different adaptation systems developed. If they are successful, the individual survives, reproduces, and the system is conserved. If not, he dies and the system disappears. This conditioning will be called *Efficacy Principle*. An example of this principle may be the extinction of the dinosaurs. After existing for more than 150 million years, all their adaptive systems failed (ceased to be effective) when there was an extreme change in global environmental conditions, possibly caused by a meteorite impact. Mammals, however, survived.

Third, we must consider that not only the efficacy defines success in survival. All adaptive systems have an implied energy cost (Raichle & Gusnard, 2002). The individual that owns should permanently spend a variable amount of resources to maintain them. It stands to reason that, throughout these broad periods of time, all the necessary resources to maintain the various adaptive systems have not always been available, so that nature will have preserved only the most efficient, that is, those that were able to maintain their resolution ability while doing it with as few resources as possible. We entitle this principle as *Efficiency Principle*. An example could be the hibernation cycle that many species develop during the winter period, allowing them to minimize energy consumption until the food and fruits spring abundance returns, besides the increase of outside temperature.

As soon as a new species appears, all its inheritated systems and tactics have to face new conditions of survival and reproduction. We could say that each species and its habitat are, in themselves, a new "experiment" that confronts all functional elements to the evolution principles filter. Therefore, if we apply a simple argument, we can affirm that the more species retain a given system, the more evolved and versatile it must be. These three principles will guide our further reasoning.

Evolution Of The Nervous System

The origin of the nervous system as we know it today (Cziko, 1995), based on the neuron as main constituent and synapses as a mechanism for interconnection between them, goes back in time over 600 million years, until a few organisms called cnidarians, among which are the jellyfish and anemones. According to recent research in Genetics (Sakarya et al, 2007), it seems that certain types of sponges, much older animals from an evolutionary standpoint, incorporate in their genetic background, some genes that encode proteins similar to those involved in synaptic communication processes in humans, or what might be called a “proto-neural” system. That means that thousands of millions of years ago, the biological and chemical processes that would lead to the development of our nervous system were already emerging, and with them, our mind.

If we apply the evolutionary principles to the nervous system we can see that, from its remote appearance, it has survived in a huge representation of animal species, which have evolved in parallel in a variety of environments. Furthermore, it has forcefully demonstrated by the fact that, in humans, the brain accounts for 2 % of our body mass but consumes 20 % of available energy. These figures tell us of the importance that the nervous system has had for our survival and that of other living beings throughout evolution.

Nervous System’s Mission

Since most of the history of evolution has been characterized for survival and reproduction as a filter and motor for adaptive changes, we will venture from that point of view, and at a functional level, the mission for the nervous system:

The nervous system is responsible for providing necessary adaptive responses, effective and efficient, enabling the organism to respond to changing conditions, either internal or external, that could jeopardize his chances of survival or reproduction.

Nervous System’s Parameters

As we have argued, the nervous system is an evolving element and, as such, must therefore meet the three principles that define this type of systems, both in structure and operation. To do this, it must act on a number of specific parameters, adjusting and balancing optimally. Since the responses give meaning to its mission, they define the specific variables that must be adjusted to meet the evolutionary principles.

First reflection we can do is about activation "necessity", meaning the fact of generating a response only in those cases where it is opportune. If the responses were generated randomly or continuously, without a need, perhaps some would be effective (few) but for certain they would not be efficient. To assess the concept of necessity, the nervous system must have some indicator that defines when it is necessary to execute a response. That indicator is called the *Activation Threshold* (A_{THLD}), and we define it as the minimum difference between the stimulus received and a reference model that produces the neural circuit activation. It is important to say that the activation threshold is a variable that can be dynamically modified. A too low threshold makes us display unnecessary responses. A too high threshold prevents us from responding appropriately to important stimuli.

The following functional parameter that intuitively we should value is the *Reaction Time*. This indicates the time since the sensory stimuli is detected, until the corresponding response is available and starts its execution. It's logical to think that the shorter the time the nervous system takes in finding a response, the greater the chances of organism to survive. From the standpoint of efficacy, it is often better to deploy a rapid response, though inaccurate and even untimely, than a slower one.

Undoubtedly, the speed in disposing of a response can save our lives, but it is also a fact that *Accuracy* is crucial in a large majority of cases. Accuracy is defined as the right set of variables that characterize response actions, which can include intensity, specificity, location and timing among others.

Thus, summing up briefly, we have three main parameters that will characterize the responses and allow the nervous system to perform well in its function; Activation Threshold, Reaction Time and Accuracy. The proper balance between the different variables will strongly condition the necessity, efficacy and efficiency of nervous system responses.

Automation

The biggest challenge for the nervous system is to find the best balance between these three variables for any particular stimulus. The best way to achieve it would be having available, from the beginning, a stimulus-specific neural pathway, designed and “wired” to provide the most accurate response in the shortest time possible, and only when necessary. This is what we call a *reflex arc*. The most responses the brain convert to a reflex arc, the best balanced they will be. This is an emergent principle that nature has resolved using neuro-genesis, synapto-genesis (Ryan & Grant, 2009) and synapse pruning (Chechick, Meilijson & Ruppin, 1999).

Having said that, we will call *Automation* to the process by which a neural circuit or pathway reach the optimal balance point of interconnection between its elements, thus providing the best possible response to a particular stimulus.

The Automation Principle suggests: “As a result of its own evolutionary principles of growth and development, the brain will always try to automate as much as it can, any developed response to a particular stimulus.”

But, of course, the variety and variability of the stimuli is so broad that it is impossible to have a specific answer genetically encoded for each stimulus, so there must be additional and more flexible systems that allow more advanced answers.

Structure and Operation

Nervous System’s Basic Functional Structure

To fulfil its role, the nervous system should continuously check the external and internal conditions affecting the body. We will call *Sensory Stimulus* the process by which the information of type (physical, chemical, electromagnetic, etc ...), intensity and duration of a variable are detected, measured, properly coded and transferred to higher centres for evaluation (Fig.1.a).

Once there, there must be a benchmark on which to assess and verify whether the stimulus is within the suitable range for organism survival. This element will be called *Reference Model* (Fig.1.b). The nervous system then proceeds to compare and calculate the difference between the stimulus and the reference model. We will call this difference *Emotional Tension* (T_{EMC}). Only if the emotional tension exceeds some specific value (Activation Threshold), the response is activated. (Fig.1.b)

But the response characteristics, their variables, sequential actions and timing have to be coded and stored somewhere for proceeding with execution. We denominate this functional element *Response Pattern* (Fig.1.c). Once the nervous system knows what to do, it implements the response by acting on muscles, glandules and others. But, since the sensory system also has the capacity to detect changes coming from the inside body conditions, those actions become new stimuli that initiate their own neural process. Due to the mechanisms of brain development, feedback and feedforward connects the responses of a neural process with the inputs of others, turning the neural responses into new stimuli (Fig.1, Neural feedback). The modification or disappearance of the stimulus that generated the response is, in itself, an external feedback.

Response Levels

As we have already seen, the very first and most balanced actions that nervous system has for reacting to any stimulus, are the reflex arcs. We say that these responses are "wired" because exists, from birth, a specific neuronal circuit to resolve the situation. It always produces the same response to the same stimulus. The fact that the origin of these responses is genetic, means that have been conserved in the genes of species over generations, which in turn tells us that have been useful to solve certain very specific, ancestral, frequent and repetitive stimuli. We can mention the crying, coughing, pupil dilatation before the light changes, secretion of sweat or the control of heart rate and respiration, among others.

But what if, due to the novelty or the variability of a stimulus, there is not a reflex arc that allows to solve it? The nervous system should begin to develop, always guided in its search by the three evolution principles, new responses from the evidence available. These answers are what we call *intelligent*, and form a broad set of strategies, more or less advanced, that allow the individual to address the most varied adaptive problems. These strategies give very good result, but have the disadvantage of requiring more time and resources to find and implement a response, thus reducing the chances of survival or reproduction. This second level of solutions is effective when the stimuli are not too much critical.

Once a new intelligent response has been developed, and depending on its stimulus frequency, the Automation Principle will act as previously exposed, trying to create the most optimized circuit for that stimulus-response pair. When finished, we will get an Automatic response, ready to be displayed if needed.

Now, let us summarize, in a more precise way, the three response types we will use from here.

Reflex: formed by specific neural circuits, genetically incorporated, which resolve very frequent situations, from the evolutionary standpoint, and are highly critical to the survival of the organism. Provide automatic responses, very fast and accurate, highly efficient in their use of resources and very effective, since the evolution has selected and retained them in the hereditary background of the species over millions of years.

Intelligent: high level cognitive systems that enable the development of highly elaborate responses to novel stimuli, repetitive or not, less critical to survival and diverse complexity. They have numerous advanced tools and multiple ways of combining them to find solutions, but that involves more extensive analysis time and greater resource utilization, resulting in higher energy expenditure.

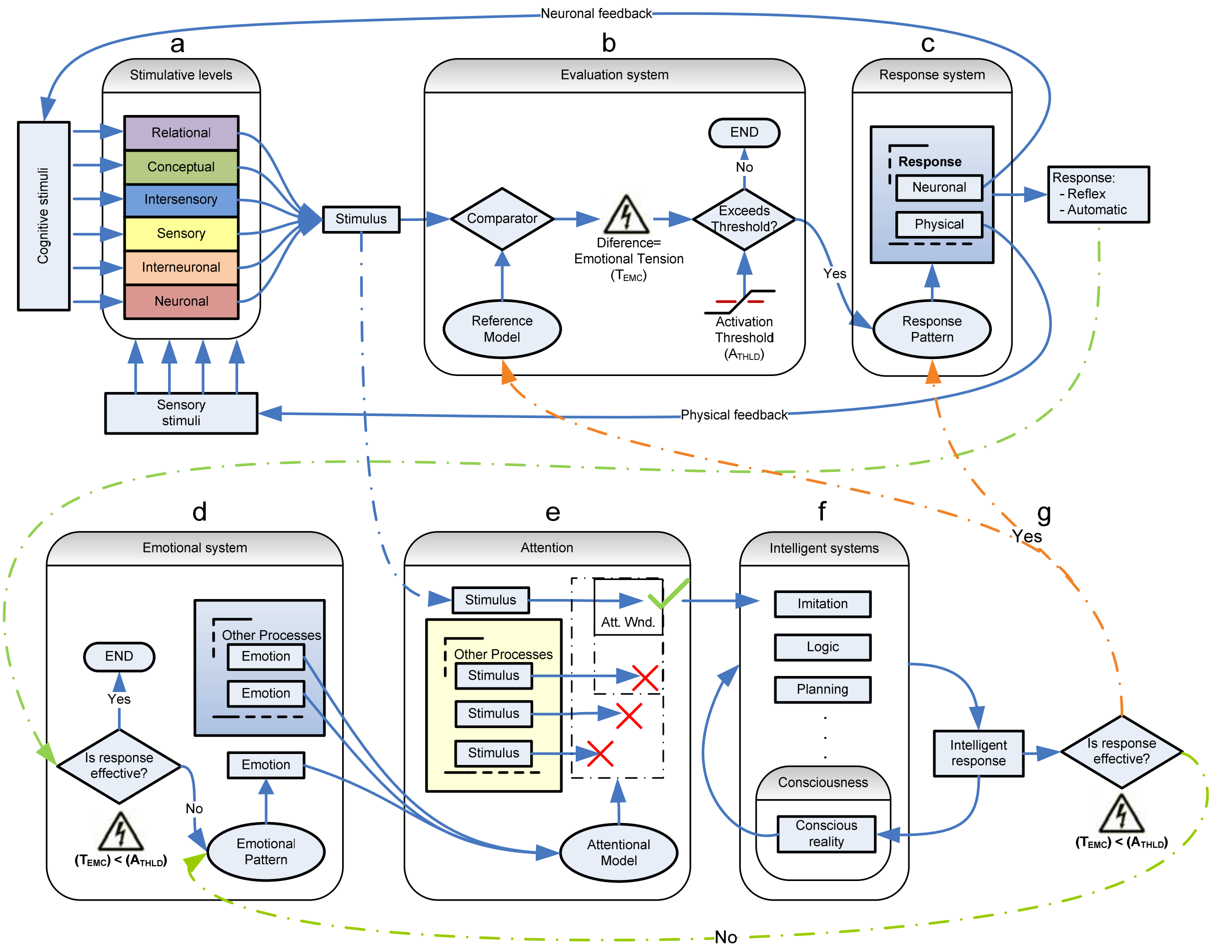

Figure 1. Schematic functional model

This figure shows the different subsystems that conforms the model that arises from the theory propositions. **(a).** Stimulative Levels: where sensory and cognitive stimuli are detected and integrated. **(b).** Evaluation System: compares the stimuli with Reference Model, calculates the Emotional Tension (E_{TNS}) and checks if it exceeds the Activation Threshold (A_{THLD}). **(c).** Response System: execute the stimuli associated responses. **(d).** Emotional System: If responses are not effective, a by defect associated emotion (Emt. Pattern) is activated. **(e).** Attention: evaluates the request's Emotional Criticality and according to it (Att. Model) resizes and focuses the Attentional Window. **(f).** Intelligent Systems: Uses a hierarchical set of intelligent strategies to find an effective solution for unresolved stimuli. **(g).** Intelligent Responses: If they are effective, are stored and linked to stimulus. If not, a new search cycle is started.

Automatic: evolutionary brain optimization mechanism that allows the creation, selection and pruning of neuronal circuits designed to transform new smart responses into automated ones. It is useful to generate responses for repetitive and varied stimuli, of middle criticality and complexity that are amenable to automation. Need more time and consume more resources to develop responses than reflex ones. Effectiveness and efficiency are achieved with repeated exposure to stimulus, gaining in accuracy and speed as it consolidates the created circuit.

If we briefly return to the evolutionary level, we can see that there are species that exhibit one, two or all three levels of response. As evolution does not develop or maintain systems if they are not needed and always tries to set the minimum resource consumption, we can argue that the different response levels have emerged as a result of adaptive pressure exerted by the environment. In other words, any organism whose environmental conditions have allowed him to survive without major problems displaying only reflex responses, it will not have invested resources to develop and maintain a costly brain. This idea explains why there are animals that have survived hundreds of millions of years without the need to strengthen their nervous system beyond a certain response level. An example could be the sharks, which have been evolving for more than 420 millions of years, that is, a hundred times the period that separates us from chimpanzees (4,5 mill), and they have not developed intelligence enough for space travelling.

Regardless of the level to which a response belongs, it may have two complementary components: a physical component comprising motor, glandular and other physical elements, which induces the body to perform the required physical actions, and a neural component that activates other neural networks, thus initiating new brain processes.

The components and variables that define a response are stored in what we call the *Response Pattern*. It is formed by genetic (reflexes), and learned (intelligent and automatic) responses.

Response Audit

Once the brain has displayed a response, it stands to reason that it should carry out some success or failure assessment. If it didn't do it and the response was not effective solving a critical stimulus, the brain would fail in its function, with the consequent risk to the survival or reproduction of the individual. If we apply the evolutionary parameters, we conclude that there must be an element to perform this role, auditing responses and, if required, activating only the necessary and sufficient resources to find an alternative response. It must also be able to grade responses depending on the characteristics of the stimulus to solve, somehow codifying its criticality. We are sure this system must exist, the nervous system has built it, must be very important, ancient and therefore genetic. But what may be that mechanism?

Emotional Theory

Emotions

The answer to that question and the main hypothesis that titles this article is:

The brain's emotional system (Fig.1.d) is responsible for verifying the success of a response and, only in case not to be effective, asks for the intervention of the advanced cognitive resources (Intelligent Systems) to find a new response for resolving the stimulus.

Why? Because in such a way, resources are always preserved to the maximum, again balancing the necessity, efficacy and efficiency, as evolutionary principles dictates.

The way by which the brain informs the higher cognition levels (Damasio, 2003) about the need to develop a new solution are what we call emotions. Based on stimulus information, emotions are able to grade its criticality and, since they are reflex answers, to start a basic stereotyped physical and neural response, while looking for an new alternative response.

Emotions are thus defined as:

Specific reflex responses of emotional system, which can activate physical and neural mechanisms, designed to alert and turn on the advanced troubleshooting brain elements, and whose properties allow encoding the criticality of stimulus that generated them.

According to this, the most important consequence is that all Intelligent Systems activity, including conscious thinking, is regulated by emotions, and those are only generated when a reflex or automatic response fails on making its work.

At this point somebody must be tempted to affirm that this is not possible, because we are able to think without any emotional state. Are we sure of that? Who has ever said that emotions have to be always extremely intense? Until today, when we think about emotions we only think in those such as love, angry, sadness, happiness, anger, etc… Those are the most extreme ones, with very intensive physical and neurological components, but that is just the tip of the iceberg. According to this theory, there exists an undiscovered and wider emotional field, where thousands of silent emotions (with low or not physical component) are fired at every moment to optimize our brain operation parameters.

What we propose here is that there is not such dichotomy between emotion and cognition; rather, at any given time, multiple physical and cognitive, not stereotyped and parallel stimuli are knocking at our emotional system's door, getting a priority card (*Emotional Criticality*), and being dispatched to be treated by the most advanced cerebral centres.

Emotional Criticality is a qualitative variable which ranges in a continuous way from extremely negative values (a stimulus to intensely avoid), to extremely positive values (a stimulus to intensely pursue).

Emotional Criticality is assigned as a result of applying the stimulus features over the Emotional Pattern, a subset of the previously introduced genetic (reflex) Answer Pattern. It's logical to think that any new stimulus must have a response, at least the basic actions to allow investigating it. By default, all new stimuli that are not associated to any reflex or automatic response are directly linked to emotional system. It is well known that at birth, a lot of different stimuli are associated to the same emotion. When a baby is cold, thirsty, hungry, wet, or he is in pain, he always displays the same emotional response; crying. Only when that fails we start changing stereotyped answer into more sophisticated ones.

At this point we have a not resolved stimulus which has already been labelled with an emotional criticality, and now what?

Attention

The Efficiency Principle tells us that the brain, as it is an evolving system, must adjust its development and ability to minimize, as far as possible and without undermining its effectiveness, the amount of resources used to accomplish its tasks. This postulate has three-reaching effects for understanding brain functioning.

1- The brain will not develop or even eliminate those neural circuits that are found not necessary or inefficient (neuronal apoptosis and synaptic pruning).

2- The brain will adjust the capacities of those systems which are necessary and will size them in accordance with the characteristics of number, frequency, complexity, simultaneity and criticality of the stimuli to be resolved.

3- Once a stimulus has been resolved, the brain will not apply any higher capacity mechanisms to it.

In addition, the Automation Principle tells us that, once a valid response is found, the brain will try to automate as much as possible as a way to optimize the balance between the operating parameters.

From the implementation of these principles (efficiency an automation), we can infer the relationship that exists between number and power of the available resources, and the frequency, variability and complexity of the stimuli the brain must solve. We argue that stimuli evolution follows a characteristic curve mainly defined by two variables; environment stimulative richness and auto-stimulative capacity. In general, the number of simple, repetitive and not critical stimuli is greater than complex, highly variable and critical ones.

The most simple and repetitive stimuli may be managed by less powerful circuits, and be more and more automated, allowing its management in parallel. In contrast, the more complex and heterogeneous stimuli require the intervention of the more advanced circuits, with a lower level of automation and less numerous. This leads us to assert that the more complex and variable is the stimulus to resolve, the lower the number of available advanced circuitry to manage it.

Because of this limitation of advanced resources, and given that the brain processes a large amount of simultaneous stimuli, conflicts will often arise when accessing them. This fact justifies that the brain must lay down some mechanism to filter and select which stimuli should have priority in using the various available resources.

But not only complexity and variability are involved in the process. Above them is the criticality of the stimulus that requests for resources. If an urgent process does not receive priority, the result can be fatal for the organism.

To solve all these problems there is a specialized mechanism to carry out, effectively, the task of filtering, prioritizing and allocating resources: Attention (Fig.1.e). Its mission is to evaluate the various simultaneous access requests to different resources, prioritize them and allow to optimally access those resources depending on their urgency.

According to this theory. Attention uses emotions to resolve those conflicts, giving different stimuli access to available resources based on the previously assigned priority, which was codified by their Emotional Criticality.

To do so, the attention, like any other system, must have some reference to assess the priority and resources that should be allocated. We call this functional element Attentional Model. The "Maslow's Hierarchy of needs" (Maslow, 1943) is a high-level generalization of Attentional Model, which provides a gradient for the criticality of the stimuli.

Based on Emotional Tension and the Attentional Model, the Attention creates and adjusts what we call the Attentional Window, selecting and filtering a greater or lesser number of simultaneous stimuli to be processed by the most advanced resources. Stimuli could be treated in parallel if they don’t need to share the same resource.

As a result of it, Attentional Window is always readapting its size and focus, conditioned by active emotions. When a very critical emotion appears, the Attentional Window becomes narrow and focuses on associated stimulus. In absence, less critical emotions are attended. At any given time we are exposed to millions of low criticality new stimuli, whether physical or cognitive, so Attention always has some emotions to process. Most of stimuli are not urgent and their associated emotions have low or none physical component and are quickly and unconsciously resolved, so they are not identified as emotions, but they are. For example, if we try to reduce stimuli (perceptions or thoughts), as usually happen when somebody first starts to meditate, the number of critical stimuli and associated emotions is reduced, since the brain doesn’t need to resolve anything, and beginners usually get asleep.

Briefly, Attention continuously receives, in the form of emotions, all requests of those stimuli whose stereotyped responses (genetic or learned), or lack thereof, have failed in resolving the situation for which they were developed. At that time, Attention assesses the criticality of different emotions and, in case of conflict when accessing a particular resource, prioritizes the order in which they are used to find new responses.

Intelligent Systems

We call Intelligent Systems (Fig.1.f) those neural circuits able to use different strategies, more or less advanced, to generate novel responses of varying complexity, by using previous cognitive elements and relationships among them, stored in Reference Model, to create new ones. Here we include from implicit learning and imitation (mirror neurons) (Rizzolatti & Craighero, 2004) up to consciousness, going through logic, planning, decision making, predictive circuits, etc…

Once a stimulus obtains access to the most advanced resources, we must re-apply the Efficacy and Efficiency Principles. The brain must find an effective response, while minimizing the time and resources to do so. To achieve this, brain must use the necessary intelligent systems, and only those, in an appropriate way according to the criticality and complexity of the proposed task. The existence of multiple subsystems, with different degrees of specialization, resolution capabilities, and energy consumption, creates a hierarchical structure for intelligent systems, which defines the order in which they will enter into action to solve a particular problem. Sometimes several of them may act in parallel on the same stimulus, while other times they might operate in a sequential manner (Paas, Renkl & Sweller 2004; Bapi, Miyapuram & Chandrasekhar, 2005)

We argue that consciousness (Tsuchiya & Adolphs, 2007) is only one of the most advanced tools, but not the only one, so many intelligent processes can operate in parallel with it, even out of its “conscious reality”. It is not the purpose of this article to analyze consciousness in depth, so we will let this aside for some future paper.

Thus, intelligence will not depend on how much sophisticated are the systems used to solve the problems, but on the right balance between the problem, the system used, and the quality of response in terms of efficacy, time and resources used to find it.

Intelligent Responses

At this point we have some different possibilities about the search results. (Fig. 2). If an intelligent response is found, it is stored (Response Pattern) and executed (physical and/or neural feedback). The only way to be effective ($T_{EMC} < A_{THLD}$) is (a) by eliminating the stimulus or (b) by modifying the Reference Model, so reducing the Emotional Tension between them. If the actual intelligent response is not effective or doesn’t exist, a higher intelligent strategy, if available, must be activated, in order to look for a more advanced response, and so repeating the process.

If all available intelligent strategies are explored and no effective answer is found, the one which most reduces the Emotional Tension will be adopted and linked to that stimulus. These ineffective answers can explain, in our opinion, most of compulsive and maniac behaviours, as well as nervous ticks. As the new response is stored, the Automation Principle must be applied and the brain begins on searching for the most efficient circuit to optimize its parameters. The automation of a solution which not completely resolves Emotional Tension implies that its associated emotion stays active, with an important cost of energy, physical and cognitive resources.

When no effective answer is found, there is another very powerful strategy the brain can apply. If we saturate the Attention with many simultaneous requests of higher priority, the unresolved stimulus will never access to intelligent systems, included consciousness. Doesn’t it sound familiar? This strategy is, by itself, an intelligent answer. To achieve this, we just need to continually expose the individual to many and highly novelty simultaneous stimuli that hoard knowledge resources, and do not let the unresolved stimulus to access into conscious reality. By this way, and although the original stimulus has disappeared, it can be continually reactivated by other neural processes, since its features are already stored in the Reference Model. This can create an unconscious self-sustained loop which can explain much typically human behaviours.

This closes the circle, showing the most beautiful face of this theory. As the Reference Model and Response Pattern are modified, and thanks to feedback, also the emotional tension is automatically changed, thus influencing the associated emotion, which in turn affects attention and that modify cognition. It’s like an incredible dance where emotion controls thinking, and immediately thinking changes emotions. Like in many other fields, nature shows us the magic of balance.

Going on with our reasoning, this theory predicts than once an effective response is found (TEMC < ATHLD), the more automated the solution is, the less cognitive resources are needed to execute it. Once an effective answer is

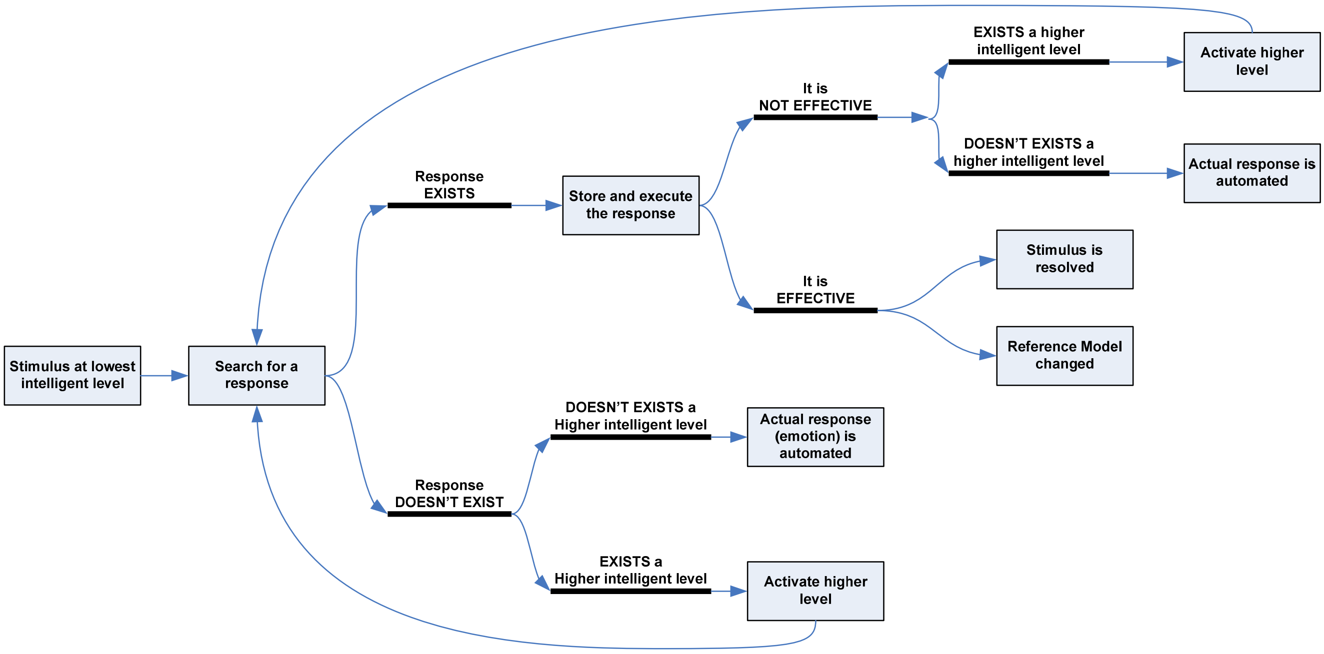

Figure 2. Decision tree for an intelligent response searching.
We show here the different branches and options that intelligent searching can go along to find an effective response to a specific unresolved stimulus.

completely automated it becomes unconscious, if not always was (e.g. implicit learning). Obviously there will be some stimuli not automatable at all, which always would have to be treated by intelligent systems, and regulated by emotions. Consequently, learning will be the process by which an intelligent response to a stimulus becomes an automatic one. The only way by which we can again make conscious an automated response is by activating a new cognitive process that generates Emotional Tension, in other words, thinking about thinking or meta-cognition. This is one of the most important implications that arise from the theory.

Implications of the theory

Control Systems

From an evolutionary standpoint, the Efficacy Principle says that it must always exist at least a basic response to address any stimulus. That implies that even when a new answer is found, the old one should be conserved, mainly if it was a reflex one (like emotions). According to this theory and the already exposed functional model, control systems emerge as a result of connecting new intelligent responses with their originating stimuli. They would be just a kind of short circuits that bypass the old solutions in benefit of the new ones. While the new solutions are effective, they are executed but, in extreme conditions (without time or very intensive Emotional Tension), they become ineffective, giving way to the older one. This approach gives account of much irrational behaviours, which arise when individuals are exposed to stimuli that overrides the range of already developed responses. An example for this would be violence as an ancestral and simple response that arises when learnt responses (e.g. education) fail to resolve the Emotional Tension.

Cognitive Elements and Heuristic Rules

To be effective on resolving a problem, intelligent systems needs to work with different elements, according to some basic heuristic rules that follow:

First, the stimulus must have enough Emotional Criticality to be selected by the Attention. The more critical it is the more time and resources it gets.

Second, it needs to have access to cognitive and relational items to combine. They had been previously developed, learned and kept in memory (Reference Model). To manage or create a new one, it must find some new relationship among the previous ones. As soon as a new element or relationship is created, it is automatically stored and becomes a new combination possibility to work with. The larger is the number of items and relationships among them…

- the more flexible, advanced and creative are the answers found.

- the longer is the time to process and find a solution.

- the higher is the energy consumption.

Third, it needs a set of different intelligent hierarchical strategies (neural circuits) to apply on them.

- The more an intelligent system is used the more advanced and energy efficient it becomes.

- The more advanced a system is the better its quality and speed are.

Fourth, it needs time to run intelligent processes. The longer the time to search for alternatives, the larger the number and the better the quality of them.

Reference Model Structure and Decision Making.

There is still another aspect that needs to be in depth studied. If an effective response for a stimulus acts over the Reference Model, modifying it as a way to resolve the emotional tension, some other elements can be affected by that change. This implies that resolving one stimulus can start a domino effect, which in turn involves increasing the emotional tension for other stimuli.

The theory predicts that statistically, the more basic is a concept, the greater will be the number of relationships and meta-concepts built on it, so the more intense will be the total emotional tension generated if it is changed. This also has a direct relationship with efficiency principle. The more is the number of synapses to change, and the stronger they are, the higher the time and energy consumption to make it. An example of this would be denial as one of the most predictable responses of human being, justified here as a quick try of the brain to maintain optimized its operating parameters..

If we have this idea into account, and given that all processes (stimulus/response) are feedback, this theory predicts that brain will try to find the best balanced solution to minimize the total Emotional Tension for a group of related concepts. This means that when assessing different responses for the same stimulus, the brain will choose the one which gets the lowest total Emotional Tension, including the all the partial tensions of affected elements along the thinking chain. A good example of this reasoning is in denial, as one of the more predictable human behaviours.

If we consider the mental processes while working with concepts, meta-concepts and relationships between them as competing agents trying to minimize their own Emotional Tension, we postulate that the brain's process of decision making would adopt the shape of Nash equilibrium (Nash 1951). This means that, once found a response, none of the processes could reduce its emotional stress by unilaterally changing its response. These consequences of the theory might have important implications for economic sphere (Khaneman & Tversky, 1979; Tversky & Khaneman 1992) that will be explored in the future.

Complete Operation Cycle

When a stimulus is detected, whether physical (internal or external) or neural (cognitive), it is automatically compared with the Reference Model and a difference (Emotional Tension) is calculated. If it exceeds the Activation Threshold, the stereotyped response (reflex or automatic), if exists, is implemented. If the response does not exist or fail, a by defect emotion (with neural and/or physical components) which is associated with the stimulus (Emotional Pattern) is activated and sent to Attention. There, all the simultaneous active emotions are assessed (referred to Attentional Model), and Attentional Window appropriately sized and focused. Those with the higher Emotional Criticality will be in parallel attended, if not in conflict for the same cognitive resource. Once a stimulus access is granted, intelligent systems begin to work on it, starting with the simplest possible strategy (Efficiency Principle), and going up along the hierarchical structure up to find a response which resolves the Emotional Tension. If no effective response is found, the more effective one will be associated to stimulus and automation principle will make its job.

Conclusions

Having exposed the most relevant elements of the theory, the main conclusions we can extract are:

- The brain will always try to provide necessary and effective responses with the lowest cost in energy, time and resources.
- The emotion-cognition duality doesn’t exist. Emotions are previous to cognition as a way for brain best balancing its operational parameters (Activ. Threshold, Reaction Time and Accuracy), in accordance with the evolutionary principles of Necessity, Efficacy and Efficiency.
- Once activated, cognition can act over emotional elements, modifying them in a way fed back, which in turn will define the future responses.

Collateral implications

Due to the article’s scope, we will briefly enumerate the different fields where the theory can have implications. If it is right, this theory could give some clues about the humanization process, by explaining why the cognitive differences between humans and chimpanzees did arise. It also gives an evolutive explanation about the relationship between emotions and learning, and the process by which our intelligence and “vision of reality” are developed. The theory also provides a solid understanding of emotional behaviours, explaining why and when emotions and rationality are displayed. This has some important consequences on the comprehension of violence, mobbing, and many other individual and social interactions. The theory also proposes an explanation for some psychological conducts like emotional loops, some types of depression, addictions and others. Mainly, it gives us a key to a wider knowledge on self-esteem, as one of the most important elements of personality. In the same way, it gives us new clues to understand the process of decision making, which has essential repercussions not only on Economics and Marketing, but also on Management and Conflict Resolution. It also gives sense to the most controversial results of some experiments on consciousness and free-will (Libet, 1985; Siong, Brass, Heinze & Haynes, 2008). This can largely affect to legal theories and practices where intentionality is the base to condemn.

All these implications and those that can't be still imagined, must be in depth investigated and developed, using this theory like a new framework for a better understanding of human behaviour.

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FIGURES

Figure 1:

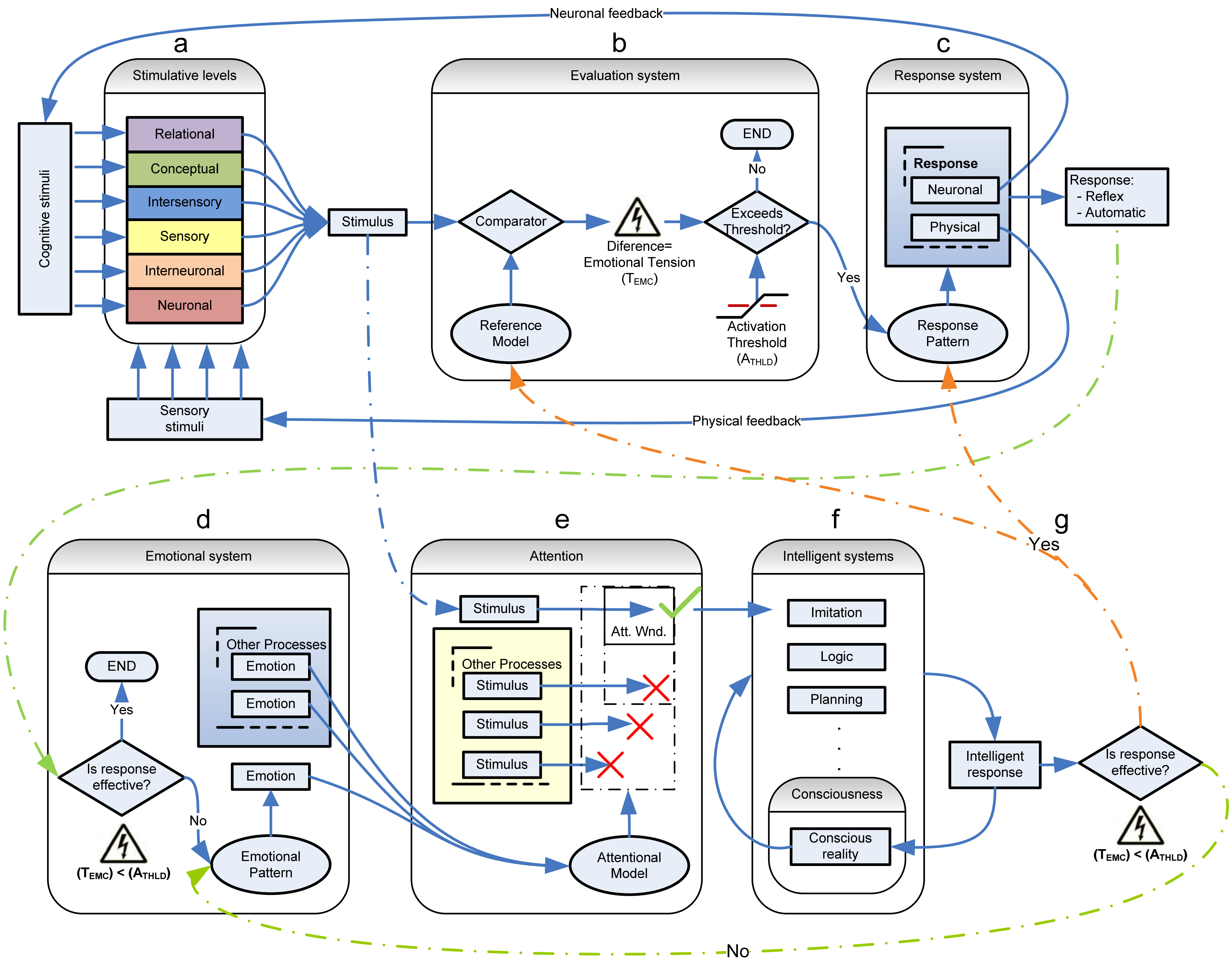

Figure 2:

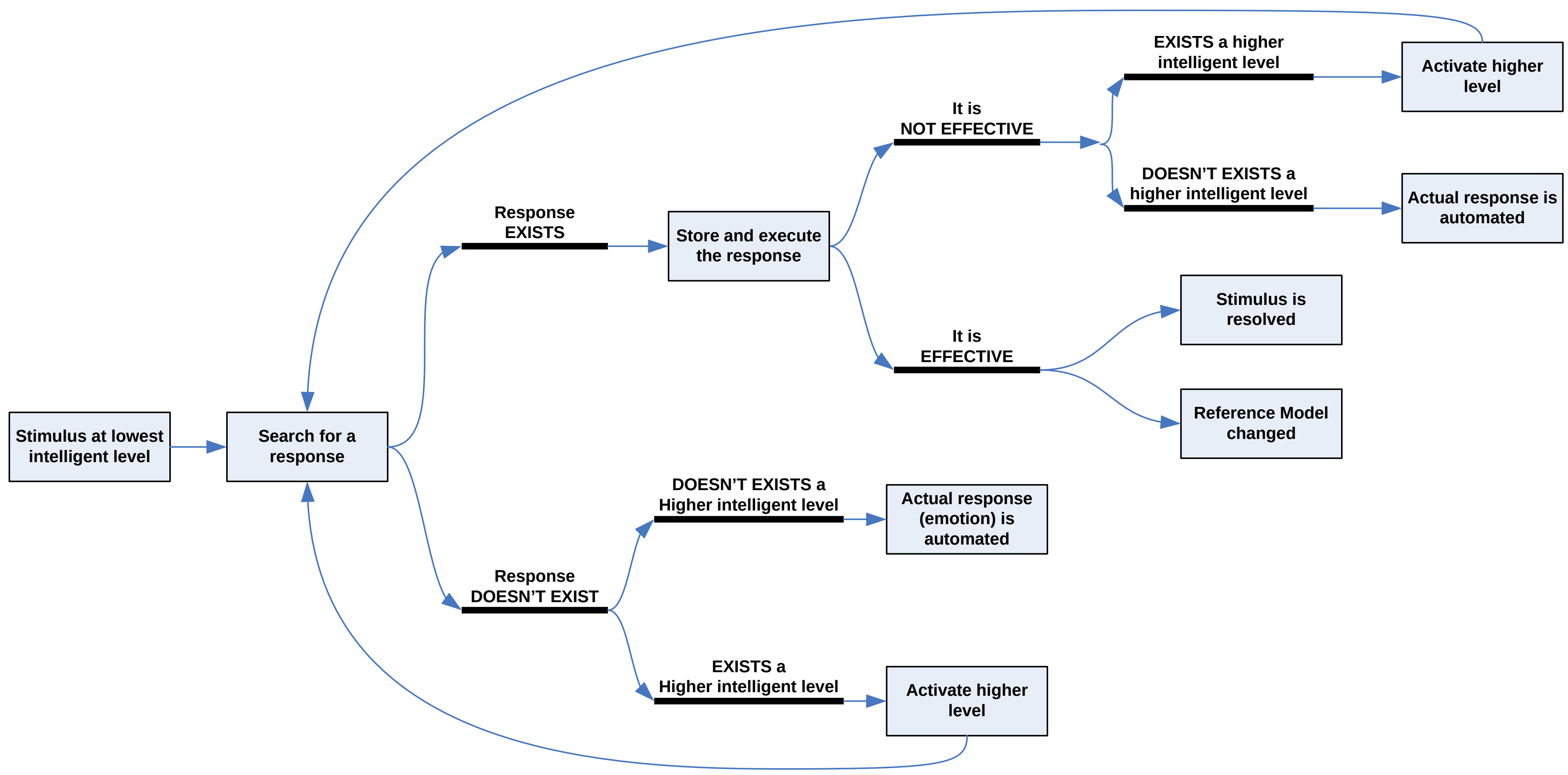
Stimulus at lowest intelligent level
Search for a response
Response EXISTS
Store and execute the response
It is NOT EFFECTIVE
EXISTS a higher intelligent level
Activate higher level
DOESN'T EXISTS a higher intelligent level
Actual response is automated
It is EFFECTIVE
Stimulus is resolved
Reference Model changed
Response DOESN'T EXIST
DOESN'T EXISTS a Higher intelligent level
Actual response (emotion) is automated
EXISTS a Higher intelligent level
Activate higher level

FIGURE CAPTIONS

Figure 1. Schematic functional model

This figure shows the different subsystems that conforms the model that arises from the theory propositions. (**a).** Stimulative Levels: where sensory and cognitive stimuli are detected and integrated. (**b).** Evaluation System: compares the stimuli with Reference Model, calculates the Emotional Tension (E_{TNS}) and checks if it exceeds the Activation Threshold (A_{THLD}). (**c).** Response System: execute the stimuli associated responses. (**d).** Emotional System: If responses are not effective, a by defect associated emotion (Emt. Pattern) is activated. (**e).** Attention: evaluates the request's Emotional Criticality and according to it (Att. Model) resizes and focuses the Attentional Window. (**f).** Intelligent Systems: Uses a hierarchical set of intelligent strategies to find an effective solution for unresolved stimuli. (**g).** Intelligent Responses: If they are effective, are stored and linked to stimulus. If not, a new search cycle is started.

Figure 2. Decision tree for an intelligent response searching.

We show here the different branches and options that intelligent searching can go along to find an effective response to a specific unresolved stimulus.