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Autism Spectrum Disorder: A New Fuzzy and Affective Mental Model

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Abstract Autism is defined as a group of basic behaviors, containing difficulties in social reciprocity, communication, and limitations in behavioral flexibility. Children with autism spectrum disorder (ASD) have problem in understanding the minds of others, their emotions, feelings, beliefs and thoughts. Autistic children usually go through a diagnostic process, as soon as their difficulties or problems arise. The diagnosis usually agrees with any of the existing medical and psychological recommendations; it only determines that a certain level of problems is reached, and the child must be considered autistic. However, the diagnosis does not evaluate all the problems and severities that the child presents, nor its detailed individual intensity, and as it is not usually repeated, it is not able to determine the appearance of new symptoms or deficiencies with age, nor the changes of intensity. The diagnosis also does not determine the affective states associated with these deficiencies, nor the intensity of these associations. Therefore, the aid offered to the autistic child cannot achieve greater efficiency, due to ignorance of these factors. The mental representation of autistic children or mental model, as we conceive it, contains all the deficits and tasks that they cannot perform, and their intensities; it goes further than diagnostic. So far, no autism mental model has been developed, according to our knowledge. The present article proposes a fuzzy affective mental model of autism, in correspondence to DSM-V, taking into account the child's affective states. The model contains all his/her particular deficiencies, intensities or severities, frequencies, and associated affective states. This evaluation is made according to affective computation and fuzzy logic, in order to take into account affection and uncertainty. The mental model can be obtained by means of a serious games methodology we have previously developed, and it can be obtained any time, in the form of a fuzzy cognitive map or a fuzzy graph. This mental model can be used to develop new techniques to improve learning of autistic children, and to integrate them into social life. Those improvements constitute our immediate future work.

Keywords Mental Model, Autism Model, ASD, Fuzzy Computing, Affective Computing, DSM-V

1. Introduction

Mental models are a form of analogical representation of knowledge; there is a direct correspondence between the entities and relations present in the representation structure (semantic network), and the entities and relations of what we are trying to represent (real network). The mental model represents a functional form of prior conceptions in relation to a specific and momentary goal. It is made up of elements and their relationships, which represent the state of things, structured in a way that is appropriate to the process on which they have to operate. Each model is therefore already predisposed in a way that is consistent with its intended use.

Generally, a mental model is a cognitive simulation of how things work and are related, or how to approach a particular problem or situation. These models are built up over time through learning, experience, and understanding of various concepts and relationships. Mental models help people make sense of the world around them, make decisions, solve problems, and predict outcomes.

This has been the situation known so far, in which what interested were the mental models of the human expert to try to implement them in the apprentices. Now, in the case of autism, what is intended is to know and represent learning problems, and difficulties of all kinds, which autistic children present to try to improve them and avoid them.

The objective of this research is to develop a conceptual or mental model that includes all the deficiencies and problems of the autistic child, and its intensities. It is another step above the diagnosis, which usually only includes the major deficiencies, and that is not usually done frequently; this conceptual model is like a mental radiography of the state of the autistic child. That more steps will allow to coherently attack all the problems existing in the autistic child, including the new problems that may arise, by frequent obtaining this model.

It is intended that this mental model can be prepared in each specific case manually, although our subsequent objective is to ensure that the computer can automatically obtain that model. Thinking about that subsequent objective, the model will include fuzzy concepts, that is, concepts that are uncertain, according to the conception of Lofti Zadeh [1]; that will allow their treatment through fuzzy logic [2], and reason with them.

Likewise, it has been insisted on the emotional and emotional aspects of the child. Affective states are extremely importance because they can trigger learning problems, and can improve them. On the other hand, and again thinking about our subsequent objective, the model tries to include all the affective relationships that are developed. It is possible to treat them on the computer through affective computing [3], [4], which not only can be occupied with determining the affective states of the autistic child, but also trying to improve them, when necessary or convenient. Therefore, the elaborate model can be qualified as fuzzy and affective.

In this perspective, the article first presents an overview of Autism Spectrum Disorder (ASD), its symptoms, and diagnosis. Then, it tries to place the model to be elaborated on the scale of the different existing scientific models, describing them. Next it introduces the new fuzzy and affective mental model of autism, and its obtaining in the form of a fuzzy cognitive map or fuzzy graph.

2. Autism Spectrum Disorder

Autism Spectrum Disorder is an intricate disease, of the social interaction of the person, expressed in multiple ways. It seems that Leo Kanner [5] was the first to identify this syndrome to state that he was present from the birth of the child. Initially, quantitative estimates gave it a presence between 0.2 and 0.45 per 1000, although according to other estimates it reached 1.39 per 1000. However, A new study conducted by the United States Government in 2014 [6] estimates that 1 in 45 children aged 3-17 suffer from autism. That increase is truly alarming.

There are guides and aids for parents, related to the symptoms and elementary diagnosis of this syndrome, such as that provided by National Institute of Mental Health [7], and the one facilitated by the World Health Organization [8], after its meeting in Geneva in 2013, which among other issues addresses the state of evidence of the ASD, and other related disorders. A fairly complete vision of autism is provided by Eric Schopler's and Gary Mesimov's editorial work [9]; the various chapters included, allow to know in detail a good part of the problems that autism presents, and its manifestations.

Various recommendations for its diagnosis have been published, such as those published in Scotland [10], andthose issued by the American Psychiatric Association (APA) in the fifth edition of DSM manual((DSM-V), which have been welcomed in various publications [11], as well as the comparison between the criteria specified by the fourth edition, the DSM-4, and the fifth, DSM-5 [12].

Other interesting publications are that of Huang-Storms [13], which provides a wide vision of the characteristics, symptoms, and treatment of autism, and that of C. Droney and collaborators [14], which helps educators and instructors in the knowledge and monitoring of autism. A more specialized job is that of Gillian Baird and collaborators [15], who analyze several differential diagnoses, such as mental retardation, language problems, lack of coordination, and other disorders; it brings an interesting perspective for parents. A work worth mention is the study carried out on the ASD, its symptoms, diagnosis, and treatments, developed by the Massachusetts Hospital [16].

On the importance and development of autism in our days there is extensive literature, as well as on its causes and origins. From it, we want to highlight the contribution of Ramachandran and Oberman [17]; starting from the anatomy of autism, they emphasize that the shooting of neurons in the Cortex Premotor, suppresses the MU wave, component of the encephalogram. All this provides evidence that people with autism have dysfunctional mirror neurons systems. As for accidental causes of autism, the work of Lidsky and Schneider can be mentioned, dedicated to poisoning [18]. Another interesting work is that contributed by Gnanathusharan Rajendran and Peter Mitchell [19]; they consider three theories of autism: mental deficits, executive dysfunction, and weak central coherence, and analyze them, trying to establish a possible unification.

The contribution of Demetria Ennis-Cole and co-workers [20] is useful for showing the effect of culture on the diagnosis of ASD and its own treatment; it can help family members, physicians and counselors. A similar direction is the work of L. Smith and co-workers [21] on the influences of the relationship between mother and his child.

Various aids of different nature have been designed to improve learning of autistic children. Of these, the animated tutor developed on computer [22] could be highlighted; it can improve the vocabulary and language of autistic children.

For good practice it is worth citing the editorial work of Stuart Powell and Rita Jordan [23]; several articles included mention learning science, dance, and drama, as well as computer-based therapy. Computer-based learning, in particular, can benefit autistic children; among the papers addressing this issue, David Moore and colleagues [24] propose a major research framework based on autism's own impairments.

As can be seen, the existing literature on autism is abundant, but so far and according to our knowledge, no mental model of autism has been developed.

3. Scientific Models

Models or scientific models, as they are frequently designed, are always incomplete descriptions of a reality, and not exact replicas, because the complete detail of it is unaffordable for its complexity. This level of incompleteness is such that it allows observation or study of that reality. That incompleteness of the model always stimulates its improvement.

In principle, although it could be obtained a very wide classification of scientific models [25] that in philosophical literature can reach twenty-five different categories, three large kinds of scientific models can be defined: physical, quantitative or mathematical, and qualitative or conceptual. Physical models are usually material reproductions at reduced scales such as reduced models of dams; that allow analyzing their elastic and resistant behavior, or small models of machines, or graphic models. Quantitative or mathematical models use this discipline, and are classified according to the mathematical subject used: linear, non-linear, algebraic, differential equations, and partial differential equations, also statistics, probability, stochastic theory, or others. Qualitative or conceptual models use a set of ideas to try to represent a non-familiar concept or reality, such as the origin of life.

However, this set of categories of scientific models is not a true classification, because there are models that participate in several categories. Thus, there may be non-quantitative mathematical models, only qualitative, as a set of relationships, which are represented by branches of non-numerical mathematics, such as linear algebra, graphs theory, or others. Even some models, in addition to using these mathematical branches, may also need to take into account intensities, so that they would be qualitative and quantitative models. The same can happen with reduced physical models, or models which in addition to qualitatively representing a natural reality, may need to measure certain parameters in the model; these would be physical and quantitative models. Hydrodynamic experience channels constitute another example of physical models; they generate waves that affect the movement and navigation of a small ship, in which their consequences must be measured; it would be another physical and quantitative model. However, models are usually labeled according to their most visible characteristic, such as physical, quantitative, or conceptual.

The applications or purposes of the scientific models are very broad, and range from the observation of an experimentally created object, such as the DNA model, or the Bohr atom model, through the data models that are used so much in the digitization of our world, to the description of its behavior in the form of simulation, sometimes including its prediction. These predictive models have had a spectacular development in our days in relation to meteorological or physical phenomena, such as climate change. Other objectives of scientific models can be the exploration of that reality, their learning, their development, or their phenomenological interpretation. In addition, we must mention the most accurate knowledge of realities, the dynamics of interactions between living beings, and others very varied in urban planning and construction.

As for the realities that models represent, their number is countless. Virtually any physical, economic, medical, psychic, or conceptual reality, can be modeled with greater or lesser success. You just have to consider a concrete discipline to contemplate a huge number of elaborated scientific models.

It is important to take into account the limitations of the model, often present in its observations, which are not satisfied with reality. These experimental errors motivate the permanent improvement of the model, to constantly adapt to reality.

Every model goes through several phases ranging from its conception, design, instrumentation, experimentation and evaluation. Its conception and design may follow very different paths depending on the type of model to be developed. The evaluation is carried out mainly by comparing its results with empirical data. If the evaluation is not satisfactory, the model is rejected or needs to be modified. One possibility of modifying the model is to reduce the reality or its field of application. In this evaluation process, its possibilities of explaining the empirical observations previously made are analyzed, as well as its ability to predict future observations, its degree of confidence, its cost, and even its simplicity [26].

According to this perspective, we try to develop a mental model which is quantitative, because it includes intensities and severities of deficiencies by means of fuzzy sets, and also is qualitative, because it considers relations and emotions according to the treatment of affective computing.

4. Mental Models

One of the brightest introductions made of mental models, based on cognitive psychology is made by Philip

Johnson-Laird, developed in the field of spatial and formal resasoning by Jhonson-Laird and Byrne [27]. The mental model promotes agreement between the structure of the data and the functions for manipulating the same data, adapting their own structure to the functions for which they are used. By helping to structure information and define a cognitive strategy, it reduces cognitive load and can have a preventive effect against cognitive overload. According to the first author, mental models cover the aspects of the mental representations, the possible differences between images and sets of propositions, the mental processes that the ordinary reasoning and their rules of inference imply, the representation of the meanings of the terms, and its possible dependence on a set of postulates of meaning, or a dictionary. In principle, the idea that man uses or can use an internal model in the world, comes from a time before the computer.

Mental models occupy a particular place in the set of models. They are the models that a human expert elaborates, when acquiring his work experience with the problems he/she has to solve in his specialty; in principle, they are constituted by articulated sets of strategies and acting techniques, including the representation of objects, and decision making. This elaboration is done unconsciously over time, so that the human expert himself is not aware of that elaboration, nor of the elaborate models. Consequently, it must be others that discover those mental models of the expert, regularly.

However, some authors such as Patrick Hayes [28] have become experts who try to analyze their own expert activity, and have analyzed all the concepts that include the understanding of liquid behavior; that allows people predict, using those elements, when a liquid will flow, when it will remain still, or spill on a fine sheet form. These works have aroused direct research in mental models, to try to improve both the understanding of certain domains and the proper problem solution, and decision making in various fields.

In principle, there are three research domains: the conceptual domains or fields of these mental models, the representation of their knowledge that usually is made from the computational semantics, and the used methodologies that are usually eclectic, including the analysis of protocols, empirical observations, simulation of psychological models, and comparison with the performance of humans. Therefore, research in mental models includes aspects of cognitive psychology, and artificial intelligence.

As for the domains, or conceptual fields of the models, Kenneth Forbus's work [29] should be cited. This author has characterized and simulated a part of spatial domain and knowledge, through qualitative rules, that include objects of that domain and their inference rules. At the same time, he has paid attention to his empirical observations to refine these models. On the other hand, Johan de Kleer and John Brown [30] have simulated the expert knowledge of electronic circuit analysis, while Alan Bundy and Lawrence Byrd [31] have simulated a particular method of integration with heuristics, which is taught to mathematics students, when they learn infinitesimal and integral calculus.

The methodologies used, as already said, are usually complex, with emphasis on psychological aspects; thus, Jill Larkin [32] compares the way in which experts and apprentices of physics represent a specific domain in which they try to solve problems, analyze their differences, and show these differences in conditions of their respective behaviors and decision making. Dedre Gentner and Donald Gentner [33] develop a theory about how the analogies are processed, which aims to show the differences they print in the development of knowledge.

From another point of view, there are works based on the analysis of protocols and experimental observation; thus, Richard Young [34] elaborates and compares various models of hand calculators through protocols analysis, to show that different models lead to different results in terms of execution and errors. Dissassa uses the observation technique in an artificial domain of a newtonian world; by observing their behavior of simple manipulations he can discover to what extent the ideal newtonian laws remain opaque for students. It is convenient here to highlight the implications of mental models with the aforementioned cognitive psychology, the neuroscience and the philosophy of the mind [35]. The book we comment contains an interesting set of articles referring to specific situations related to the aforementioned sciences, such as relational reasoning and visual images, emotions and decisions, and the perceptual nature of mental models.

One of the last published works on the ontology, design and operation of mental models is due to editors Jan Treur and Laila Van Ments [36]. In principle, these authors have a possible cognitive architecture of mental models that classify in static/dynamics of the world/mind. They can be used for internal simulation, adapted or controlled. The works that are included in this book show the current situation of the research of mental models, their management and development, and their use in practical cases.

On more specific topics, it is convenient to include the work of Janne Hukkinen [37] on modern environmental management and the models that it uses, and that of Robert Kraut, Susan Fussell, and Javier Lerch [38] at the Carnegie Mellon University, that address the important issue of shared mental models (SMM), and their impact on the performance and efficacy of equipment, also analyzed by Ronal Singh, Liz Sonenberg, and Tim Miller [39]. From another point of view, Patricia Werhane et al. [40], discuss the barriers to a moral decision in the design of the ethical context, and the role played by mental models.

All this research has contributed to facilitating catalogs of strategies and/or tactics that try to improve human reasoning and decision-making in research and dissemination books. Among them include the contribution of Peter Hollins [41], which defines 30 mental tools that differentiate the average man from the exceptional, divided into five sections, and include some tactics, known as the Occam razor, Murphy's law, and Parkinson's laws.

Along the same lines we must mention the three books on great mental models [42], [43], [44], edited in Ottawa, with the slogan that the quality of our thinking depends on the mental models that are in our mind. The first volume is dedicated to general concepts of our thinking, referring to the key to better understanding the world is to build a network of mental models. It includes nine general models that range from some first principles taken from the Greeks, through creativity, as a fun of intelligence, to reach a second-order thought, and probabilistic thinking. It also includes ideas about falsification, necessary and sufficient conditions, and causality against correlation. The second volume is related to physics, chemistry and biology; it contains, among other aspects, issues of relativity, thermodynamics, inertia, speed, catalysis, activation energy, evolution, ecosystem, and hierarchical organization, together with an attempt to relate everything. In the third volume there are models and ideas related to feedback loops, balance, bottlenecks, safety margin, algorithms, critical mass, chaos dynamics, sampling, randomness, and global and local maximum. These volumes suppose a great effort to help and understand the world around us, and our involvement in it.

In another sense, we must place the work of Albert Rutherford [45] regarding the learning of decision-making, advanced deductions, and problem solving skills from mental models and system maps. The author tries to promote vision and thought by systems, not by dispersed and separate elements. He tries to follow Jay Forrester's ideas, about systems dynamics. In principle he considers three main categories of systems: social, industrial and the ecosystem. Social systems contain all the rules and norms that the human being creates. Industrialists provide everything that sustains our lives, while the ecosystems supply the natural resources we need for survival. The book includes rules to build a good model, from the stages of: define, expand, and add. Similarly, it presents rules to build conglomerate maps (cluster maps) and their interconnections, such as causal loop diagrams. However, Rutherford fails to penetrate the strength of mental models, which do not necessarily have to use these rules.

The elaboration of mental models of an expert is not an easy task, however, there are tools, such as BCTA [46], that allow to extract the models that a human expert uses, with his/her collaboration, through a collection of interviews and problem solving questions.

However, the autism case is completely different. In this context the role of the expert should be played by the normal child, whose mental models of functioning cannot be obtained. That is why in this case the interest focuses on the problems and deficiencies of the autistic child to try to correct them; these are the elements that make up his/her mental model.

4.1. Acceleration of the Transfer of Novices to Experts

Mental models characterize the fundamental difference between apprentices and experts, [47] that is found at the end of university studies, seeing the differences that exist between the expert's behavior in the face of the problems of a certain environment, and that of the apprentice, which is the newly graduated. The mental model of an expert marks the learning that the apprentice must perform to achieve that level, and that will force him to modify his mental models. Artificial intelligence has contributed to obtaining and using mental models [48] in collaboration with other techniques of knowledge elicitation.

Once obtaining the expert's mental model, a whole collection of exercises and problems can be developed that allow the transition to be accelerated.

This context of experts and apprentices, has been the usual application of mental models.

4.2. Intelligent E-Learning Systems Based on Mental Models

Mental models have also contributed to the design of intelligent e-learning systems [49] based on the expert's model and that of the student.

The expert's model contains:

a) The conceptual graph of the expert's field.
b) The management system of your own experience, which includes a whole family of mental models, each composed of a collection of increasing complexity models, both for the number of variables and for the circumstances, it considers.
c) It also contains the system of relations between these families of models with each other and with the conceptual graph.
d) The selection strategies of mental models.
e) Techniques and plans for learning the components of the conceptual graph and the expert experience.

The student's model contains:

a) The initial knowledge of the student and his basic cognitive skills before learning.
b) The student's exchanges history with the system and all its details.
c) The cognitive student model, which represents his mental state, and integrates his profile, such as his capacity, efficiency, attention, interest, and motivation.
d) The acquired knowledge and their skills represented by its conceptual graph, with all the learned elements.
e) The experience acquired by the student, represented by an experience management system.

4.3. Mental Models and Communication

One of the important issues to which mental models are applied is that of communication in general, and in its particular aspects. Thus, the editors Lita Lundquist and Robert Jarvella [50] present a set of works related to language, text, and knowledge, which show, for example, the necessity of understanding legal rules to comprehend legal texts, the differences in argumentation and inferences between apprentices and experts, and the importance of the representation of knowledge in the economic context. Sabrina Kessler and collaborators [51] show how academics in Germany, Austria, and Switzerland, practice and understand the communication of science.

A recent topic is that of shared mental models, already mentioned [38]. An interesting contribution is that of Jandre van Rensburg and collaborators [52] that underlines the importance of these mental models shared in certain contexts. In order to consolidate the work carried out, they prepare a five-dimensional scale that allows the measure and comparison of various shared mental models. Another work of interest is that of Ronal Singh and collaborators [53], who present a detailed analysis of the case of a work team that performs interdependent tasks. They elaborate a multiagent system that allows channeling tasks efficiently. Nor have these models been applied in some way to autism.

5. Autism Not-Mental Models

Already in relation to autism, a series of not-mental models of different nature have been developed. Regarding its monitoring and treatment [54], the Lovaas model is mentioned mainly at the University of California Los Angeles UCLA, which contains a detailed protocol to be followed by autistic children, parents, doctors, and pedagogues, with interesting results. Besides, the Early Start Denver model (ESDM) [55] developed at the University of Colorado, University of Washington, and the MIND Institute of the University of California in Davis, is a very detailed model that includes evaluation activities, and treatment, or improvement; and finally, the one used in The New England Center for Children, which has provided important help to autistic children for more than 40 years.

Another interesting model is SCERTS [56] that synthesizes, in an important way, other skills-based approaches or relationship development. It also provides a frame of reference to improve communication and socio-emotional skills in autistic children. Betty Williams and Randy Williams [57], also using models of the applied analysis of autistic children, have made an important contribution to the subject.

From a psychiatric point of view, we must mention the contribution of William McKinney [58] who, in addition to establishing the basis and justification of a new comparative psychiatry, focuses on the elaboration of animal models, for various types of disorders; these include affection, anxiety, schizophrenia, and alcoholism disorders. He analyzes the future of animal models and the development of their basic science, even recognizing the limits that this topic presents.

Another important work is the neuronal network model of autism learning, prepared by Ira Cohen [59], based on neuropathological research suggesting that the autistic people have, or very few or too many connections in different several brain areas. The model generates verifiable hypotheses about the understanding, treatment, and phenomenology of autism. Within this line of scientific models applied to autism, the work of Arthi Kannappan and collaborators [60] that use fuzzy cognitive maps is to predict autism.

It is interesting to know the existence of these non-mental models of autism, because it is possible to think of a possible future connection of our mental model with models such as Lovaas. The cooperation of both could be beneficial for everyone.

6. Autism Mental Models

In the usual case of learning, the mental models that interest are those of the expert; the student must settle for those models. The apprentice must try to reach those models to become an expert. In autism, the role of an expert is played by the normal child without autism, which performs a series of actions that he has instinctively learned, whose mental models we cannot extract.

On the other hand, in the case of the autistic child, his/her mental model contains all the imperfections, and actions that he/she does not know how to execute, or that performs them awkwardly; it also contains the affective states associated with these difficulties, and their most important characteristics. That is why in the latter case, his/her mental model is essential, because it shows all his/her limitations, which can be very varied. These details can then help to establish techniques or strategies to get the improvement of his/her learning.

6.1. Previous Considerations

The elaboration of a mental model of an ASD patient requires taking into account a series of previous considerations.

First, the ASD manifests itself in a very diverse way. Typically, it occurs during the first three years of childhood and has an impact on the possibilities of communication and interaction of a person with his peers. ASD is a complex neurological and development disorder. Their signs include possible inabilities or learning difficulties: Dyslexia, Dyscalculia, Dysgraphia, Nonverbal Learning Disability, Visual Processing Disorder, Dyspraxia, CAPD (Central Auditorly Processing Disorder), ADD or ADHD (Attention Deficit Disorder).

However, it can also present other disorders, due to comorbidity, such as bipolar disorder, Aphasia/Dysphasia. The main causes of these learning disabilities are family inheritance, possible diseases during and after birth, tensions of different types in childhood, such as head injuries, high fever, or nutritional deficit, and comorbidity, or the propensity that children with other syndromes more easily acquire these disabilities.

Secondly, it is necessary to take into account the signs or symptoms that these syndromes present in children with autism, which have been widely referenced in specialized literature; the symptoms of autism vary over the years [61].

7. Autism: New Fuzzy Affective Mental Model

Next we will detail the new conceptual fuzzy and affective model of autism that we propose. It will serve as a guideline to obtain the specific model of each child, which includes his/her particular deficiencies, its intensities or severity, frequencies, and associated affective states.

This model becomes a child's mental radiography as clearly as possible, so that each present deficiency and its intensity can later be addressed, and try to compensate with relevant measures. That important issue will not be considered in this article. The mental model goes further than the diagnosis. For the latter, it is enough, according to the DSM-V [62], that is found:

a) Permanent deficits in socializing and interacting in a wide variety of contexts.
b) Iterative samples of restricted behavior, attentiveness or activities manifested in at least two contexts.
c) These symptoms must be present in the first stage of development.
d) These symptoms cause distancing in one or more areas of the usual functioning.
e) These perturbations do not seem to be best explained by an intellectual or general developmental problem.

On the other hand, the mental model needs to take into account all the child's deficiencies and their characteristics and intensities, in order to be compensated with the appropriate techniques. Besides, the mental model gives great importance to the affective states of the autistic child, as manifested in deficiencies, taking into account its importance for learning. That is why its link with a certain affective state is analyzed for each deficiency, and also the intensity of this link. This will allow to provide emotional and cognitive aids to improve learning deficiencies.

7.1. List of Deficiencies

It is not possible to elaborate a universal fuzzy model with a specific set of learning deficiencies, since they change with the age of the autistic child, and in each specific case they can present unique characteristics or details. However, a list of general and concrete deficiencies is then facilitated, which can guide to expand, detail, or specify them, in each particular case.

The initial list of deficiencies has been divided into the following families: 1) affective or emotional, 2) verbal and language comprehension, 3) monitoring of visual objects, 4) attention and response to basic sounds, 5) other social behaviors, 6) combined tests and deficiencies, 7) group behaviors. Each family must include specific and concrete deficiencies, not general, to better reflect the particular conditions of the autistic child. Some of these deficiencies may belong to several families according to their characteristics present in the autistic child, or clearly decompose in several of them. The detail of the families is as follows:

Family 1: affective or emotional

1- Inability to concentrate.
2- Tendency to get distracted.
3- Alternative feelings of euphoria/optimism and sadness.
4- Feelings of anxiety or hopelessness.
5- Indifference to pain.
6- Suicide thoughts.
7- Do not seek comfort in difficult times.
8- Possibility of severe suffering due to minor changes in the environment or over time.
9- Fast discourse, racing thoughts, agitation, greater physical activity, irritability.
10- Recklessness, difficulty sleeping, and appetite disturbances.
11- Failures to recognize the presence of other people or their emotions.
12- Extreme irritability.

Family 2: verbal and language comprehension

1- Problems or difficulties on the communication of desires or needs.
2- Difficulty in remembering sequences or numbers or spelling of words.
3- Invert or misread letters, words, and numbers, when reading or writing, unfinished words.
4- 4 Problems of understanding and repetition of various sentences, depending on difficulty, age, etc.
5- Problems of understanding of certain words and what is said.
6- Leave long readings.
7- Grammar problems.
8- Capacity to follow a short story and memorize it.
9- Difficulty learning songs and rhymes.
10- Delay to speak.
11- Short conversations and questions.
12- Pronounce words aloud while writing.
13- Trouble copying notes or identifying changes in classroom displays, signs or notices, omitting words or lines while reading.
14- Difficulties with expressions, verbs and actions.
15- Difficulties with reading comprehension or memorizing information during silent reading, especially when combined with strong verbal skills and listening comprehension.

Family 3: visual objects monitoring

Researchers have determined eight different types of visual processing disorders, which affect various abilities and present their own challenges. The types of visual processing problems are as follows: a) visual discrimination; b) optical sequencing; c) visual figure-ground differentiation; d) pictorial memory; e) visual-spatial relation; f) visual closing; g) letter and symbol reversal; h) visual-motor processing. Among them, it is possible to quote the following disabilities:

1- Often rubbing the eyes or complaining of visual fatigue.
2- Difficulty focusing on visual tasks or being disrupted by visual information.
3- Difficulty in seeing a form or image in a background.
4- Affective scenes with objects to aim in videos or not.
5- Difficulty in writing or color within the lines.
6- Disgust for writing or drawing.
7- Show a disinterested in movies, television or videos presentations.
8- Be clumsy or run into things.
9- Obsessive attachment to items that appear on the display: keys, rubber bands, switches, etc.
10- Difficulty in the visual discrimination of letters, forms, patterns or objects.
11- Difficulty in the visual sequencing of letters, numbers, words, symbols or images.
12- Difficulty seeing where objects are located in space, either relative to themselves or to other entities.
13- Problems involving tracking objects (animal, geometric, images of cars, cyclists, motorcyclist) moving with different strength, color, path and velocity, with or without sounding accompaniment, with or without a pedagogical agent.
14- Difficulty understanding distances, reading maps, estimating time, or imagining the relation between objects described in a written or oral narrative.
15- Difficulty identifying the light points with various specifications: light intensity, color, velocity, path, and its modifications, and running time.

Family 4: attention and response to basic sounds

1- Difficulty responding to sounds, which can be pure, identical repeating tones, simple melodies, and special sounds through keyboard with drums or noise, etc.
2- Difficulty in remembering oral instructions.
3- Possible repetition of the response to the presentation of new items (pedagogical agents, sounds, etc.).
4- Distracted by noise.
5- Possible answer to a certain element unrelated to the test.
6- Difficulty in following the instructions in a series.

Family 5: other social behaviors

1- Self-injurious behavior.
2- Atypical eating behavior: excessive food selectivity.
3- Restricted interests that are abnormally intense or focused (attachment to objects, excessively narrow or worrying interests).
4- Restricted and repetitive interests of behavior, or activities.
5- Learning social rules: dressing, responding events, etc.
6- Inflexibility on routines, repetitive patterns of behavior, or strong resistance to change (insistence on the same driving route, repetitive questioning or extreme anguish to small changes).
7- Abnormal sleep patterns: difficulty-reconciling sleep. Wake up frequently, and wake up early in the morning.
8- Agressions.
9- Proper use and understanding of nonverbal communication (visual contact, facial expressions, gestures, body language, combination of verbal and nonverbal efforts).
10- Tantrums.
11- Excessive or under reactivity to an unusual interest in the sensory entries of the environment (pain/heat/cold, sounds or texturing, odors, or touch of objects, Light bothered or rotating objects).
12- Socio-emotional reciprocity (share interest or emotions, point objects, start social situations, round trip conversation).
13- Allow and maintain typical social relations of age (showing interest in others, share imaginative game, adjusting the behavior to coincide with situations).
14- Repetitive session, motor movements or use of objects (hand flapping, echolalia, not functional use of objects).

Family 6: combined tests and deficiencies

1- Difference in memorization of what they have seen or read, whether in the short or long term.
2- Use of capital letters and punctuation.
3- Capacity to follow an interview.
4- Capacity to follow a short story and memorize it
5- Ability to read aloud.
6- Capacity to count coins, invoices, and give change.
7- Weak mathematical skills, confused mathematical signs and symbols, or omitted steps in resolution of equations
8- Bad writing.
9- Capacity to know and differentiate symbols, and operations.
10- Spatio-temporal deficit.
11- Capacity to know positive, negative numbers and fractions.
12- Capacity to estimate the duration of time, start time, and end of time.
13- Difficulty in recognizing objects or familiar words, when they are only partially visible.

Family 7: group behaviors

1- Complete the work as quickly as possible only to finish it.
2- Say that the work is too difficult.
3- Change places often.
4- Do and maintain typical social relationships of age (show interest in others, share imaginative games, and adjust behavior with small changes to fit in situations).
5- Refuse to follow-up the teacher's instructions.
6- Leave an activity or task.
7- Use and understand nonverbal communication (visual contact, facial expressions, gestures, body language, combination of verbal and nonverbal effort).
8- Do not want to go to school.
9- Socio-emotional reciprocity (share interest or emotions, point objects, start social situations, round trip conversation).
10- Refuse to work at school or put resistance to homework.

7.2. Elements Associated with Each Deficiency

Each deficiency has a fuzzy set associated (Table 1), with the following elements:

1- Severity or intensity. Detailed by a number that belongs to the whole [0, 1].
2- Frequency with which that deficiency appears. A number that belongs to the set [0, 1] marks it.
3- The most frequent emotional state associated. It is determined, first by the number of the emotional state that appears in Family 1.
4- A real number that belongs to the whole [0.1], which shows the intensity of this association.

As an example, the following description of the space-temporal deficit can be shown:

Space-temporal deficit (it is the deficiency), with the associated fuzzy set: [**0.25** (its intensity is weak), **0.75** (its frequency is important), **2** (the most frequent associated state is the tendency to be distracted), **0.75** (this association is intense)].

Table 1. The associated fuzzy set of each element of deficiency

Elements	The associated fuzzy set			
Intensity of the deficiency	[0, 0.25] (weak)	[0.25, 0.5] (medium)	[0.5, 0.75] (important)	[0.75, 1] (very important)
Frequency of the deficiency	[0, 0.25] (weak)	[0.25, 0.5] (medium)	[0.5, 0.75] (important)	[0.75, 1] (very important)
The most frequent emotional state associated	It is determined by the number of the emotional state that appears in **Family 1** at the list of deficiencies above.			
The intensity of association	[0, 0.25] (light)	[0.25, 0.5] (medium intense)	[0.5, 0.75] (intense)	[0.75, 1] (very intense)

8. Obtaining the Fuzzy Mental Model

Before obtaining the autistic fuzzy mental model, the child's diagnosis is done; usually, it includes a study of the progress of a group of students to identify learning problems.

In addition, a medical examination is usually carried out, including a neurological one, to eliminate other possible sources of the child's troubles. The child's social contact, and school development, his/her family history, and possible academic and psychological evidence are also reviewed. Therefore, in addition to the collaboration of medical and psychology professionals, this fuzzy mental model requires a very varied collection of appropriate tests to determine all the elements of the model.

For this purpose, we have developed the KASP [63] methodology, already tested and used, which allows the elaboration of these tests, based on the theory of serious games. Serious game is understood by any game whose primary objective is not mere entertainment. Its potential is very important, given the effect that emotions have on learning, recognized today throughout the world. However, there is an important academic literature on the nature, composition and effects of these serious games.

This methodology provides an evaluation technique of learning deficiencies in autistic children that allows measuring the degree of assimilation of a concept by a preschool child; it has important advantages, such as the identification of strategies for continuous learning.

An important collection of serious games has been designed with KASP methodology. They cover all deficiencies included in the seven families of the model. They are divided into two categories: the first one allows the basic discovery of deficiencies, while the second one permits to deep in the problem showing all its details, intensities, features, and the degree of assimilation of concepts by means of its evaluation technique. That way learning problems can be valued and studied in depth, including their evolution. The games are shown on a computer so that the child can see moving objects and colors of the game, as well as sounds.

Obtaining the mental model goes through the following stages:

1- By means of the serious games of the first category or the diagnosis, several important deficiencies are discovered.
2- The serious games of the first category are used to discover new learning problems.
3- The games of the second category are used to deep into the problems found in 1. Obtaining their intensities, severities, and related affective states.
4- The games of the second category are used to deep into the problems found in 2. Obtaining their intensities, severities, and related affective states.
5- Elaboration of the fuzzy cognitive map (Figure 1).

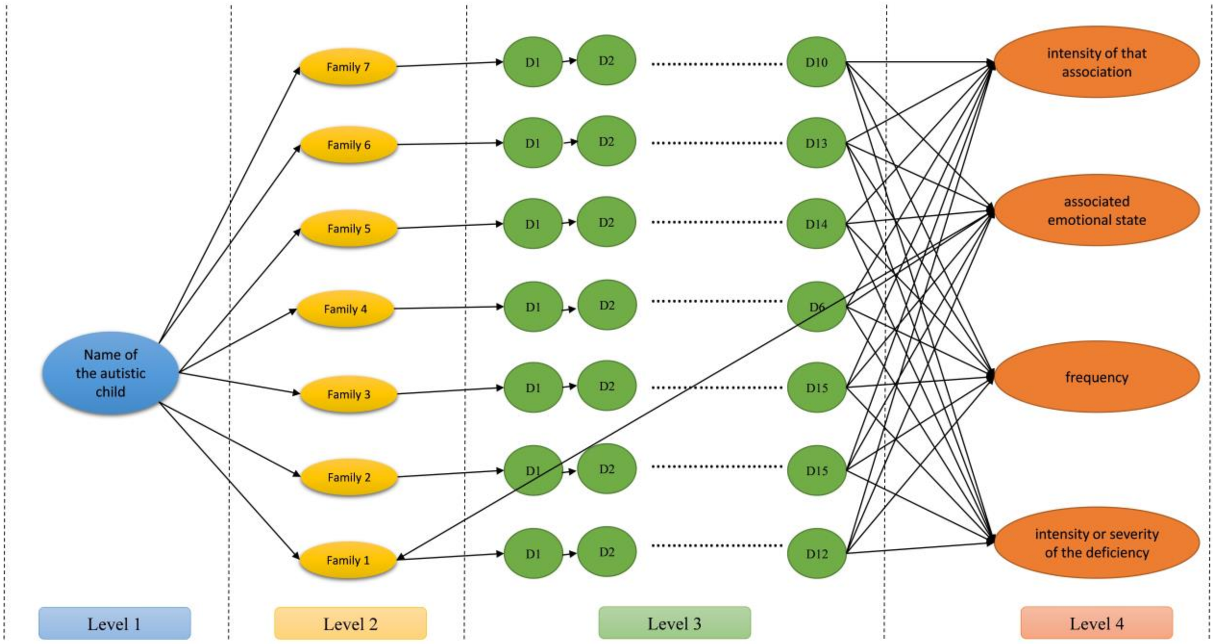

Figure 1. Detail of the fuzzy cognitive map

9. Formalization of the Autism Fuzzy Mental Model

The described mental model can be formalized as a fuzzy cognitive map or fuzzy graph, which is described (Fig. 1) by its levels:

Level 1: Name of the autistic child, date of birth.

Level 2: Families of deficiencies: the seven described above.

Level 3: List of deficiencies included in each family: those described above.

Level 4: For each deficiency, the associated fuzzy set already stated is included; it is formed by: intensity or severity of the deficiency, frequency, associated emotional state, and intensity of that association.

The arches of the fuzzy graph that unite the deficiency with these elements of the fuzzy set have associated the numbers that detail that severity, frequency, associated emotional state, and intensity of that association.(Figure1)

10. Conclusions

The description of the work done allows the following conclusions:

1) Autism is a syndrome that deserves important attention, not only for its broad personal, family, and social consequences, but for its growing development, which seems not to stop at the moment.
2) 2)-Until the present, much attention has been dedicated to the study of its symptoms, and its diagnosis. The existing literature permits these tasks with enough precision, but other elements are still unknown.
3) Among them are the mental models of autism, which constitute a step beyond diagnosis, since they become a radiography of all the child's mental problems and deficiencies related to ASD.
4) With the help of the KASP methodology for the elaboration of serious games as tests, an affective-fuzzy mental model of the child with ASD has been developed. The methodology provides a specific evaluation of the degree of assimilation of concepts. It is not possible to develop a unique model, given the variety of cases with ASD and its changing characteristics with age. That is why the mental model proposed can be updated, detailed, or developed to the extent that it is needed. This does not alterthe practical procedure to obtain it. The mental model considers with care, and shows, the affective problems associated to these learning deficiencies. It can be obtained by any other methodology able to develop enough tests to know and evaluate each learning deficiency.
5) The mental model includes fuzzy or uncertain concepts; it can be reasoned with them by means of the fuzzy logic.
6) With this mental model, it will be possible to provide concrete aids for learning, developing serious games that require low levels of concentration or learning, and then producing other games that are gradually increasing those levels. This learning will be reflected in the evolution of the child's mental model that can be obtained at any time.
7) The limitations that the developed mental model shows may come from the fact that the collection of serious games, or the set of tests to be developed, is not complete enough to be able to determine all the existing mental problems in all their intensity.
8) For the time being, the mental model developed is exclusive to autism, and its extension to other syndromes or diseases is not contemplated.

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