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Heuristics for User Interface Design in the Context of Cognitive Styles of Learning and Attention Deficit Disorder

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Additional information is available at the end of the chapter

1. Introduction

Several companies and institutions now realize knowledge as an active relavant for the market organization differentiation. This scenario explains the need for systems that assist the user in the acquisition process and knowledge management. Intelligent systems, known as expert systems (ES) [19] serve to this purpose in the extent that they have signed as facilitators in this process. These are systems that are based on expert knowledge, on any subject, in order to emulate human expertise in the specific field. To obtain this knowledge, the knowledge engineers, also called software engineers, need to develop methodologies for intelligent systems. In this area there is still no unified methodology that provides effective methods, notations and tools to aid in development. Among the most used technologies we can mention: KADS [10], MIKE [2] and Protégé [8]. KADS is a structured way of developing these systems that provides a special focus on the characteristics and problems of development of the SE. KADS uses the waterfall model as a basis to guide the development and adds refinement stages of use and knowledge [10]. Moreover, the MIKE methodology (Model-Based and Incremental Knowledge Engineering) makes use of formal specification and semi-formal techniques during the incremental development of the system. The phases of this model are four (Figure 1), being the first, knowledge acquisition, made in a cyclic manner between the subphases of task analysis, model construction and evolution. After the acquisition phase, the design, implementation and evolution are cyclical until the system is built.

It is an approach to build domain ontologies and includes the notion of a library of reusable problem-solving methods (PSMs) that perform tasks. In PROTÉGÉ-II, PSM are decomposable into subtasks. Other methods, sometimes called sub methods, can perform these subtasks. Primitive methods that cannot be decomposed further are called mechanisms. This decomposition is made to allow the reuse of knowledge, an essential part of the methodology. The choice of which method is suitable for the development of an intelligent system is essential, given the complexity of systems in the field of artificial intelligence (AI). It is important to define a process that systematizes the life cycle, allowing a greater skill in eliciting and models description. In this work, it was elaborated a guide for knowledge acquisition based on ontologies [9] and applied to the extension of an expert system of recommendations (guidelines) for designing human-computer interfaces.
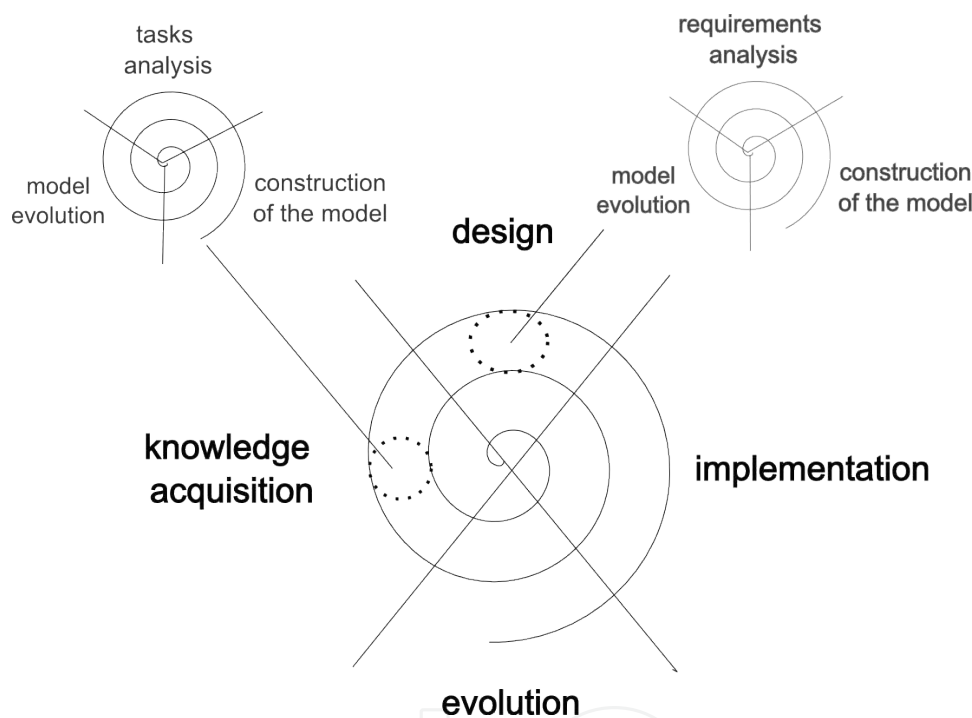

Figure 1. Stages of knowledge acquisition, design, implementation and evolution from MIKE.

This expert system called GuideExpert was expanded to include recommendations about profiles of users with learning disorder (TA), attention deficit disorder / hyperactivity (ADD / H) and advices on cognitive learning styles (ECAS). The learning disorder is defined where individuals can not develop as expected in appropriate age scholl [22], on the other hand the deficit of attention disorder/ hyperactivity and impulsivity [1]. In turn, the cognitive learning styles represent a categorization of the cognition particularities with their respective skills [21]. There are several recommendations on how computer interfaces should be designed in order to attend, in a satisfactory way, users with learning disorders and different cognitive styles, among other features. Thus, the aim of incorporating this knowledge to the GuideExpert base needed the establishment of a process for knowledge acquisition which will be presented in the next section.

2. Knowledge acquisition for the new GuideExpert acquaintance

The GuideExpert system is an expert system developed to assist the designer of human-computer interfaces during the phases of design and evaluation of interfaces. The system consists of five elements: user interface, inference engine, working memory, knowledge base and database. Figure 2 shows the architecture of the expert system. Through a series of questions and screens, the system selects a series of recommendations (called guidelines) of experts in the field of interfaces. The GuideExpert in its first version consisted of three hundred and twenty six guidelines of elicited interfaces projects from various authors and experts in the field of interfaces. To search the knowledge base of the GuideExpert it was defined the meta-guidelines. They are concepts which embrace the guidelines according to the common characteristics and goals [6].
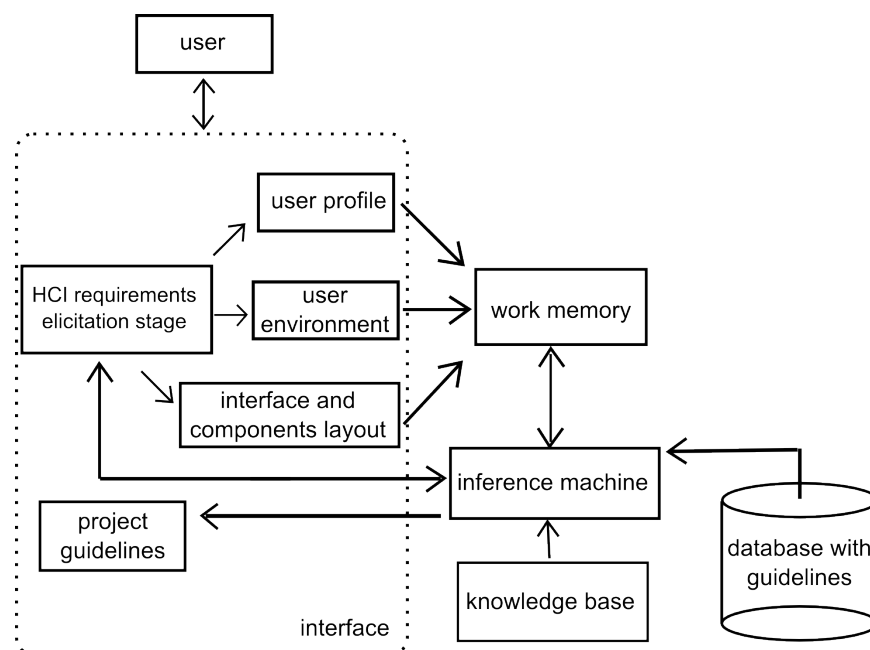
Figure 2. GuideExpert expert system

In the second phase of the project, it was seen the need to incorporate in the system, the guidelines relative to the diversity of user profiles. We identified several recommendations, heuristic and knowledge about adults, children, handicapped users, users with deficits of attention and etc. In order to make the knowledge acquisition in this domain it was elaborated a guide based on Ontologies. Ontology is a formal and explicit specification of a shared conceptualization [9]. The ontologies are used to structure and share the knowledge. They can be seen as the highest level in a hierarchy of knowledge composed of vocabularies, thesauri, taxonomies, ontologies and frames. A taxonomy is to classify information in a hierarchy (tree) with the generalization relationship "kind-of" (parent-child) [4].

The existence of a taxonomy in GuideExpert system, formed by the meta-guidelines, motivated the ontology conceptualization for projects in human-computer interfaces. For the cre-

ation of ontologies there are different methods belonging to the Ontological Engineering area. The goal of these methods is to provide tasks or steps to be followed in creating the ontology. Among the best known in litaratura we can mention: the method of Uschold [23], Horrocks [11], and Noy and McGuiness [14]. Uschold proposal called "Skeletal Methodology" uses scenarios to describe knowledge. Questions or types of questions are made primarily in order to specify the knowledge that is not being adequately addressed by the ontologies and that will be conceptualized through questions.

The Ian Horrocks method, is composed of the following phases:

- Determine how the world (domain) must function

- Determine domain classes and properties

- Determine domains and scopes (range) for this domain property

- Determine classes characteristics

- Add individual and relationships

- Iterate the steps until end the ontology conceptualization

- Specify an ontology

- Care if the ontology already exists

- Verify the consistency using a rationalization tool or inference motor

- Verify if classes are coherent

The Ian Horrocks method goes through the definition domain, the definition of classes, properties, etc. Another methods also start the creation of ontologies focusing on domains, classes and hierarchies, but though questionings. This is the case of the 101 method proposed by Natalya Noy and Mac Deborah McGuiness [14]. This method brings together recommendations and experiences using the tool for editing ontologies, Protégé 2000 [17], the Ontolingua language [16] and the tool Chimaera [5]. This methodology focuses on the Ontology conceptualization phase, divided into seven steps, which involves: definition of the ontology classes, storage of the classes in the hierarchy, defining properties and definition of the instances.

The steps that comprise the methodology proposed by Noy and McGuinness are [14]:

1. Determine the scope of the ontology: to determine the domain and scope it is suggested the following questions:

1.1 Which domain is desired to cover with the Ontology?

1.2 With which purpose the Ontology will be used?

1.3 For wich questions the Ontology mus provide answers?

1.4 Who is going to use and maintain the ontology?

2. Consider the reusing of another ontologies: is whether ontology exists and refine or extend the model to new domain or task.

3. Enumerate important terms of the ontology: is to define a list of the most common terms in the domain and the properties they possess:

3.1 Which are the terms that are desired to be included?

3.2 Which are the properties of these terms?

4. Define the classes and class hierarchy: is to determine the consistency of the class-subclass hierarchy, ie it should be noted that a class has more or less subclasses There are several strategies for defining the hierarchy: top-down, bottom-up or mixed.

5. Set the properties of the classes: it is to create some concepts in the hierarchy, and then their properties.

6. Set the values of properties (also called facets) is to describe the types of data (values), allowed values, domain, scope, minimum and maximum number (cardinality) for property values, and others.

7. Create instances: it consists in choosing the class for which you want to create instances filling the property values for each instance.

The method of Noy and McGuiness was adopted here in order to define concepts, properties and relationships for the domain knowledge of Human Computer Interface. Thus, we defined the classes and relationships of the knowledge of the system GuideExpert.

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2.1. GuideExpert Ontology

The Guidelines of the project of the GuideExpert were classified in a taxonomy consisting of 10 meta-guidelines, including: Feedback System, Data Protection, Documentation, interaction, presentation of data, Internationalization of interfaces, Colors, Terminology Interface, Design, and Assisting people with disabilities.

From this taxonomy, the ontology was defined, following the steps of the methodology proposed by Noy and McGuinness [14]. At the stage of conceptualization of theontology for the system GuideExpert it was elicited domain, objective information, users, tasks and resources, namely:

• Domain definition: concepts of human-computer interfaces;

• Definition of the main goal or purpose: create an ontology to guide the search for guidelines (recommendations) of project interface;

• Definition of informations about the ones that should provide answers: related to the concepts established on the metaguidelines.

- Definitions of the users: the potencial users of the ontologies are the engineers of the interfaces Human-Computer and learners of the development of interfaces projects.

- Definition of tasks: the main tasks held for the development of the ontologies consist in following the steps of the Noy and McGuiness methodology in this first step of the research.

- Definition of the resources: the resources needed for the development of the ontology are the computational tool to model the ontology and the language to formalize it. These steps will be developed in the next steps of the project.

Subsequently, based on the taxonomy, it was defined the classes and relationships. The main classes were expanded in most relationships and subclasses according to the recommendations of guidelines that exist in the system GuideExpert. Figure 3 shows the concept of class interaction with the relationships used (Table 1).
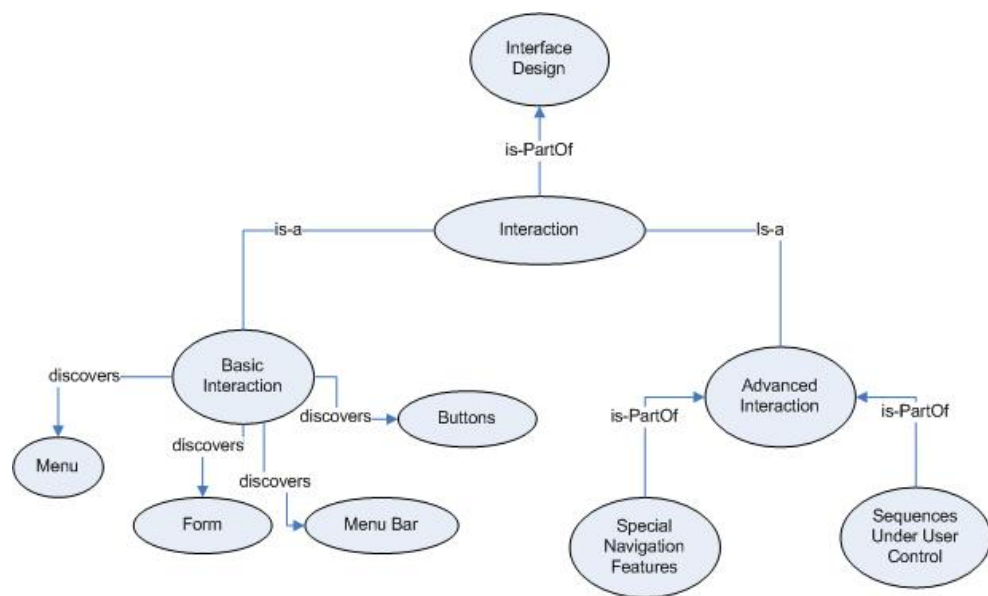
**Figure 3.** Diagram of the subclass interaction ontology.

Relationship	Meaning
Is-a	Indicates that one class is subclass of another.
s_PartOf	Indicates that one classe is part of another
hasValue	Indicates that one class obtain values from another class.
defines	Indicates that one class defines a determinate concept from another class
discovers	Indicates that a class discovers a determinate pattern by another class

Table 1. relationships dictionary

Once elicited the ontology, it was used for the acquisition of knowledge about the guidelines for user profiles. For each of the ontology classes it were surveyed authors and experts in the field of interfaces. Thus, it was possible to expand the taxonomy with more concepts and relationships. The method of eliciting followed, based on the ontology, was the following (Figure 4):

1.   Selecting of a class of the ontology of the GuideExpert.

2.   Elicit questions that can be answered by specialists.

3.   Make the acquisition of this knoweledge.

4.   If a new knoweledge if found, describe the class and add it to the ontology.
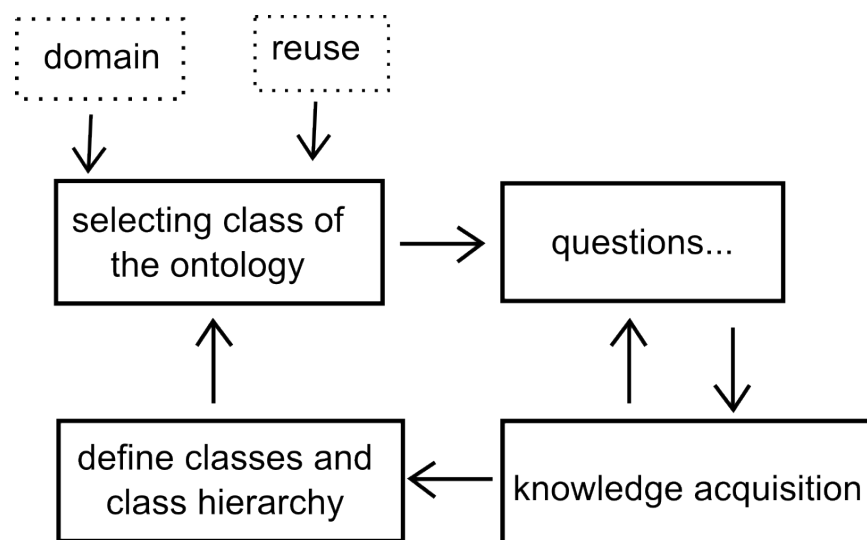
Figure 4. Knowledge acquisition process based on ontologies used in GuideExpert.

It was incorporated into the knowledge base of the GuideExpert, one hundred thirty six specific guidelines of the profile of users and special features such as: ADHD users, users with Analog Analytical cognitive style, etc.

3. Heuristics for user interface design in the context of cognitive styles of learning and attention deficit disorder

The user population is not a system composed of only one type of user. In general, there is a mixture of multiple profiles of users who need to somehow get their needs met [15].

Speaking of users interacting with computers, we refer to the user's knowledge that should be taken into account in the design of an IHC. Below are some features that must be observed during the interface design [12],[13],[20]:

- The presence of an internationalized system or used in more than one country or region. Each country or region has its own peculiarities. Dialects, cultures, ethnicities, races, etc. All these elements end up generating needs that to be satisfied;

- These characteristics are considered common in a traditional interface, may not correspond to those made for children. They have unique needs for their age. Beyond these specific needs for the children users the designers need to deal with the dangers that are usually present in a web environment, such as pornography and violent or racist content;

- The existence of elderly among the users should be checked for these and needs met;

People with special needs are another installment of the user community of the system and need adjustments in the system to operate in the environment without difficulty.

For the ECAs we used the basis of the research article: Project Tapejara from Souto [21]. The ECAs refer the subject's characteristic way of learning new concepts or even to generate elaborations of prior knowledge. According to Madeira, et al. (Bica et al., 2001), the ECAs are: Analogue-Analytical (AA), Concrete-Generic (CG), Deductive-Evaluative (DA), Relational-Synthetic (RS) and Synthetic-Evaluative (SA).

- Analogue-Analytical Style: using prior knowledge, seek information using standards of comparison. The information is analyzed in blocks. Performs elaborations relating the previously acquired knowledge and the new.

- Concrete-Generic Style: trying to understand the contents in a linear and sequential way; works with memorization through systematic exemplification. The individual is pragmatic and careful.

- Deductive-Evaluative Style: is systematic and critical, making analysis of the information. Does not consider concrtet examples. His work and attention are high.

- Relational-Synthetic Style: the individual better understands the information through pictures, colors, diagrams, etc. Has the ability to abstract hypotheses.

- Synthetic-Evaluative Style: by intercalation between the global view of data and its evaluation, seek to learn new information, analyzing them as a whole. They organize the study material, preferring theoretical material; they are systematic.

Souto [21] states that users having Analytic-Analog style "may require more time for learning, because when confronted with new information, tend to get a considerable depth on the subject, through intense".

Users having Concrete-Generic style, Souto [21] says that they "tend to be pragmatic and careful in their learning situation. The learning objectives, evaluation criteria and feedback must be clear to this style, because then he can work towards the goals".

Users having Deductive-Evaluative style "may come to disregard large number of concrete examples, when they believe they have already understood the logical pattern underlying the new information" [21].

Relational-Synthetic style users "tend to have ease of mind to work with images and appreciate the use of charts, diagrams and demonstrations. They are profecient in working with charts and mind maps" [21].

Synthetic-Evaluative style was not evaluated because "the subject of this class carryies features from the analytics, synthetics, and evaluative" [21].

In analysis of the cognitive styles of learning, this study concluded that:

- Analogue-Analytical style (AA): the user cares about the information in blocks, prefers everything organized. Regarding to the interfaces, it is more preferred that objective, organized, with infomation presented clearly, without many shades. These users prefer the basic colors, or colors worked according to the information and its importance.

- Concrete-Generic style (CG): colors should be worked upon the variations of the same color, ie, linearly, less elaborate, meeting the expectations of those who receive information and belongs to that kind of style.

- Deductive-Evaluative style (DE): the information may be indirect, can cause the user having to think to acquire information.

- Relational-Synthetic style (RS): users better understand the information presented through images, different colors, diagrams, etc. The own style is defined with the use of characters, colors and pictoric examples.

- Synthetic-Evaluative style (SE): the presentation is not what counts most, but the content. A presentation with plenty of written information is of utmost importance. Coherence and justification of the data determine how the user will engage with the text.

From the CLSs (Cognitive Learning Styles) studied, we found that it is extremely important to take into account the characteristics of each user in the construction of new interfaces for the computer. We must take into consideration the colors used in the construction of the interface, the way that the information must be displayed, directly or indirectly, if the interface must be objective or not, using figures. It was necessary to relate the CLSs with users suffering from Attention Deficit Disorder (ADD) or Attention Deficit Disorder with Hyperactivity (ADHD) because they are related to learning style and how each acquires knowledge.

The people with ADD and ADHD can not develop the scholar knowledge as expected for their ages. The diagnostic in the scholar age is common because in this period can be found the difficulties of attention and remain silent as the studies of Siqueira and Gusgel Giannetti [22], Rosa Neto and Poeta [18].

This research contributed to the GuideExpert tool incorporating new knowledge items to it, enabling the groups of users with different learning styles (CLSs) and users suffering from attention deficit disorder (ADD and ADHD) to obtain special guidelines.

Meta*GUIDELINES*	
9.13	**Volume/sound design**
9.14	**Mouse design**
9.15	**Keyboard design**
9.16	**Source design**
9.17	**Help design**
9.18	**Link design**
9.19	**Figure/image design**
10	**Assistance to people with disabilities**
10.3	**Asssitance to people having ADHD**
10.4	**Assistance to people having visual disabilities**
11	**User Types**
11.1	**Elderly Users**
11.2	**Children Users**
12	**CLS – Cognitive Learning Style**
12.1	**AA – (Analogue-Analytical)**
12.2	**DE – (Deductive-Evaluative)**
12.3	**RS – (Relational-Synthetic)**
12.4	**CG – (Concrete-Generic)**

Table 2. Augmented expert system taxonomy

```
R1: When carriers_ADD == child
      Then meta-guideline = help_add; user_child
R2: When carriers_ADD == elderly
      Then meta-guideline = help_add; user_elderly
```

Figure 5. Rule Knowledge Base - People with ADD - Children – Elderly

Eighteen new classes were created and added to the taxonomy, according to the surveys [3], [22] and [18]. The newly added metaguidelines are listed at Table 2

R1: When carriers _ADD == child
Then meta-guideline = help_add; user_child
R2: When carriers _ADD == elderly
Then meta-guideline = help_add; user_elderly
R3: When carriers _ADHD == child

R1: When carriers _ADD == child
Then meta-guideline = help_adhd; user_child
R4: When carriers _ADHD == elderly
Then meta-guideline = help_adhd; user_elderly
R5: When carriers _ colorblindness== child
Then meta-guideline = help_ colorblindness; user_child
R6: When carriers _ colorblindness == elderly
Then meta-guideline = help_ colorblindness; user_elderly
R7: When carriers_visual_impairment == child
Then meta-guideline = help_ visual_impairment; user_child
R8: When carriers _ visual_impairment == elderly
Then meta-guideline = help_ visual_impairment; user_elderly
R9: When carriers_special_need == child
Then meta-guideline = help_ special_need; user_child
R10: When carriers_ special_need == elderly
Then meta-guideline = help_special_need; user_elderly
R11: When eca_aa == child
Then meta-guideline = eca_aa; user_child
R12: When eca_aa == elderly
Then meta-guideline = eca_aa; user_elderly
R13: When eca_cg == child
Then meta-guideline = eca_cg; user_child
R14: When eca_cg == elderly
Then meta-guideline = eca_cg; user_elderly
R15: When eca_da == child
Then meta-guideline = eca_da; user_child
R16: When eca_da == elderly
Then meta-guideline = eca_da; user_elderly
R17: When eca_rs == child
Then meta-guideline = eca_rs; user_child
R18: When eca_rs == elderly
Then meta-guideline = eca_rs; user_elderly

Table 3. Rule Selection

The knowledge basis of GuideExpert consist in the "WHEN-THEN" rules. This study adds the 18 selected rules that were created according to the preview research to the base already built, and follow the same syntax as shown in Table 3.

GUIDELINES
1. Guideline: Use blinking displays 2-4 Hz with great care and in limited areas [1].
2. Guideline: Use up to three sources to draw attention [1].
3. Guideline: Use the inverse staining [1].
4. Guideline: Use up to four color standards [1].
5. Guideline: Use only two levels of intensity [1].
6. Guideline: Children approve the use of animations and sound [2].
7. Guideline: Avoid using scrolling for children [2]

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Figure 6. Guidelines - People with ADD - Children

Cognitive profile of learning

1. What would users prefer?
a. Exercises with figures?   ○ Yes   ○ No
b. Examples with figures?   ○ Yes   ○ No
c. Schemes with figures?   ○ Yes   ○ No
d. Do the user give   ○ Yes   ○ No
preference to textual
examples with figures?

Graphical Interface

2. Which objects you need guides?
○ Help   ○ Figures   ○ Message   ○ Keyboard
○ Button   ○ Graphs   ○ Menu   ○ Selector
○ Textfield   ○ Window   ○ Mouse   ○ Volume
○ Colors   ○ Link   ○ Table

Figure 7. Cognitive Learling Style elicitation.

As example is shown in Figure 5, the rule knowledge base for people with ADD related to children and elderly people. It was increased to the knowledge base tool.

For the construction of the selection rules we cross information of users of ECAs with ADD and ADHD disorders and other characteristics, we used the parameter age (child and adult). The resulting guidelines for the rule R1, for example, is shown in the Figure 6, which was selected set of guidelines for users with ADD and set of guidelines for user-child.

Figure 8. User Profile Analysis

Figure 9. HCI evaluation interface

We recommend changes to the GuideExpert interfaces because of the addition of new taxonomies. The changes were suggested in the items: task analysis (because it does not allow the user to choose the user "child" and also to choose the needs of the users); context analysis (new

items of graphical user interface were added); evaluation of interface design (new items of choices were added for the visual deficient, special needs, ADD, ADHD and others).

GuideExpert user interface was updated with new questions related to the cognitive learning style, as shown in Figure 7.

Figure 8 shows the elicitation of the difficulties. The question is if the user has some kind of need such as: ADD, ADHD, color blindness, visual impairment, other disabilities. The system also questions about the user's age (Figure 8, highlighted in red).

The other GuideExpert user interfaces that have changed refer to task analysis, where new items were added to the description of the GUI and interface evaluation. Options have been added to select among different profiles: child users, visually impaired, special needs, ADD, ADHD (Figure 9, highlighted in red). The screen shown in Figure 9 allows the Guide Expert system to select a series of recommendations to evaluate an interface. In order to allow this, the user must highlight the main features of the interface.

By extending GuideExpert it will be possible to specialize more and more recommendations; it will help the designer to automate a way of selecting guidelines that will guide the design or evaluation of interfaces.

4. Conclusions

It was observed during this study through the references related to the proposed theme, authors are conceptualized as Nielsen, Shneiderman and Plaisant, making several recommendations for building interfaces for children, elderly, etc. However, most of the recommendations deals with isolated aspects of the characteristics of users. It was noticed a large gap in this area in order to relate more than one feature. Given this problem, this study examined the learning styles and attentional deficits, allowing to generate a series of recommendations, guidelines, that fit the specific characteristics of the users profile. At the stage of acquisition of this new knowledge it was used as basis the class ontological description related to the content of the knowledge of GuideExpert. Following the methodology for ontology construction, it was made the acquisition of knowledge and conceptualization of new classes. Thus, a new taxonomy was added to the GuideExpert system together with the guidelines. The use of these recommendations helps the designer to interface with more knowledge giving the possibility to access them in an automated fashion and with various features, resulting in better recommendations and with best models specified by users.

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