Intuitive understanding of a modeling language

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ABSTRACT

The Human Cognitive Modeling Language (HCM-L) was developed for the Ambient Assisted Living (AAL) domain with the goal, to be easily understandable by future users: doctors, caregivers and even end-users themselves, i.e. anybody who needs help for successfully performing an activity. HCM-L is a lean modeling language with only a few concepts. The graphical notation was created considering principles for designing cognitively effective visual notations. This paper presents studies which tested the intuitive understandability of models that are formulated using this language.

CCS Concepts

• Software and its engineering → Context specific languages → Domain specific languages

• Computing methodologies → Modeling and simulation → Model development and analysis → Modeling methodologies

• Human-centered computing → Visualization → Visualization design and evaluation methods

• Human-centered computing → Collaborative and social computing

• Information systems → Information systems applications → Process control systems

Keywords

Ambient Assisted Living; Conceptual Modeling Method; Domain Specific Modeling Languages; Intuitive Understandability.

1. MOTIVATION

The use of Domain Specific Modeling Languages (DSMLs) has become popular within a variety of application fields [19]. This is mainly due to the fact that such languages come with a manageable set of concepts which, in addition, are tailored to the respective domain and thus should be easily to understand by domain experts like managers or clerks in a business, doctors and care givers or even patients in the health care domain. The usual objective of DSML development is thus supported, namely to better integrate domain experts into development processes, or to provide them a means for analyzing and assessing domain specific structures or processes.

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In contrast, understanding and employing general purpose modeling languages like the UML, as is usual, e.g., in software engineering, demands a considerable learning effort regarding syntax, semantics and methodology for effective use. This pays off when universal applicability and a wide range of generic concepts is needed. For domains like Active and Ambient Living (AAL) [1], however, such wide range may impede the efficient and effective use by non-experts who should be able to understand and validate models intuitively.

This paper deals with the intuitive understandability of models that are formulated in HCM-L [33], the Human Cognitive Modeling Language. HCM-L has been developed for the AAL domain with a particular focus on human behavior modeling and its related context. The research is part of the HBMS[1] (Human Behavior Monitoring and Support) project which aims at establishing a support system for older persons in order to extend their ability to live independently in their familiar home. A HCM-L model describes the everyday behavior (the activities of daily life [20]) of one particular person and is used by the HBMS system as a knowledge base for reasoning and providing support, in situations this person will need it [19]. The HBMS stakeholders are doctors, caregivers and even end-users themselves, so in fact anybody who needs help for successfully performing an activity. The HCM-L development was driven by the goal to allow for models that are understandable by such users. This paper presents the results of experiments we ran to assess the achievement of that target, i.e., the main focus was not to evaluate if HCM-L is easy to understand and learn for modelers. A previous evaluation of presentation alternatives for user-centered support has been published in [42].

The structure of the paper is as follows: Section 2 sketches the research method we applied for the given study. In section 3 we shortly discuss related work concerning Domain Specific Modeling Languages as well as basics on user-centeredness and intuitive understanding. Section 4 introduces the HCM-L by using the same example as was employed in the evaluation study. The study and its main results are presented in section 5. The paper closes with a short outlook on future research and with a list of references.

(optional) Self-Experiment

As one can test individual intuitive understandability of models easily for oneself, we suggest the reader to make a self-experiment and to perform the following steps:

1. Have a look at the figures in the appendix and write down on a sheet of paper what you think that these graphics and their elements mean. Answer the questions in table 1 (section 5.3).
2. Analyze the text of step 1: find the same or similar words of your text in table 2 and, for existing ones, mark the corresponding hypothesis as success candidate.
3. Check the answers of table 1 (step 2) with the correct results in table 2 and for correct ones, mark the hypothesis as success candidate.

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4. Compare the success candidates from step 3 and 4. A hypothesis with success in both steps indicates, that intuitive understandability is confirmed for at least this part of the model. Unsuccessful hypotheses are candidates for improvement.

If you are a modeling expert in any modeling language, the results may be distorted, as you know common modeling elements, structures and Boolean algebra. However, in this case, not successful hypotheses are candidates for a significant improvement.

2. RESEARCH METHOD

To test the intuitive understandability of HCM-L models we performed a qualitative study using a comprehensive graphical model example with a focus on behavioral aspects; advanced textual model elements like logical conditions and instructions were omitted. The study was divided into two parts: (1) a qualitative content analysis [27] of textual model descriptions provided by the test persons and (2) determining the percentage of correct answers to concrete model-related questions, and finding conclusions based hereon. Consequently, the reader will not find within this paper a statistic method with threshold values telling, when something is understood or not.

Figure 1 shows the basic setting: A model M (on MOF level 1 [37]) that is formulated and represented using the HCM-L (the metamodel defined on MOF level 2 is compared to what observers (the test persons) perceive [2]. As the "perceived model" p(M) is not directly accessible, the test persons are asked M-related questions to be answered in natural language resulting in a representation r(p(M)); this should allow to evaluate the correctness and completeness of their perceivings. I.e, we check the conformance

$$M \approx r(p(M)),$$

where "$\approx$" clearly (1) depends on the questions asked, and (2) could result in a measure based on correct, missing and wrong answers. However, we did not define such measure but restricted to the percentage of correct answers.

Basically, this approach follows Moody [35], where human graphical information processing is divided into two phases: perceptual processing (seeing) and cognitive processing (understanding). [35] reports on several empirical studies in software engineering that have confirmed that the visual form of notations significantly affects understanding especially by novices.

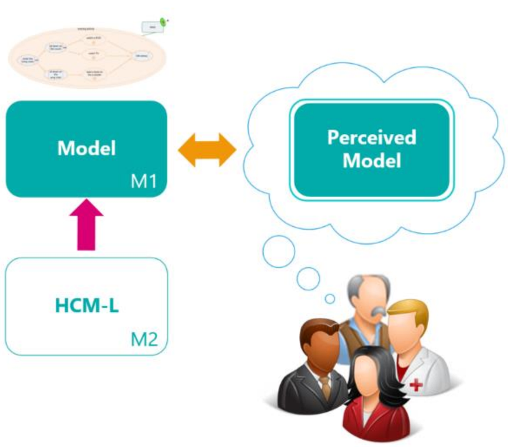

Figure 1. Model and Perceived Model

[2] Note that this is a kind of "linguistic perception" as introduced by Heinz von Förster [11], [12]

3. RELATED WORK

Domain Specific Modeling Languages allow describing relevant aspects of a Universe of Discourse (UoD) by concepts that are common in the respective domain. I.e., in contrast to general-purpose languages, domain concepts are embedded in the semantics of a DSML [29]. The Open Model Initiative (OMI [17]) encourages the development of domain specific modeling languages.

The syntax, semantics and notation of a DSML typically is defined based on a meta-model, represented on level 2 of the OMG Meta Object Faciliy MOF [37], and implemented using a meta-modeling platform like for instance ADOxx® [9]. Karagiannis and Kühn [18] mention, that in addition to language definition and implementation, a modeling procedure model including appropriate mechanisms and algorithms should be provided in order to establish a modeling method [34].

Human- (or User-) centered approaches are commonly known in the Human-Computer-Interaction domain [3]. In the modeling domain, e.g., [25] presented a user-centered approach for requirements engineering. User-centeredness can be seen as a multidimensional aspect including user focus, work-centeredness, user participation and system personalization [15]. This means, among others, that the development of a user-centered system has (1) to fit the needs and abilities of the individual user, (2) to exclude all internals of computer technology, (3) to ensure, that users actively participate in the development process, and (4) that the diversity of users is handled by adapting the system to the user during usage.

Besides reading, structural comprehension is needed for *understanding* the textual description in models (literal meaning, inferential meaning and evaluative meaning) [4], e.g., in order to identify a sequence of events [14]. As already showed by [23], using diagrams helps to improve human information processing.

Moody [35] identifies the following components of human graphical information processing: perceptual discrimination and configuration, attention management, the working memory (the known bottleneck) and the long-term memory. In addition, he presents nine principles for creating a cognitively effective visual notation: a language that follows these principles, should be understandable by the users, the language is created for.

Burton-Jones, Weber and Wand [7] provide guidelines for the evaluation of the 'performance' of conceptual modeling grammars for domain understanding before designing and programming an information system. [43] presents an analysis of different studies about human factors research on conceptual data modeling. [13] discusses several empirical studies comparing conceptual modeling techniques with the tasks to interpret or create diagrams and propose a theoretical framework for an empirical evaluation of grammars. [2] extend this framework and present a review of studies with entity-relationship vs. object-oriented modeling techniques.

Intuition refers to mental representations of facts that appear self-evident [8]. Intuitions are the result of personal experience, e.g., [10] for mathematical statements, or [40] for decision research in the management domain. Therefore, the notion of intuition cannot be defined in a way such that it is possible to decide whether a statement is intuitive or not. Intuition can be trained, as for example mathematical statements through teaching in schools or universities [8].

Intuitive understanding of models is crucial for building a user-centered knowledge based support system for any domain. Intuitive understanding is related to requirements enumerated in different frameworks for model quality: Batini et al. discuss it with the terms ‘readability’ and ‘self-explanation’ [5], Krogstie et al. call it ‘pragmatic quality’ [22] and Moody and Shanks name ‘simplicity’ and ‘understandability’ [36] as important aspects.

Subsequently in this paper, the term *intuitive understanding* is used in the sense that a person understands the semantics of a model (texts and structure) created using a given modeling language without further support.

It has been requested since long that a conceptual modeling language should be intuitively understandable for end-users, see e.g. [25]. Several related studies have been reported. A list of empirical investigations for comparing different notations with the focus on their *intuitiveness*, *understandability* and *complexity* can be found in [16]. To mention some of them: Peixoto et al. [38] compared BPMN and UML Activity Diagrams with respect to users without any prior experience. Sarshar and Loos [28] compared EPC and Petri Nets. Mendling, Reijers and Cardoso [41] presented an empirical research about the understanding of business processes in an EPC-like notation. Bennett et al. [6] carried out a survey and evaluation for tool supported understanding of reverse-engineered sequence diagrams. Recker and Dreiling [39] presented an explanatory study about understanding process modeling languages (EPC vs. BPMN).

4. THE MODELING LANGUAGE HCM-L

The domain specific modeling language HCM-L was developed for conceptualizing human behavior including all relevant context of one person in focus. HCM-L is a lean modeling language which serves to represent and reproduce episodic knowledge of a certain person without loss. The scope is limited to the episodic knowledge of a person (autobiographical events and contextual information) and is further restricted to activities, which should be supported by the HBMS-System. As the models are to be used as a knowledge base for support, the future users should be able to understand the models (a) to validate, if the right models were included, which means behavior a person wants to have supported, (b) to verify, if the models of a certain behavior were correct, and (c) to check the completeness, which means if all wanted behavioral tasks were modeled in the system.

HCM-L uses approved concepts from other modeling languages, but excludes concepts that are not relevant for the AAL-domain. The concepts were derived from analyzing the target AAL domain of (instrumental) activities of daily life [20] and their context [21]; the graphical notation considers the nine principles for designing cognitively effective visual notations [35]. In [26] a comprehensive control pattern-based analysis revealed, that all relevant semantics can be expressed using HCM-L when modeling activities, their hierarchies, and the relevant context information.

We introduce here the HCM-L using an example of human behavior: some sort of ‘leisure activities’ of a person in the evening, before he is falling asleep. In this example, Harold, a 70 year old man, can sit down on the wing chair and read a book on the e-reader, or he can sit down on the couch and either watch TV or watch a DVD. In each of this cases, he falls asleep after some minutes and therefore reaches his goal: to sleep.

Conceptual modeling usually starts with identifying and modeling relevant structural properties of a given Universe of Discourse, e.g., objects (classes), relationships (associations) and properties (attributes). Basic human abilities like to abstract and such master complexity are utilized for performing these tasks. Based on structural aspects, functional and dynamic aspects are modeled in a next step.

Conceptual modeling using HCM-L works the other way round: dynamics are in focus. As in activity theory [24] activities, actions and operations are the main concepts of human behavior. Following this idea, dynamic aspects – the observed behavior – are modeled first. Relevant structural aspects related to this behavior, i.e. its static “context”, are modeled afterwards.

As activities are in focus of support, creating a HCM-L model starts with these concepts: They are called ‘Behavioral Unit (BU)’ in our DSML. Figure 2 shows a BU ‘evening activity’. Each set of BUs is created for one person, as the support will be individually given for each person based on these models in the knowledge base.

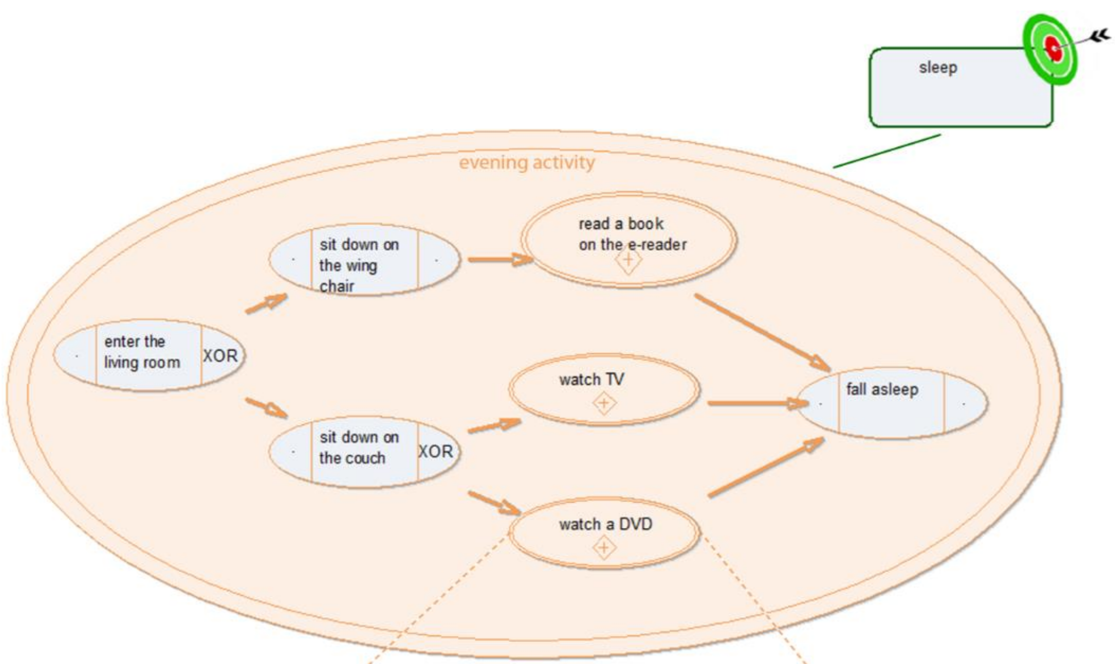

Figure 2. Example BU (Behavioral Unit) ‘evening activity’ with several Operations and a Goal

There is a sequence of actions to be completed to reach the goal for this activity. The actions are modeled with the HCM-L concept 'Operation' and the sequences is shown as they are linked by 'Flows'. To express that Operations are 'part of' the BU, they are graphically drawn inside a BU.

An operation without outgoing flow means that the BU's goal is reached, e.g., in Figure 3 'watch the film'. Alternative actions or possibilities for a free choice in ordering of several actions are expressed by Pre- and Post-Condition Expressions, i.e. they allow arbitrary granularity for the control flow (graphically simply by naming the logical operator, see AND or XOR in Figure 3).

HCM-L allows for hierarchical structures: 'watch a DVD' in Figure 3 is part of the BU 'evening activity' in Figure 2, and 'evening activity' may be part of a larger BU 'day routine'; as well, more detailed information about actions may be needed for support; e.g. a sequence of actions might be necessary to be able to 'watch TV'. Therefore, an operation can be a BU, too.

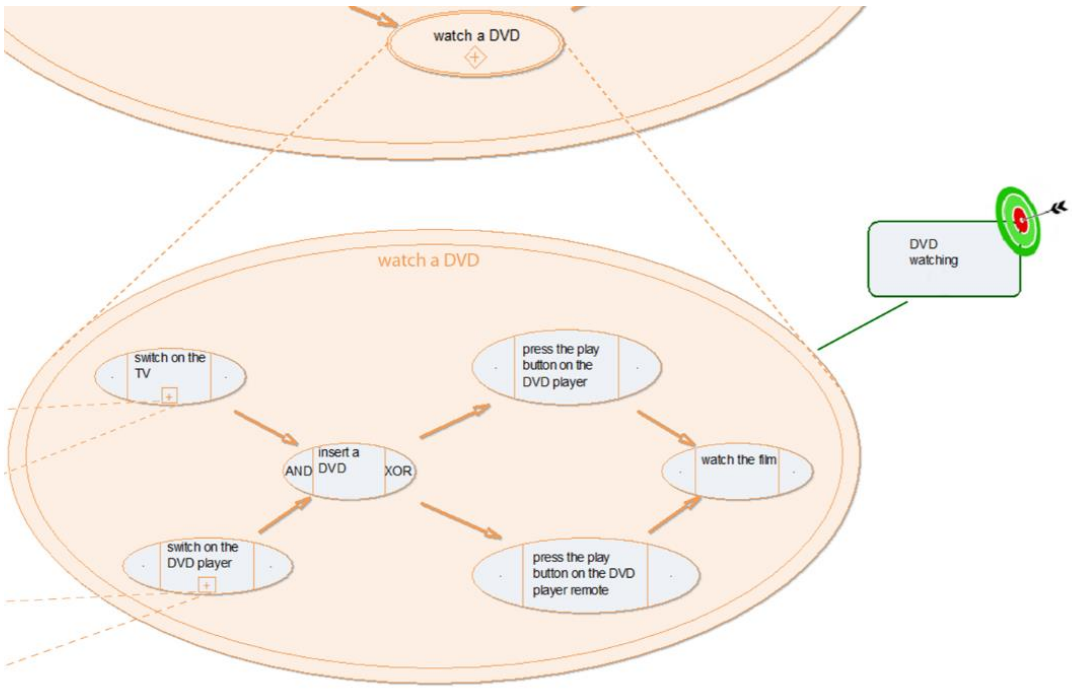

Figure 3. Example BU 'watch a DVD'

Several sequential operations of a BU can be summarized in a 'Makro'. It has no semantic meaning but can be used to simplify BUs. Figure 4 shows such 'Operation-Makro' elements: 'switch on the TV' and 'switch on the DVD player'. Instead of the 6 Operations (connected two times with the dotted lines), just two Operations are displayed in the BU, which helps to reduce complexity (see principle complexity management [35]).

Modeling structural, spatial, personal, social and temporal contexts additionally to behavioral information, increases the model entropy and therefore the amount of helpful support information. Taking the example from Figure 4: Knowing that the TV remote is in the bathroom, and the person wants to switch on the TV in the living room, it is clear that support information can be given by telling the person to get the remote from the bathroom first.

The different contexts are interrelated. Therefore, in accordance with the principle of cognitive integration [35], they have to be connected in a model as well. Therefore, we defined the following views to support mastering the complexity of the models:

(1) the already mentioned relation where the BUM "watch a DVD" in Figure 3 is part of the BUM "evening activity" in Figure 2,
(2) the "Structural Context" that covers personal and social information about a person, the resources needed for an operation and the surrounding where the behavior takes place,
(3) the "User Context" that integrates the Behavioral Unit Model and, per operation, the Structural Context; i.e., all the structural information like calling, executing and participating elements for each operation are modeled in the User Context.

The Task context provides an overview over all existing User Contexts saved in the modeling base.

These different contexts are presented as own model-types (and therefore own files) in the HCM-L Modeler [32], a modeling tool based on the meta-modeling platform ADOxx®. In HCM-L Modeler, Figure 2 is of model-type 'Behavioral Unit Model (BUM)'. The expansions of the two Operation-Makros (each three Operations) in Figure 4 are of the model-type 'Makro' in the HCM-L Modeler. There is a link between each Operation-Makro concept in the BUM and the resp. 'Makro'-file.

More detailed information about the HCM-L can be found in [33]. For an updated version of the structure of the context models see [30]. The HCM-L Modeling tool is freely available at: http://www.omilab.org/web/hcm-l/.

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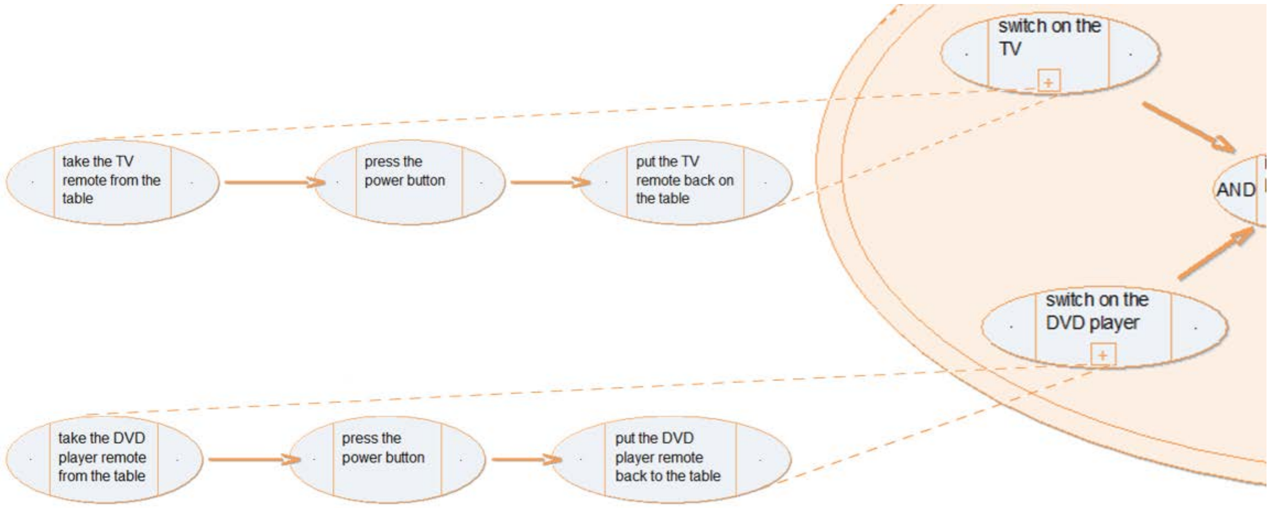

Figure 4. Expanded Operation Makros

5. EVALUATION

One of the key requirements of the HCM-L development was the intuitive understandability of HCM-L models by future users. Therefore, the evaluation aimed at testing the intuitive understandability of a concrete and sufficiently (w.r.t. the HCM-L concepts) comprehensive model by non experts. As has been pointed out in section 3, this includes assessing readability, self-explanation [5], and pragmatic quality [22], i.e. simplicity and understandability [36].

First results of a preliminary evaluation were already published in [32], for a detailed explanation of these results see [31]. In what follows we report on a more comprehensive and recent study. It was, apart from the design and development of the survey subjects, performed in three steps: a pre-test, and two experiments with analogous settings, which are subsequently named study 1 and 2. As these experiments were carried out in German with Austrian citizens, we translated the questions and results into English for this publication.

5.1 Hypothesis

Based on the chosen research method as outlined in section 2, we state the main research hypothesis: *A model created with the HCM-L is intuitively understandable by non experts, without learning the semantics of the concepts and the grammar of that modeling language.*

It is clear, that complex conditions and instructions of the language are and will stay only understandable by experts. Thus, they are not part of the hypothesis.

In particular, we tried to find out if persons are able to understand the following aspects in a model without previous explanations:

- (H-a) human behavior (activities) and several actions,
- (H-b1) sequences of actions that lead to (H-b2) a goal,
- (H-c) concrete actions connected with decisions and conditions,
- (H-d) that conditions are defined with logical operators,
- (H-e) that there exist hierarchies and sub steps,
- and that activities have a defined (H-f1) start and (H-f2) end action.

These aspects together constitute the hypothesis and, therefore, are used for the evaluation of the hypothesis: They were related with each category of the qualitative content analysis as well as with each question of the questionnaire. In a pre-test, the questions and the categories were checked and slightly revised.

In the context of HBMS we deal with models that reflect the everyday behavior (the "activities of daily life" [20]) of a person who is to be supported by the HBMS system. Consequently, this person as well as his/her potential caregivers, doctors etc. will be familiar with the modeling domain, independently of the concrete model chosen for an understandability check.

Following the framework for the empirical evaluation of conceptual modeling techniques proposed by [13] our study can be characterized as follows:

Variables:

- Content: Process models
- Grammar constructs: all relevant modeling concepts of HCM-L
- Nature of the comparison: intragrammar as only one grammar is under consideration
- Medium of content delivery: graphics on paper
- User characteristics: level of modeling expertise: non expert; level of domain expertise: expert
- Task: Interpretation / "reading"

Dimensions:

- Focus of observation: intuitive understandability

5.2 Participants

The studies had a sample size of 54: The participants of study 1 were first year students, 10 of Business Administration (group 1) and 14 of Informatics (group 2). The participants of study 2 were 30 Psychology students (group 3). Groups 1 and 2 had nearly no knowledge about conceptual modeling, group 3 absolutely no. The participants were chosen because they have the same characteristics as we expect from possible future users: they have a basic interest in technical systems but no or few knowledge about conceptual modeling.

5.3 Setting

The participants did not receive any information about the goal and hypothesis of the study, only about general settings. The study was anonymous but the three pages were numbered to know which pages fit together. It was performed in two parts (pages B and C, with questions) and was based on a diagram (page A) showing an instance of a HCM-L model with two BUs ('evening activity' and 'watch a DVD') and several operations (see appendix).

In a first phase, we showed them the diagram. They were asked to describe on page B as detailed as possible what this graphic was about:

"Describe in as much detail as possible, what these graphics and their elements mean. Please write down everything you think of."

After 15 minutes they got page C with a list of questions (see Table 1) and some statistical questions about their English skills, their previous knowledge in conceptual modeling and their relation to e.g., abstraction and mathematics.

In a pre-test the practicability of the study was evaluated and the formulation of some questions and categories slightly changed. Table 1 shows the final questions used in the studies as well as the correct answers of the questions. Question 6 also includes the numbering of the twelve Operations including the sub-steps (Operations in the related BU and both Operation-Macros) on the diagram.

Table 1. Questions and correct answers of page C

No.	Question	Answer
1	What is the first step of the shown actions?	Evening activity
2	What can a person do after entering the living room?	(either) sit down on the wing chair or sit down on the couch
3	Which goal has 'evening activity'?	sleep
4	Is it possible to perform the activities 'watch a DVD' and 'watch TV' in parallel?	no
5	Circle the element in the diagram, which is reached, if the goal is fulfilled.	Fall asleep
6	In how many steps is the goal of the 'evening activity' reached (a) without sub steps (b) with sub steps? Number the counted steps on page A.	(a) 4 (b) 12
7	What means the + at the element 'switch on the TV'? What is the difference to the + at the activity 'watch a DVD'?	In both: there are sub-steps + at the element 'switch on the TV': the sub-steps cannot exist alone + at the activity 'watch a DVD': the sub-steps are an own concept with an own goal

5.4 Main Results

The answers on page B were hand written texts between a half and one page. The qualitative content analysis was based on the occurrence of the aspects of the hypotheses and semantically similar words, which were categorized before the test, e.g., for identifying the 'end' (category end), phrases like 'as a result', 'leads to', 'ends in', 'end state', 'terminates', 'stops with' or the explicit mentioning of the last operation were counted.

Table 2 shows the results from study I (students of Business Administration and Informatics) and study II (students of Psychology). The majority of the participants mentioned a general description of the steps (actions), understands that the model shows activities and actions within a certain sequence and that a hierarchy exists. For the participants of study I it was clearer, that there is a start and endpoint, whereas this was mentioned by 50% and less of the participants of study 2.

Table 2. Results of graphic interpretation (Study 1 & 2)

Hyp.		Business Admin. Study 1	Informatics Study 1	Psychology Study 2	Sum (weighted)
	Description of the steps	100,0%	92,9%	60,0%	75,9%
	Mentioned in the text:				
H-a	Activities/Actions	90,0%	85,7%	87,0%	87,2%
H-b	Sequences	90,0%	92,9%	83,0%	86,9%
H-f1	Start	80,0%	64,3%	50,0%	59,3%
H-f2	End	100,0%	85,7%	37,0%	61,3%
H-c, H-d	XOR Semantics	90,0%	85,7%	60,0%	72,2%
H-c, H-d	AND Semantics	60,0%	57,1%	40,0%	48,1%
H-e	Hierarchies	70,0%	78,6%	57,0%	65,0%

Table 3. Correct question answering (Study 1 & 2)

Hyp.	Question	Business Admin. Study 1	Informatics Study 1	Psychology Study 2	Sum (weighted)
H-f1	1	100,0%	85,7%	100,0%	96,3%
H-c, H-d	2	100,0%	92,9%	100,0%	98,1%
H-b2	3	60,0%	64,3%	46,7%	53,7%
H-d	4	90,0%	92,9%	73,3%	81,5%
H-f2	5	70,0%	50,0%	66,7%	63,0%
H-e	6a	70,0%	50,0%	36,7%	46,3%
H-d, H-e	6b	0,0%	14,3%	10,0%	9,3%
H-e	7	50,0%	78,6%	33,3%	48,1%

The understanding of logical operators was mixed: the XOR semantics was understandable by the majority in both studies. In opposite to that, the AND semantics was not clear for or not mentioned by the participants.

As the answer of page B was free text, it is not clear, if the participants did not mention all aspects because it was a matter of course for them or because they do not get the concepts. Therefore, the hypotheses are checked altogether with the results of the questions of page C.

Table 3 shows that, except from finding out the sub-steps (questions 6a, 6b and 7), any other aspect was understood by a majority of the participants. The low percentage of question 6b relates mainly to the problem of capturing the meaning of the logical operators, especially of the AND as a pre-condition.

To summarize the results following the hypotheses, we can see that it was clear for the participants, that the diagram showed human behavior with actions and activities (H-a) which have a sequence (H-b1). That these actions lead to a goal (H-b2) seems to be clear for a slight majority. The incorrect answers of question 3 mentioned the last action of the BU instead of the goal.

That the actions are connected with conditions (H-c) was mentioned in the description of the steps of part B, but the terms were not explicitly used. There were differences is understanding the condition concepts: To comprehend the concept XOR (H-d) was better at asking a direct question in part C (98.1% and 81.5% in questions 2 and 4 to 72.2% in part B). Understanding the AND was not easy enough for the participants, as part B (48.1%) and question 6b (9.3%) showed.

To find out the sub steps (H-e) seemed to be not easy. In question 6 the wrong answers were mixed: they did not count the first and/or the last action and/or they counted alternative actions too. In question 7 nearly the majority realized, that the signs showed sub-steps, but a further explanation of the difference was not possible.

To find out the start (H-f1) and end (H-f2) resulted in higher positive results in part C than in part B, i.e., when asking a more concrete question. To find the start was simple, as 96.3% managed to do that in part C. To find the end action was also possible for 63% of the participants. All wrong answers referred in this case to the goal, which shows that this concept is not clear enough at the moment.

Figure 5 shows how confident the participants were at answering the questions listed in Table 1. This shows, that the participants were quite sure to have the right answers at the beginning, questions 6b and 7 are the only ones below 70%, but also on a high level related to the correctness of the answers.

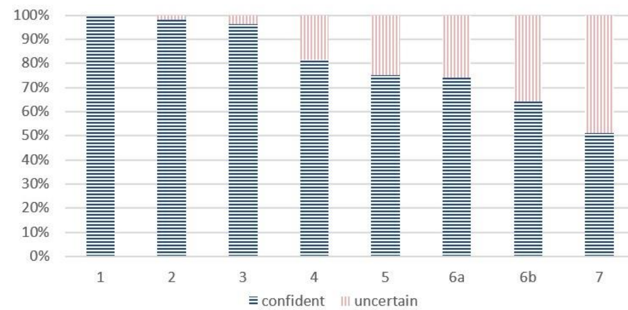

Figure 5. Confidence of the participants in answering the questions

All participants had at least basically English knowledge, to understand the texts of the model elements. 87% had at least basically interest in abstract ideas from, e.g., Mathematics.

6. CONCLUSIONS AND OUTLOOK

To summarize the studies, it turned out that most concepts and the main idea of the models were intuitively understandable by the participants, whereas there are still areas to focus further research on.

One might argue that the modeling domain targeted by the HCM-L is familiar to nearly everybody and thus easy to understand. However, when dealing with domain specific languages the potential addressees will be “domain experts” by nature, irrespective of whether the domain has a large or a small community. I.e., designing a DSML always addresses the understandability by domain experts.

The complexity of models corresponds to the complexity of matters in a domain. A DSML has to provide concepts and constructs to cover all relevant aspects of its target domain and to provide means for managing complexity. Matters in the domain targeted by HBMS, i.e. the support of activities of daily live, are of medium complexity. Consequently, HCM-L could be designed as a very lean nevertheless powerful language. This might have facilitated intuitive understandability but not automatically guaranteed.

To understand the conditions seemed to be a problem for several participants. One solution might be to step through the activities, to see what effect a condition has on the flow of execution. This might also be a good way to understand the concepts of sub steps. A first version of the 'Model Stepper' is already implemented [32], where it is possible to stepwise pass through a BUM. As a more formal expression of the condition language is still under development, the Stepper has to be improved after completion.

For a better intuitive understanding a redesign of the concept goal is under consideration. An own model-type for goal modeling would also improve the understanding of relations between the goals different BUMs as well as restrictions between them.

Another future prospect is to create a more intuitive representation for the structural context, which was not tested within the studies presented in this paper.

Finally, it would be worthwhile to investigate if the questions shown in table 1 could be generalized such that they could be used for evaluating the understandability of other process languages.

7. ACKNOWLEDGMENTS

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8. REFERENCES

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9. Appendix

Complete diagram of the study.