An Argument for More User-Centric Analysis of Modeling Languages' Visual Notation Quality

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Abstract. In this position paper we argue against the application of universal quality criteria for the visual notation of modeling languages. Instead, we make a point that (1) the cognitive capabilities that modelers have, and (2) the different cognitive requirements placed on them while modeling specific aspects (e.g., processes, goals, regulations) mean that a visual notation should be optimal for a specific modeling effort, and not a best-for-everyone solution. We clarify this point by giving an example of a modeling effort where this comes into play, and propose a research agenda that can set out to deal with these issues.

Keywords: Modeling language · Visual notation · Cognitive requirements

1 Introduction

Many modeling language notations are not as suitable for their users as they can be. One major component of that is the fit, or lack thereof, with their users' cognitive properties. As a result, elements of modeling languages may be difficult or outright counterintuitive for their (intended) users. On the one hand, sometimes a visual notation is too sparse in what it offers, causing its users to improvise and make up their own additional symbols and structures. On the other hand, sometimes a notation will offer so many different elements that it becomes difficult to still easily comprehend the models created with them – let alone knowing which notational elements to choose while modeling.

There is a large body of research focused on the comprehensibility of modeling language notations, analyzing and critiquing their quality from a variety of perspectives. This research is generally based on theories and frameworks that synthesize existing literature, best practices, and insights from other fields like cognitive science, semiotics, and interface design in order to arrive at a well-informed best practice for how a visual notation ought to be (re)designed. Earlier frameworks used for such improvements, like the Cognitive Dimensions of Notations [3], although widely used at some time, have been critiqued to lack scientific rigor [4], and were further developed into more well founded set of principles constituting a design theory for visual notations: Moody's "Physics of

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Notations" [4]. Moody's work has been actively used to analyze, critique and propose improvements to the visual notations of a number of modeling languages, including for example UML [6], i* [5], UCM [1], and BPMN [2].

2 The Modeler-Notation Mismatch

The systematic way in which this single, 'universal' theory for improving a visual notation has been applied to such a diverse amount of modeling language notations is problematic. Applying the same standards of quality to languages that are used for different purposes, capturing different aspects[1] is a practice that should be critically reflected on. By applying one theory and one set of quality criteria to the notations of all our modeling languages we essentially say that there is little difference in the quality criteria important for these modeling languages. But is that really the case? Should the quality of the notation used for, say, a UML class diagram giving a quick overview of the component structure of a web service be judged in the same way as the notation for a complex overview of an organization's total process structure in BPMN?

While there is ample work on model quality, also performed on specific languages [8,11] (albeit having much less interest on the notational quality), the focus on the person doing the modeling remains under researched. We see two points here that deserve more attention to determine whether a single theory to critique visual notations by is optimal:

1. Modeling efforts have different purposes and cognitive requirements

The creation of conceptual models is done to facilitate communication between stakeholders, capture (current) knowledge of a domain, to reason with those models about the domain, and so on [7]. While there are many other purposes as well such as the more practical modeling of (IT) solutions and their impact [12], creating a model that represents (some part of) a domain remains the major focus for most modeling efforts. If the purpose of a model is to communicate with other non-technical stakeholders (e.g., 'the business'), such models – if shown to them at all – should be as simple and understandable as possible. But when these models are used between experts to create a systematic mapping of all elements in a domain, or to create a comprehensive overview of the dynamics and interconnections between, for example, processes of a business, it stands to reason that the model can be more complicated. In this case the purpose of the models are clearly different. The *cognitive requirements*, that is, the mental skills and properties expected of their users to work with them correctly and easily is likely different, with the latter model demanding more abstraction capabilities. The requirements and quality criteria that we set for the visual notation used for these two modeling purposes should thus not automatically be the same, as the former model has to be much more forgiving than the latter.

[1] By different aspects of we mean different areas of modeling like process modeling, goal modeling, software architecture modeling, and so on.

2. Differences between (groups of) modelers themselves

Determining the quality criteria for how understandable a visual notation is purely on basis of the elements of the model and its notation (e.g., enforcing upper limits on shapes and colors, limiting complexity via the amount of elements shown) foregoes a major aspect of the modeling process: the people doing the modeling. Earlier research has shown that for model understandability personal factors have a stronger positive correlation than the properties of the model itself [10]. This means that even when a model is unclear, for instance the notation used for it is too vague or ambiguous, the model can still be understood fine depending on the person interpreting it. Indeed, Petre found that: “experts are capable of understanding even complex and poorly laid out diagrams” [9]. It has also been shown that people have different abstraction levels, which impacts their ability to model complicated domains or aspects (cf. [13,14]). Focusing purely on the intrinsic quality of the notation without involving the (cognitive differences) of their users then forfeits a major, perhaps primary component of understandability. Thus, not only the properties of a model and its notation, but also those of the users of the model should be taken into account when making claims about how understandable a notation is. As modeling different aspects and using them for different purposes likely place different *cognitive requirements* on their users, it stands to reason that being aware of their differences and cognitive capabilities becomes important.

Based on these arguments, it does not seem to make sense that the analysis and critiquing of the quality of a modeling language’s visual notation should be performed on a one-size-fits-all basis using one ‘optimal’ theory. Instead, a clearer understanding of the cognitive requirements placed upon modelers engaged in modeling different kinds of aspects, combined with an understanding of what (quality) aspects of a notation are most important to them should be achieved before anything else. After achieving such understandings, (re)designing optimal visual notations for modeling languages can then be done more in line with the actual cognitive requirements placed on their users.

3 An Example Modeling Effort

To motivate our idea we will give a fictional example of a modeling effort where we belief the quality criteria for the visual notations used should not be judged by the same standards.

A rather large, internationally operating business wants to stay up to date with the ever-changing business environment, new regulations placed upon it by local and international regulating bodies, in doing so optimizing how it works. Hopefully by doing so also maximizing its profits. The main product they offer to consumers is a complicated package of services and products say, of a pharmaceutical nature. Not wanting to simply experiment with how they do business by trial and error, their first step is to create a comprehensive Enterprise Model that captures all the important aspects of their organization, hopefully being able to use this model to make well informed business decisions with. They contract a company to do so, which sets out to map these different aspects. They model all their business processes (i.e., what they do) in BPMN, the exchanges between company and consumer where value is generated in e3Value, the strategic and tactical goals of the enterprise in i*, a number of other specialized aspects in equally as specialized modeling languages, and finally, a comprehensive integration in an EM language, say, ArchiMate.

The enterprise modelers start creating an overview of all the aspects, and quickly run into the point that some aspects of the business are more complicated than others. The process structure is complicated, but manageable as the main issue is simply the sheer number of processes to capture and interrelate, nonetheless managing to do so without to many inconsistencies. They then move on to capture the regulations the business needs to adhere to, for example in how many pharmaceutical objects they are allowed to sell to intermediaries per time unit, and so on. These models become quickly very complicated as they run into inconsistencies between national and international regulations, and as the legal advisors of the business inform them of ways to work around certain regulations but not others. Another team of modelers sets out to capture the value exchanges, which for this business were fairly straight forward, clearly generating value at points of sales, and generating value at points of exclusivity contracts, and so on. The different levels (and kinds of) complexities of these models made it so that for some aspects the modelers wanted to be able to use a great amount of visual elements, shapes, colors, and so on to clearly denote all the different elements in the domain, and to use even more visual markers for conflicting information in the regulation models.

Being experts in their field, the modelers who captured all the regulation information chose to extend the notation they used with additional symbols, just to be able to more accurately capture all the different elements. While this decreased the ease of reading of these models for non-experts, they quickly realized the business stakeholders preferred to be told *about* the models, instead of being shown them and asked to work with them. Thus, in the end the modelers decided to adapt the modeling languages they used to (perhaps) the limit of their cognitive abilities where it was necessary to do so, using some other languages as-is because the domain was not too demanding, and finally always communicated with the business using PowerPoint and pen and paper sketches[2]. When the business asked the enterprise modelers to translate their ideas and strategies for changes in the business into the model environment, the modelers did so, and convened the outcomes to them in more simplified models and natural language.

In this example, due to the different requirements placed upon modelers by the aspect they worked on (e.g., the complexity of regulations, the great amount of processes), they decided to adapt the notations they used to deal with them.

[2] While this is a fictional example, it is be backed up by the real-world practice of modeling. As evidenced by a quote from an ongoing series of interviews we are performing among Enterprise Architects: “The primary tool for communicating [with business people] is PowerPoint”.

The models whose purpose was to capture the information about a domain were accepted to be more complicated, because the modelers themselves could deal with it and translate it to more understandable explanations for business stakeholders. Thus, we strongly believe that efforts to optimize a modeling language's visual notation should be done in line with the requirements placed upon it by the specific *purpose of the modeling effort*, and by the *cognitive requirements* placed upon its users.

4 Research Agenda

We propose the following research agenda to deal with the issue we have presented and exemplified in this paper. The major aims are to have a stronger understanding of the personal differences between people in regards to how well they can still understand a model and use it, and whether such differences can perhaps be said to be specific to particular modeling efforts and domains. These tie into two hypotheses to be tested by investigating some research questions.

Hypothesis 1. *The quality criteria for the visual notations of different modeling efforts and aspects are not universal.*

We see the following questions contribute towards the testing of this hypothesis.

1. What quality criteria for the visual notation of a modeling language are most important to its users?
2. Does the creation and use of models of different aspects place different (levels of) cognitive requirements on its users?

The first would be investigated by using factor elicitation (i.e., Repertory Grid) and structured interviews with users of multiple modeling domains and efforts. The second question can be explored by using the Think-Aloud-Protocol for a number of modeling tasks of different aspects. In such a study participants would be asked to model a textual description, and to verbalize all their thoughts. Analysis of the recording of such sessions together with coding schema to determine the difficulty users verbalized would give a good approximation of the different levels of cognitive skill that users experienced.

Hypothesis 2. *The visual notation of a modeling language can be optimized for the modeling of a specific aspect with a specific purpose.*

The following question here contributes towards the testing of this hypothesis.

3. Given prior cognitive requirements for specific aspects, what is the optimal trade-off between complexity and usability for modeling a given aspect?

Investigating this research question relies on data elicited from the earlier research questions. If quality criteria are important to users, and different cognitive requirements from aspects are known, a design science approach with a strong focus on evaluation can then be taken. Several 'dialects' of the visual notation for a specific modeling language can be made and evaluated with users in to find a balance between how well the notation accommodates the modelers in their work, and how difficult the created models become to work with. This can be done through experiments, again using Think-Aloud-Protocol, where modelers are asked to capture the same domain in a number of different dialects, and coding of the recorded verbalizations are used to determine which dialect is most successful. As a result, a notation optimal for the specific aspect(s) and modelers involved should be found.

5 Concluding Outlook

We have argued that analyzing and critiquing the visual notation of modeling languages should not be done to a universal standard. We made a point that different aspects of a domain might place different (cognitive) requirements upon its users, and that users have different cognitive abilities in themselves. Visual notations should thus optimized for such specific modeling efforts. The research agenda we proposed can lead to changes in the way modeling languages are developed, as it could lead to guidelines for adapting the visual notations more closely to the needs of the domain and aspect the language is used for, as well as the people (envisioned) using the modeling language.

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