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Factors of process model comprehension—Findings from a series of experiments

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ABSTRACT

In order to make good decisions about the design of information systems, an essential skill is to understand process models of the business domain the system is intended to support. Yet, little knowledge to date has been established about the factors that affect how model users comprehend the content of process models. In this study, we use theories of semiotics and cognitive load to theorize how model and personal factors influence how model viewers comprehend the syntactical information of process models. We then report on a four-part series of experiments, in which we examined these factors. Our results show that additional semantical information impedes syntax comprehension, and that theoretical knowledge eases syntax comprehension. Modeling experience further contributes positively to comprehension efficiency, measured as the ratio of correct answers to the time taken to provide answers. We discuss implications for practice and research.

1. Introduction

In recent years, the documentation of business processes and the analysis and design of process-aware information systems has gained attention as a primary focus of modeling in information systems practice [10]. The so-called practice of process modeling has emerged as a key instrument to enable decision making in the context of the analysis and design of process-aware enterprise systems [11], service-oriented architectures [13], workflow operation [26] and web services [14] alike.

Process models typically capture in some graphical notation the tasks, events, states, and control flow logic that constitute a business process. Process models may also contain information regarding the data that is processed by the execution of tasks, which organizational and IT resources are involved, and potentially capture other artifacts such as external stakeholders and performance metrics, see e.g. Ref. [49].

Many benefits are associated with business process modeling. For instance, practitioners have identified process improvement, communication and shared understanding as the most important process modeling benefits [17]. A prerequisite for realizing these benefits, however, is that the quality of process models are perceived as good by their audience, making the *understandability of process models* an important topic for research relevant to all potential uses of process models [2]. Several studies support this view. For instance, the perceived quality of a process model is a key factor contributing to organizational re-design project success [21]. Accordingly, our interest in this paper is to examine how analysts develop an understanding of process models.

More specifically, we study (a) factors characterizing the process model in terms of the activity labels used in the models, (b) factors characterizing the person interpreting the models in terms of relevant modeling expertise, and (c) how these factors affect process model comprehension. The relevance of this research stems from companies making significant investments in process modeling training, with the view of developing a body of process modeling expertise. Indeed, modeler expertise has been established by surveys as an important factor for process modeling success [3] and modeling grammar usage [40]. Furthermore, prior experiments demonstrate that model factors (e.g., an increase in model complexity) affect understanding [45,47]. Notably, these experiments use abstract activity labels (A, B, C, etc.) in their process models, which, in turn, raises the question whether the usage of activity labels that carry real domain semantics leverages or impedes understanding.

The aim of the research reported here is to combine these preliminary insights in the definition of a series of experiments. Accordingly, the contributions of this paper are threefold. First, we build on the cognitive load theory to conjecture that real activity labels should decrease syntactical process model understanding. This hypothesis is confirmed in our experiments. Second, we argue in line with prior research that higher modeling expertise results in better understanding performance. This hypothesis is generally confirmed, too. Third, we define different measures of expertise including theoretical knowledge, prior modeling experience, and intensity of modeling. The experiments show that theoretical knowledge is most significant with its impact on performance. Our findings have implications for research on model understanding, in particular regarding cognitive load considerations, and for

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practice by demonstrating the relevance of theoretical knowledge of process modeling to understanding these models. This insight, in turn, is relevant to informing a staged teaching strategy that educates practitioners about how to read process models.

The rest of this paper is structured as follows. Section 2 introduces the theoretical foundations of process model comprehension. We identify matters of process model understanding and respective challenges. This leads us to factors of understanding. Section 3 describes the research design and Section 4 the results along with a discussion of threats to validity. Section 5 highlights implications for research and practice. Section 6 concludes the article.

2. Background

In this section, we discuss the background of our research. Section 2.1 summarizes which formal conclusions can be drawn from a process model and how understanding performance can be measured. Section 2.2 formalizes our hypotheses.

2.1. Process model comprehension

Process modeling has emerged as an important practice to guide decisions in systems analysis and design. In fact, process modeling is the number one reason to engage in conceptual modeling altogether [10], and also considered the number one skill demanded from IT graduates.[1] Analysts develop process models to capture relevant information about a business process they seek to re-design, analyze, or support with an appropriate information system. A business process that is in place to deal with a book order may, for example, contain a task to receive the order, which is followed by another one specifying that the book is to be sent to the customer who ordered it. A model of this process would, therefore, include sequences of graphical elements to describe these tasks and the order in which they have to be performed. Process models can be elicited through interviews with relevant stakeholders, or derived from organizational documents such as business policies [54]. Figs. 1 and 2 show two variants of a typical process model, conveying information about important tasks and the control flow that specifies the execution of these tasks.

In reaching an understanding about how individuals comprehend the content of process models, we realize that there is a broad spectrum of matters that can be understood from a process model. The SEQUAL model by Lindland et al. [24], for instance, distinguishes syntactic, semantic, and pragmatic dimensions of model quality. Consider Figs. 1 and 2, which show two structurally equivalent process models. The model of Fig. 1 contains activities that are labeled with capital letters. Therefore, this model can only be analyzed from a *syntactical* point of view. On the other hand, the model of Fig. 2 includes German language activity labels. As these labels point to a specific real-world application domain (i.e., they describe which activities in the real-world domain *specifically* are to be executed), they enable the discussion of the model from a *semantic* point of view. If now this model is communicated in a particular context, e.g. it is communicated as a normative model, then we can also investigate its *pragmatics*. In this way, a process model can represent knowledge for action [22].

Semiotic theory postulates that comprehension, and consequently, communication, can be understood as a ladder: syntax (how do I faithfully combine grammatical elements in a process model? [7]) must be clear before semantics can be discussed, and semantics (what do the grammatical elements in a process model mean? [7]) must be clear before pragmatics can be considered. In this regard, it is a primary interest to analyze in how far stakeholders are able to understand process models on a syntactical level. Other interpretations are flawed if syntax

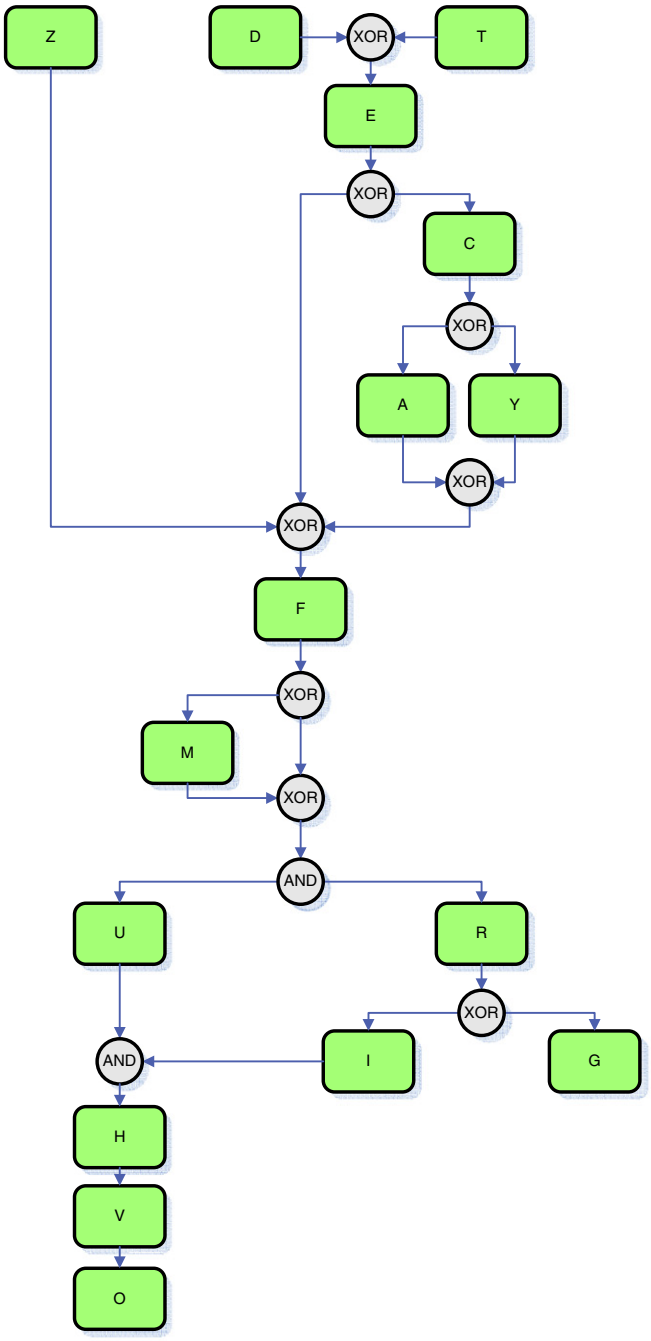

Fig. 1. Model 4 with letters.

is not correctly understood. This is also acknowledged by prior studies that focus on formal and syntactical aspects of process models [44,45].

Looking at which factors influence the comprehension of the syntactical content of process models, prior research has discussed several factors of process model understanding including model purpose [45], problem domain [23], modeling notation [1,15,48], visual presentation [34,39,46], and process model complexity [8,27]. Personal factors, on the other hand, have been less intensively researched to date. This is not to say that no research has been conducted. The experiment by Recker and Dreiling, for instance, operationalized the notion of process modeling expertise through a measure of familiarity with a particular modeling notation [41]. In an experiment by Mendling, Reijers, and Cardoso, participants were characterized based on the number of process models they created and the years of modeling experience they had

[1] http://www.networkworld.com/news/2009/040609-10-tech-skills.html