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How visual cognition influences process model comprehension

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ABSTRACT

Process analysts and other professionals extensively use process models to analyze business processes and identify performance improvement opportunities. Therefore, it is important that such models can be easily and properly understood. Previous research has mainly focused on two types of factors that are important in this context: (i) properties of the model itself, and (ii) properties of the model reader. The work in this paper aims at determining how the performance of subjects varies across *different types of comprehension tasks*, which is a new angle. To reason about the complexity of comprehension tasks we take a theoretical perspective that is grounded in visual cognition. We test our hypotheses using a free-simulation experiment that incorporates eye-tracking technology. We find that model-related and person-related factors are fully mediated by variables of visual cognition. Moreover, in comparison, visual cognition variables provide a significantly higher explanatory power for the duration and efficiency of comprehension tasks. These insights shed a new perspective on what influences sense-making of process models, shifting the attention from model and reader characteristics to the complexity of the problem-solving task at hand. Our work opens the way to investigate and develop effective strategies to support readers of process models, for example through the context-sensitive use of visual cues.

1. Introduction

Business process models play an important role in different phases of the business process management lifecycle [1]: These models structure the overall process landscape, they serve as input for analysis, and they can be used as blueprints for process implementation. Business process models (or *process models* for short) are created and utilized collaboratively by process analysts, process owners, process participants, and senior management. They should be presented and designed in such a way that these different stakeholders can best utilize them for the respective tasks at hand.

A prerequisite for an effective usage of process models is that stakeholders can readily understand them. Recent research has investigated process model comprehension by evaluating different types of factors, including model complexity [2,3] as well as model reader characteristics [4–6]. What if we now consider the same model and the same model reader while the comprehension tasks differ? Existing work does not provide any explanation why certain comprehension tasks appear to be easy to solve and others difficult [7]. Yet, understanding the reasons why certain comprehension tasks are difficult bears the potential to support modeling in a more effective way. First of all, based on such insights, tool features can be designed to help the model viewer in reading and understanding a model. Second, modelers can be directed to those parts of their model that are likely to be difficult to understand by the intended readership.

In this paper, we address this research gap from a theoretical angle. We analyze the comprehension process from the perspective of visual cognition in order to build hypotheses of comprehension task performance in relation to process models. We test our hypotheses using a free-simulation experimental design [8] in order to integrate visual cognition data from an eye-tracking device. The results underline the importance of visual cognition for process model comprehension. Factors associated with visual cognition explain a good share of the overall variance in comprehension performance and mediate classical factors such as model complexity and personal differences. This has implications for designing process models in practice and for research on conceptual models altogether.

The rest of the paper is structured as follows. Section 2 summarizes prior research on process model comprehension and develops hypotheses based on visual cognition. Section 3 presents the design of our study, and Section 4 provides the results. Section 5 discusses implications of this research. Section 6 concludes the paper and points to directions of future research.

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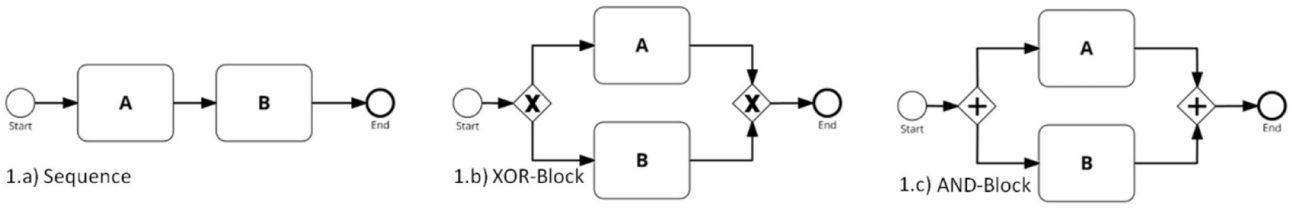

Fig. 1. Control flow representation in BPMN process models.

2. Background

In this section, we present the background of our research. First, we summarize prior research on process model comprehension. Then, we discuss visual cognition and its link to the notion of a relevant region. Finally, we present our research question along with corresponding hypotheses.

2.1. Process model comprehension

Processes are typically modeled using graphical languages, for example the Business Process Model and Notation (BPMN) (http://www.omg.org/spec/BPMN/2.0/). Fig. 1 shows some of the essential building blocks of a BPMN model. The simplest control flow that can be expressed is a sequence (Fig. 1.a). This represents that once activity A is completed, activity B can start. Fig. 1.b) shows a decision, as an XOR-block, modeling a choice represented by a so-called gateway (diamond shape with an x): the process has to continue either with A or B, but not both. Fig. 1.c) illustrates how concurrency is modeled. The AND-split (diamond shape with a +) triggers both branches such that A and B can be executed independently from one another, while any next step to be executed is feasible only after both A and B are finished.

In practice, process models are complex and often deviate from the simple block structures shown in Fig. 1. For example, Fig. 2 shows a BPMN process model from [1] that is already somewhat harder to understand. This model shows that a process can be triggered by an *Incoming call*. The first task, *Call Registration*, leads to three possible courses of action following the XOR-split. If for example, an *External Referral with form B4* is received, two tasks need to be executed following the AND-split. Only after both the tasks *Telephone confirmation to external part* and *Archiving system* are completed, synchronized by an AND-join, the *Inform complainant* task can be executed, which completes the process. Typical comprehension tasks for such a BPMN model are questions like "Are the tasks *Telephone confirmation to external party* and *Incident agenda* exclusive to one another?" or "Is *Archiving system* always the last step to perform in the process?"

The prerequisite for a process model to be useful is that it can be readily understood by the involved stakeholders. Research into process model comprehension is, therefore, concerned with identifying measures that capture comprehension effectiveness and efficiency, as well as the factors that make comprehension easy or difficult [9]. Comprehension in this context is measured using comprehension questions as tasks, which help to assess if a person can correctly determine the behavioral relationship between activities in a process model (e.g. concurrency, exclusiveness, sequence, etc.) [2,10]. The performance of answering such tasks in terms of accuracy (i.e. giving the correct answer to a comprehension question) and duration (i.e. how fast the answer is given) can then be used to measure comprehension [11]. Factors that have an impact on comprehension include model characteristics, language characteristics, and personal characteristics.

Model characteristics include the size as the number of model elements and complexity as the number of connections between these elements: the bigger and the more complex the model, the more difficult it has been found to be understood [12]. For example, the model in Fig. 2 is difficult to comprehend because its structure that involves six gateways is complex. One example of complex gateway behavior is the AND-split and XOR-join combination that links the two exclusive branches *External referral with form B4* and *Internal referral with form B2*. Various ways to operationalize size and complexity have been used yielding comparable results [3,13,14]. Most prominently, *structuredness* appears to be of specific relevance in this context [15]. The model in Fig. 2 is not structured, since there are split gateways that do not directly match a corresponding join gateway of the same type. For example, one would expect the XOR-join before the *Archiving system* task in the middle of the model and the XOR-join before the last AND-join of the model, to have a corresponding XOR-split.

Modeling language that have an impact on comprehension can be related to, first, the formal concepts covered and, second, the notational symbols. Deficiencies in both these matters tend to affect comprehension negatively [16,17]. Also, language complexity seems to be an issue that modelers often try to sooth by restricting the symbol set [18].

Finally, *personal characteristics* have been found to be important for comprehension. Performance of experts appears to be much better

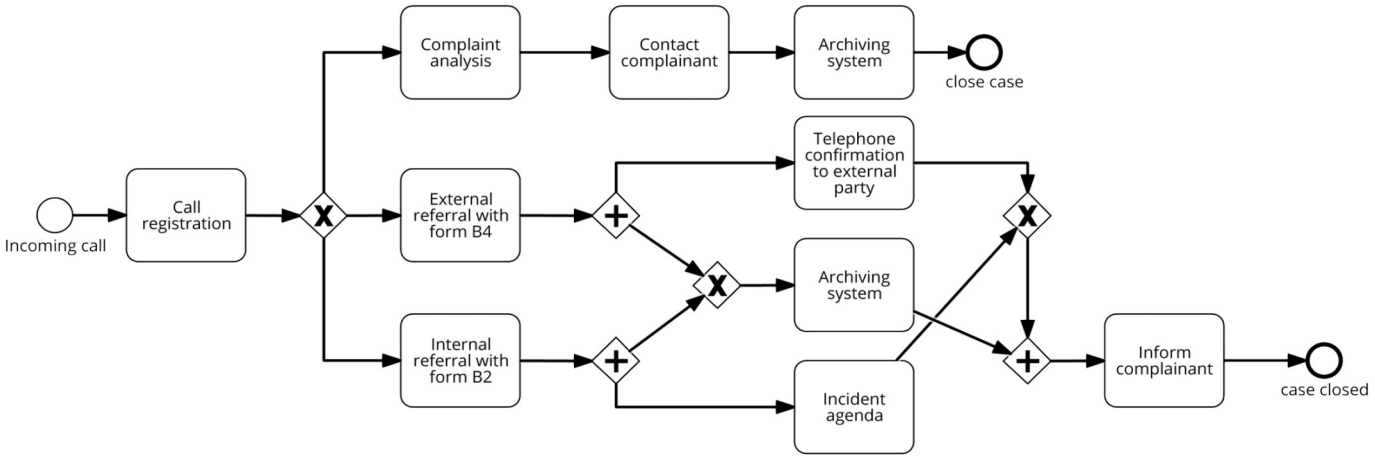

Fig. 2. Example of a BPMN process model for complaint handling with quality issues [1].

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