THE ROLE OF COGNITIVE STYLE IN THE COMPREHENSION OF SYSTEMS ANALYSIS TOOLS

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Abstract- Comprehending information presented in the systems analysis and design (SAD) tools by users is very important for successful information systems development. The comprehension performance is best when there is a fit among the cognitive style of the individual performing the task, the information-representation format being used, the complexity level of the task, and the task size. Previous research in this area has produced conflicting results due to consideration of only a few of the factors. This comprehensive study fills the previous research gap using systematic, speculative, judicial, and heuristic cognitive styles and SAD tools of Decision Tables and Structured English.

Keywords- Cognitive Style, Software Development, Task Complexity, Decision Tables

I. INTRODUCTION

Cognitive style refers to individual differences in cognitive processing in terms of individual’s preference for perceiving, acquiring, and processing information (Benbasat and Taylor 1978). The role of cognitive style in software development has been studied in the past in various contexts including software design (Benbasat and Taylor 1978, Spence and Tsai 1997), software inspection teams (Miller and Yin 2004), software diagram comprehension (Bruce et al. 2004), and small software development teams (Gorla and Lam 2004). There are four types of cognitive styles used by previous researchers (Mason and Mitroff 1973, Miller and Yin 2004) – systematic style (prefer factual/objective data that is processed in a logical manner), speculative style (prefer subjective data and logical processing), judicial style (prefer objective data that is processed through subjective values), and heuristic style (prefer subjective data that is processed through subjective values).

There has been little research to investigate factors affecting the comprehensibility of representation types, such as textual representations and decision tables (Pazzani 2000); further there has been little agreement among researchers as to the superiority in terms of comprehensibility of representation types from the human users’ point of view.

Huysmans et al. (2011) conducted a laboratory experiment with the objective of assessing the comprehensibility of four representation types (decision trees, decision tables, propositional rules and oblique rules) and concluded that decision tables outperformed the other representation types in comprehensibility.

On the other hand, in an empirical study conducted by Sharafi et al. (2013), it was found that graphical representations did not outperform textual representations in accuracy of comprehension by software developers.

II. THE STUDY

The comprehension performance is affected by cognitive burden that is dependent on multiple factors: domain complexity, representation size, processing activities, and the interplay between them (Swait and Adamowicz, 2001; Huysmans et al. 2011). The major factors affecting the comprehensibility of information presented in a representation type include human factors of the users, representation type, problem size, the task complexity, and the interactions between them. In previous research, only a few of the factors affecting comprehensibility have been studied ignoring the other factors (Huysmans et al. 2011; Gorla et al., 2013), which might be the reason for conflicting results in previous research on comprehension performance.

In this study, we consider all the above four factors (viz. cognitive style of the users, characteristics of the representation type, the problem size, and the complexities of the task assigned to the users), and conduct a laboratory experiment to determine the impact of these factors on the comprehensibility of representation types that are commonly used in systems analysis and design (SAD) tasks. The comprehension performance is measured by the accuracy of understanding the information presented in the SAD tools. The goals of the research are: (1) to determine the effect of each individual factor (cognitive style (systematic, speculative, judicial, and heuristic) of software developers, SAD representation type, SAD task size, and SAD task complexity) on comprehension performance, overall, (2) to determine the effect of two-way cognitive fit (cognitive style-representation type fit, cognitive style-task complexity fit, cognitive style-problem size fit, representation type-problem size fit, task complexity-representation type fit, and task complexity-problem size fit) on comprehensibility of SAD tasks, and (3) to determine the effect of three-way cognitive fit on comprehensibility of SAD tasks.
In this experiment, we use four cognitive styles (systematic, speculative, judicial, and heuristic), two representation types (Decision Tables, DT and Structured English, SE), two levels of task complexity (simple and complex), and two task sizes (small and big) and study the effect of the cognitive burden due to interaction between these factors on comprehensibility. The results of the research will determine the cognitive styles of stakeholders that are associated with high comprehension accuracy with DT and SE or with simple and complex tasks or with small and large problem sizes. These results can be used either to select project team members with suitable cognitive styles for each structured tool or task complexity level or problem size; these results can also be used to decide on the SAD representation types or task complexity or problem sizes that are suitable for the mostly prevalent cognitive styles that exist in software teams.

III. BACKGROUND

It has been established in the literature that human factors play an important role in software development productivity (Hungerford, Hevner, and Collins, 2005; Chilton, Hardgrave, and Armstrong, 2005) and technology adoption (McElroy, Hendrickson, Townsend, and DeMarie, 2007). In particular, personality traits of software engineers have been shown to have significant impact in software team performance in software engineering tasks (Gorla and Lam, 2004). Key aspects of an individual’s personality that directly relate to decision making behavior include distinctive ways of acquiring, storing, retrieving and transforming information, which have been found to be consistent over time (Myers and McCaully, 1985). Based on an experiment involving experienced software developers and their verbal protocols while reviewing software design with entity-relationship diagrams and data flow diagrams, Hungerford, Hevner, and Collins (2005) found that human information processing strategies used by software engineers play an important role in the comprehension of software diagrams and in searching for software defects. In the study by Miller and Yin (2004), it is found that a software inspection team with diverse information processing strategies produce superior results as the team can detect maximum number of different errors. The Myers-Briggs Type Indicator (MBTI) is one of the world’s most popular questionnaires for measuring individual personality styles. MBTI was developed by the mother-daughter team of Katherine Briggs and Isabel Myers (Briggs and Myers 1977). It is based on the notion that behavior which appears to be random actually adheres to a discernible pattern. There are four types of individual personality styles, based on individual preference for existence in the world, preference for perceiving data, preference for reaching conclusions, and preference for making decisions. While the four personality styles exist in literature and practice, only two dimensions (Sensing/Intuitive and Feeling/Thinking) are considered as cognitive styles by management science researchers and the other two (Extrovert/Introvert and Judgment/Perception) describe action-taking styles (Miller and Yin 2004). In line with Miller and Yin (2004), we consider the former two personality dimensions in this research: perceiving data and reaching conclusions, resulting in four cognitive styles.

Perceiving data - sensing or intuitive: This personality category denotes how people perceive data. Sensing people take in information through the five senses, like things that are definite and measurable, rely on facts and concrete data, and reach a conclusion step by step. Intuitive people take in information through their minds and have the ability to know things without the use of rational thinking process; creative and big-picture people; follow their inspirations; and dislike taking time for precision.

Reaching conclusions - feeling or thinking: Feeling people make decisions based on emotional basis; they decide through feelings, whereby they rely upon human values and beliefs. Thinking people are unemotional; they use logical/rational reasoning process in arriving at conclusions; they are analytical and use data to make decisions; and they desire to fit problems and solutions into formulas.

By combining people's preference for receiving data and the people's preference for reaching conclusions (as described above), four types of problem-solving types are achieved (Mosley 1991): Sensing-Feeling (SF), Sensing-Thinking (ST), iNtuitive-Feeling (NF), and iNtuitive-Thinking (NT). These four styles represent relative preferences for information acquisition and processing. In most individuals, one mode of perceiving data and one mode of evaluation are characteristically developed while the other modes are underdeveloped (Mason and Mitroff 1973).

Sensing-Feeling (SF) type individuals rely on facts and concrete data, but reach decisions based on emotional basis. They approach decisions from a factual point of view, but are receptive to others’ approval. They pay attention to detail and perceive objects as they are. Their evaluations lie on the personalistic lines of good/bad and like/dislike. They evaluate data based on moral standards. Miller and Yin (2004) terms SF as judicial cognitive style that prefers objective data that is processed through their subjective values.

Sensing-Thinking (ST) types rely on concrete data and use logical reasoning process to reach conclusions. They prefer using technical skills and employ facts and objects. They pay attention to detail and perceive objects as they are. They evaluate
information based on formal systems of reasoning as true/false judgments. They formulate models and make rules to solve problems; unless they can do this, they are unable to understand it. They are compulsive in systematizing everything. In summary, ST is termed as systematic cognitive style that prefer objective data that is processed in a logical and rational manner (Miller and Yin, 2004).

INtuitive-Thinking (NT) problem solving types are big-picture people interested in solving unstructured problems by using logical thinking process. They perceive data as it might be, see through the facts and extrapolate beyond the facts. They evaluate information based on formal systems of reasoning as true/false judgments. They formulate models and make rules to solve problems; unless they can do this, they are unable to understand it. They are compulsive in systematizing everything. Thus, NT is called speculative cognitive style as it uses subjective data and performs logical processing.

INtuitive-Feeling (NF) types make decisions on pure instinct or intuition and do not use logical reasoning process. They are creative and conceptual, but use their skills to serve others’ needs. They perceive data as it might be, see through the facts and extrapolate beyond the facts. Their evaluations lie on the personalistic lines of good/bad and like/dislike. They evaluate data based on moral standards. Thus NF type can be termed as heuristic cognitive style that uses subjective data with a subjective valuation.

IV. METHOD

Task performance is best when there is fit among the cognitive style of the individual performing the task, the information-representation format being used to operationalize the task, the complexity level of the task, and the size of the task. Figure 1 has the research model. Some sample hypotheses include: Judicial cognitive style outperforms with DT compared to other three cognitive styles. Systematic cognitive style outperforms other cognitive styles in complex tasks.

V. EXPERIMENT

One hundred and eighty business students of a Midwestern urban university in the USA were selected for this study. The use of student subjects in place of practicing software engineers accorded us such an opportunity and is consistent with recent studies (Burton-Jones and Meso, 2006; Falk et al. 2010; Liyanarachchi, 2007; Trottier et al. 2011). The group consisted of 58.9% graduate students and 41.1% undergraduate students at the senior level. Each student selected was enrolled in an introductory computer information science class. The course was a core requirement for all business majors, therefore the subject pool represented all potential majors in the college of business rather than being dominated by one major. Majority of the participants have some work experience with an average of 7.6 years.

The format of the testing was comprised into three parts: 1) MBTI test, 2) introduction to the SAD tools and 3) testing with SAD tools. Each student was given forty minutes to complete the MBTI. The MBTI is a standardized self-explanatory multiple-choice questionnaire in which there are no right-or-wrong answers. The MBTI test was used in the past to analyze personality in software engineering research (McDonald and Edwards, 2007) mainly to identify personalities that are associated with good software engineering performance (Capretz, 2003) and to identify the composition of software teams that are associated with high productivity (Gorla and Lam, 2004; Miller and Yin, 2004). The students were then given a lecture describing the two structured tools: SE, and DT. The lecture included an introduction to explain the objective and procedure for the experiment, an example that walked through typical questions using the tools, and another example in which students were required to solve sample problems for practice.

Following the lecture on the structured tools, a ten-question sheet was provided to each student. The research task selected is a credit/discount facilities problem, which does not give any bias in favor of any specific business major. Furthermore, the task does contain one or more of the basic constructs of any process or software module, such as sequence, condition, nesting, and iteration. The allocation of a structured tool to a student was random with the students not knowing which tool they would be using until the start of the test.

CONCLUSION

This is a work-in-progress paper. In order to fulfill the objective of this research, the significance of the effect of each of the four individual factors on comprehension performance will be assessed using ANOVA. Likewise, the significance of two-way interactions and three-way interactions on comprehension performance will be assessed through ANOVA. The results of the research will determine the cognitive styles of stakeholders that are associated with high comprehension accuracy with DT and SE or with simple and complex tasks or with small and large problem sizes or combination of these factors.

REFERENCES


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**Figure 1. Research Model**

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