Cognitive Mismatch In Accounting Systems: An Object-Oriented Perspective

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Abstract

This paper investigates human cognition from an object-oriented perspective to reduce the gap between users' cognitive structures and the presentation format of the accounting function. Three constructs of cognitive structures (i.e., propositional networks, schemas, and object-based) are contrasted to develop a set of postulates and testable hypotheses. The available evidence from the extant literature in accounting and cognitive science is used to derive support for the research arguments. The paper concludes that object-based representation appears to be a better construct for human cognition. Implications of this research for the design of accounting systems, decision aids, and knowledge transfer techniques are discussed.

Introduction

One of the success criteria of accounting systems is the provision of information which corresponds with user's information needs. A critical factor in the set of information needs is the mental model employed by users in making decisions. Yet as many researchers concur, accounting systems fall short of matching information with user's cognitive needs (Benbasat and Dexter 1979; Lin and Harper 1981; McCarthy 1982). A contributory factor in this distrust process is the use by accounting of technical classification framework which is different from common-sense usage (Everest and Weber 1977). Processing such accounting information, especially by non-accounting users, in a decision matrix is likely to be cognitively strenuous with possible adverse effects on decision quality. This study addresses

these issues by proposing an object-based representation for accounting systems. Objects are considered a natural metaphor for human cognition (Coad and Yourdan 1990). If accounting systems use object-based structure in their information organization then their divergence from user's cognitive models could be minimized.

The objective of this paper is to develop using deductive analytical reasoning, testable postulates and hypotheses about the role and implications of cognitive mismatch in accounting domain; though none is subject to data testing. Cognitive mismatch is defined as the lack of congruence between the structural organization of information presented to users (hereafter called the presentation format) and the mental model employed by them to process such information. The degree of divergence between the presentation format of accounting systems and users' cognitive structures seems to affect the

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quality of decisions. Cognitive structures, as a black-box phenomenon, can be inferred indirectly by measuring performance using different presentation formats. The research arguments are derived from the benefits claimed in the literature in favor of object-oriented paradigm as a possible representational construct. Future extensions of this research need to impart empirical validity to the set of postulates and hypotheses proposed here.

The study assumes significance at least on four broad planks. First, accounting systems design must incorporate users cognitive structures to enhance effectiveness and efficiency of decisions. Second, professional accounting judgments stand to benefit by a reduction of cognitive mismatch during audit planning, evidence collection, and opinion formation phases. Third, research aimed at developing effective accounting decision aids should present information to users congruent to their cognitive models. Finally, knowledge-transfer (either in the traditional class-room or corporate training sessions) in accounting domain should develop materials and techniques which match trainees' cognitive processing model to improve memory and retention rate.

The discussion proceeds as follows: The following section reviews existing theories of cognitive structures, and proposes object-oriented model as an alternative. The third section develops research postulates and testable hypotheses using the representational issue in accounting. It also discusses significance of the research objectives in relation to the accounting function. The final section offers some directions for future research.

Nature Of Cognitive Structures

The phrase cognitive structure is used in this study to denote mental model employed by users to process stimuli. Some of the more common theories of cognitive structure advocated in the literature include propositional networks, schemas and frames. These models have been used in various domains and disciplines in-

cluding accounting, artificial intelligence and social psychology. Schemas and frames are broadly similar in nature in that both facilitate recall systematically through long term memory (Calfee 1981); hence the former phrase will be used to refer to either of the representational models.

Propositional networks organize knowledge as combinations of nodes which are composed of propositions, the relations, and the arguments. Links between nodes determine the association of ideas. Prior research on propositional networks seems to conclude that the frequency of experience causes the strengthening of links and the occurrence of concepts closer to each other (Anderson 1990; Weisberg 1969). Also, the spatial storage of concepts in memory seems to affect their retrieval in a decision matrix (Collins and Quillian 1969). Thus, performance is a function of spatial structure and connectivity of networks.

Schemas organize knowledge as sets of slots which may be arranged hierarchically. Slots contain the attributes and their values of the stored concepts. The hierarchical structure may be divided into either generalization hierarchy or part hierarchy. Schemas represent only common attributes about specific concepts as opposed to proposition networks which represent their important features. Encoding information in the form of schemas is thought to facilitate knowledge representation about various categories (Anderson 1990). However, the extent of applicability to cognition of schemas as developed and practiced in the field of artificial intelligence (e.g., see Winston 1984) is still debatable.

This study advances object orientation as an alternative model of cognitive structure. Object oriented methodology has evolved in the field of systems and computer science. It has been advocated as a possible model of human cognition (Coad and Yourdan 1990). But a formal framework of cognitive structure utilizing features of object-oriented model is still lacking. Any data testing through experimental design must be preceded by a theoretical framework.

Representational Postulates

Cognitive mismatch was described above as the divergence between the presentation format and users' cognitive structures. An alignment (divergence) between the two sets of information-organization is expected to be positively (negatively) correlated with performance. Studies in accounting and social psychology reveal that information search activity is cued by the presentation format (Gibbins 1977; Tversky and Kahneman 1981). The implication is that if the cue and presentation format match with the cognitive structure of users, then information recall and decision making should benefit in both efficiency and effectiveness:

P1: Cognitive mismatch adversely affects performance.

The issue of cognitive mismatch is widespread in the decision of professional accountants, design and maintenance of accounting systems, and accounting instructional systems. During the evidence evaluation and opinion formation phases, auditors engage in a matching process which correlates the available evidence with mental prototypes of related problem solutions (Libby 1981). Experiments with novices and experts in various domains have established that the cognitive structure of the latter is more systematically organized than that of the former (Chase and Simon 1973; Lesgold 1988). These studies suggest that the organized nature of cognitive structure accounts for effective and efficient user decisions. Hierarchical arrangement of concepts appears to be one of the factors in the organized cognitive structure, and hence, for the superior performance of experts (Ormrod 1990, Bindra 1976). Such an architecture also facilitates management of complexity during processing of stimuli (Tversky 1972; Hogarth 1980). The network model of the propositional architecture makes it a web of inter-connected nodes. As experience grows, the network is believed by some, to get modified to reflect traces of hierarchical pattern (see Anderson 1990). In contrast, both schemas and object-orientation are inherently hierarchical models:

P2: Organized cognitive structure is hierarchical in nature.

H21: Presentation format using propositional networks or scripts increases the cognitive mismatch.

H22: Presentation format using frames, schemas or object-based representation reduces the cognitive mismatch.

The benefit of hierarchical structure stems from the inheritance of attributes and/or methods. Absence of hierarchical structure in propositional network does not facilitate inheritance feature. Thus, network presentation format is not expected to aid efficient processing better than schemas or object-based organization. This principle forms the basis of an explicit expression of commonalty. Common attributes and services are specified only once, at the highest possible node with the most general concept. Properties or attributes are passed on from a super-ordinate class to its sub-ordinate classes up to and including the atomic unit.

The sub-classes in the object-based representation are not merely the instances of each of their super-classes. Instead, these can be thought of as a division of a family into its functional classes. Object-based inheritance differs from other models in the fact that each object in the hierarchy possesses attributes and services encapsulated within it. Inheritance can be blocked by overriding a different attribute in the concerned object. Also, it is not necessary that an object must perform some service on other objects. It may exist as a stand alone object just to receive messages or get services being performed on it. :

P3: Hierarchically organized cognitive structure facilitates inheritance of attributes and/or methods.

H3: Decision involving instantiation and inherited attributes/services are efficient using a hierarchical presentation format.

Decision process involves activating concepts to impart a judgmental perspective. Experience facilitates modification of concepts and/or methods. Object oriented technique treats attributes (called passive features) and exclusive services (called active features) on those attributes as an intrinsic whole. This principle is referred to as information hiding or encapsulation. It helps to minimize rework when effecting modifications. Encapsulation can be compared to an integrated circuit which is a miniaturized piece of silicon chip containing several hundred functional circuits embedded on it. Once an object is encapsulated with the attendant attributes and services, change of requirements should become less of a cognitive effort. This seems to coincide with the functioning of the human brain where modifications are believed to be made only in the affected knowledge (object) without disturbing the whole cognitive structure. Localized volatility appears to be an essential part of cognition, and is aptly captured by the principles of object-oriented methodology.

A network representation models concepts and their associated methods as sets of propositions. Frequent encounters with similar situations would force cognitive structure to either closely associate methods with concepts or else strengthen the connectivity. Cognitive function, thus, becomes a function of learning curve whose slope depends on the frequency of experience with a fact. Schemas representation does not store methods for concepts. Such a representation falls short of depicting the dynamics of cognitive structure. The retrieval/search process for disassociated presentation format would require more cues and increase processing time:

- P4:** Active and passive features of a concept in cognitive structures are spatially close together.
- H41:** Processing information requiring both attributes and methods is more efficient using an object-based presentation format.
- P5:** Spatial closeness of attributes facilitates expertise formation.
- P6:** Organized cognitive structure facilitates

Abstraction is a major principle to manage complexity. It implies ignoring those aspects of a concept that are not relevant to the current purpose in order to concentrate more fully on those that are relevant (Oxford 1986). Auditors' judgment process involves focusing on certain aspects in preference to others. How much of the available aspects get focused at any point in time is a function of organization exhibited by cognitive structures. Abstraction in cognition is implied in the findings of DeGroot (1965), and Chase and Simon (1973), who in their problem solving experiments showed that an expert has a large repertoire of specific patterns that can be accessed in the memory and quickly recognized. In contrast, a novice's knowledge structure may be more loosely organized, containing information that is most centrally relevant to the problem as stated but lacking any information about related principles and their applications (Lesgold et. al. 1988). An expert may be able to abstract large chunks of information than a novice; also each chunk may contain larger and more organized information than a novice. The number of chunks, however, is likely to be the same for both experts and novices (Miller 1956).

Abstraction of real world can take two distinct forms. Procedural abstraction is characterized as a function/sub-function process. Subdividing a broad problem statement into logical steps is one of the most natural ways of handling complexity. Secondly, data abstraction forms the basis for the primary organization of thinking and specification. Thus, the mental image processing involves a search for objects which are correlated in terms of their attributes. The method of representing objects and their attributes in the object-oriented methodology specifically facilitates the data abstraction way of retrieving information and making references. Abstraction from network and schema based presentation formats is expected to be less efficient in view of the absence of information hiding. The extent of organization of data and procedure within each model accounts for the expected differences:

abstraction.

- H6:** Information abstraction is most (least) efficient for an object-based (propositional network based) presentation format.

Effective and efficient decisions require ready access of attributes and methods to avoid response delay caused by higher search time. In case of concepts belonging to a common hierarchy, availability of attributes and methods does not appear to be a problem; inheritance feature facilitates sharing of all common attributes in the parent object with its instantiated sub-classes. However, concepts belonging to different hierarchies are inter-connected with the help of message passing feature. From a psychological perspective, this principle assumes significance in the preservation of a cognitive economy aspect of mind. While being a part of functionally different classification structures, an object can share features from other classification hierarchies during processing a stimulus. For example, an object within an 'asset' class would communicate with another object within a 'liability' class to process a transaction using specific encoded methods. The commonality principle ceases to operate, however, when an attribute of an object is too crucial for it to exist without it, in order to have any semantic content. An object within a hierarchy receiving the message sent by another object belonging to a different hierarchy acts on the stimuli based on methods embedded in it. Message passing feature helps avoiding a complete traversal of links typical of propositional networks. Other presentation formats (i.e., schemas and propositional networks) do not exhibit message passing property. Thus, the processing efficiency for non-object-based presentation formats is likely to be less compared to their object-based counter parts:

- P7:** Cognitive structures use message passing to relate concepts belonging to different hierarchies.
- H7:** Processing efficiency for decision involving combination of concepts in different hi-

erarchies is superior for an object-based presentation format than a network or schemas.

Accounting related judgments, especially non-routine, are complex and dynamic (Gibbins and Wolf 1982). The decision matrix in any two situations has rarely the same features. This implies that cognitive structure should be capable to adjust response to a stimuli generated at different times. Capacity to respond to a stimulus differently at different times is called polymorphism and is specific only to object-oriented model. Polymorphic response capability is not exhibited by propositional networks or schemas:

- P8:** Cognitive process is versatile and dynamic.
- H8:** Multiple response processing is efficient for a stimulus organized according to object-based model as opposed to either propositional network or schemas.

Implications

A resolution of the issue of cognitive mismatch is significant for the design of accounting systems. As a tool for providing input to users, accounting systems should present information organized in a format which reduces the gap with users' mental model. Reduction of cognitive mismatch would also help to increase the reliability of information generated by the accounting function. It is the author's belief that the existence of parallel accounting systems theorized in the literature (Johnson and Kaplan 1987) has both conceptual and cognitive perspectives. The conceptual perspective deals with the content of information, and has received much recent efforts. The cognitive aspect, especially its mismatch, still needs to generate specific theory based foundations for empirical validation.

Further, a reduction of cognitive mismatch should be an integral objective in professional accounting judgments. This will improve productivity of accountants at staff, senior and manager levels. Also, the efficiency and precision of judgments during evidence collection and

opinion formulation stages should benefit when the structural format of information set matches with the cognitive structure of decision makers. Third, various decision aids in accounting is likely to get higher acceptance and effectiveness when their query and information generation schemes are made to align with users' mental models. Finally, the mismatch is especially relevant in knowledge transfer programs. The material and methodology of knowledge transfer when developed to match user cognitive model would enhance knowledge retrieval and learning rate.

Conclusions

This paper analyzed cognitive mismatch in terms of specific criteria which are thought to affect decision making in accounting. The general hypothesis entertained in this study pertains to adverse effects on decision quality of information organized and presented to users in a format which is at variance with their cognitive structure. Two existing theories of cognitive models (propositional networks and schemas) were investigated and contrasted against the proposed alternative of object-oriented paradigm. The study advanced the proposition that object orientation is a better and more functional construct of human information processing. Object-orientation has been practiced and applied in systems design, but only advocated in literature as a possible model of human cognition. This study is the first theoretical framework known to actually apply its salient features to cognition. The extant literature in accounting systems and decision research was used to derive specific postulates and testable hypotheses using object-oriented features with the aim of reducing the cognitive mismatch. It was also argued that other competing models of cognition do not fully capture all aspects of cognition. Information presented in either one of those models may increase the cognitive mismatch and reduce the decision quality.

Suggestions for Future Research

The future extensions of this research needs to provide empirical validity to the set of

postulates and hypotheses proposed here. It would be particularly interesting to find if certain decision tasks in accounting are more responsive to object-oriented presentation format than others. Accounting domain provides a rich variety of decision matrices which differ in detail and structure.

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