



Adapting the Adaptive Toolbox for Strategies in Cognitive Work Analysis

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ABSTRACT

Motivation – To improve underdeveloped methods and tools for the Strategies Analysis phase of Cognitive Work Analysis.

Research approach – Literature review and discussion.

Findings – Strategies Analysis theory and methods can be hard to describe consistently, and compare across analyses. Psychological theories of bounded cognition such as the Adaptive Toolbox perspective may be useful in addressing these problems.

Research limitations – This is a work in progress and the conclusions have not yet been demonstrated.

Originality/Value – This is the first paper to compare Strategy Analysis and the Adaptive Toolbox. It would benefit cognitive engineers interested in developing methods.

Take away message – Weaknesses in CWA should be addressed by incorporating complementary theories.

Keywords

Cognitive Work Analysis, Task Analysis, Strategies, Bounded Rationality, Adaptive Toolbox, Methods

INTRODUCTION

Cognitive Work Analysis (CWA) has persisted as a useful Cognitive Engineering framework. However, most applications demonstrate only the first two phases of CWA. Strategies Analysis (StrA), the third phase, is under-represented and its conceptual distinctions and modelling tools have not changed since early publications (Rasmussen, 1994). While recent publications have applied StrA theory (Burns, Enomoto, & Momtahan, 2008), they leave analyses implicit.

Rasmussen intended CWA as a "conceptual marketplace", an integrative framework for useful Cognitive Engineering theories, methods, or tools. Given the lack of StrA development, we will discuss how new theories can be adapted to the characteristics of CWA and current weaknesses in StrA. We propose incorporating elements from the study of bounded ecological rationality, such as the Adaptive Toolbox perspective on cognition (Gigerenzer & Selten, 2001).

THE ROLE OF STRATEGIES IN CWA

Strategies Analysis is one of several complimentary perspectives in the CWA framework. The five phases of CWA distinguish:

1. Work Domain Analysis (WDA): the structure of the working environment using several levels of decomposition and means-ends abstraction.
2. Control Task Analysis: a) recurring work domain situations, b) tasks performed in each situation, and c) possible cognitive *products* in control task sequences.
3. Strategies Analysis: prototypical categories of cognitive *processes* that can achieve parts of activities
4. Social-Organization Analysis: options to allocate work between actors, including communication.
5. Worker Competencies Analysis: possible modes of human behaviour and relevant performance criteria.

Strategy Definition

Within the CWA framework, a Strategy is defined as a category of cognitive processes that transforms a state of knowledge into another (Vicente, 1999). Input and output states of knowledge are often drawn from a Control Task analyzed previously. Strategies' cognitive processes have been characterized by a collection of:

- sets of observations
- models (mental or otherwise, at varying abstraction)
- tactical rules to guide processes

StrA presumes that several strategic processes are always available to produce the same knowledge product in complex work environments. Thus, StrA also describes worker criteria or environmental cues that are associated with strategy shifts. Criteria that have been suggested include mental effort, detail of observations, complexity of models, generalizability to other domains, etc. (Rasmussen, 1994).

Difficulties with Strategies Analysis

The scope of StrA is ambitious and can be difficult to apply in real work systems. Two challenges we have encountered in applying StrA are:

The environmental representation problem

Strategies in CWA are defined as categories of cognitive processes, but some StrAs (Vicente, 1999) have produced descriptions phrased in terms of choosing between alternative functional means to achieve system processes. For an ecological approach to express the environment's role in cognition, relevant features must be consistently represented (Hilliard, Thompson, & Ngo, 2008).

The domain-dependence problem

StrA is intended to inform design by remaining actor-, and device- independent. However, applications have used domain-specific modelling descriptions. Vicente (1999) suggests adapting Elementary Information Processes (EIP) (Payne, Bettman, & Johnson, 1993) as building-blocks for modelling strategies. However, EIPs were developed in the context of multiattribute decision-making, and poorly represent the range of cognition observed in representative environments, such as coordinated sensorimotor control, recognition-based pattern matching or attunement to rich environmental cues (Gigerenzer & Selten, 2001).

These two challenges may be addressable by adapting modelling practices from psychological theories. We next discuss the Adaptive Toolbox family of candidate theories.

COMPATIBILITY OF THE ADAPTIVE TOOLBOX

Strategies in CWA and the Adaptive Toolbox literature are defined similarly, and despite their differences may have the potential to complement each other.

Similarities

Both approaches deal with a process description of cognition, specified as multiple sets of tactical rules and adaptive shifts. Most crucially, both assume human rationality is bounded or ecological, and describe cognition in terms of both an environment's structure and an actor's processing abilities.

Differences

One key difference between Adaptive Toolbox and CWA approaches is their orientations as psychological theory and design framework. CWA seeks only to inform effective designs, while the Adaptive Toolbox literature seeks to be a truthful account of human cognition. (Kirlik, 1995)

As a design framework, CWA must address a full range of work-relevant expert human behaviour. Thus, StrA models not only heuristic reasoning (the focus of the Adaptive Toolbox), but also deliberate reasoning, automatic processing, and manual sensorimotor control.

Complements

Differences can be complementary. For example, environmental structures such as uncertainty or

frequency distributions have been considered by the Adaptive Toolbox approach as characteristics that govern which cognitive strategies humans will use. So far, CWA has not modeled these characteristics as they have been considered too variable. However, if such qualities are general constraints on effective cognition, then including them in CWA may help describe strategies more consistently.

Likewise, CWA strategies are specific to systems and activities while the Adaptive Toolbox aims to explain cognition in typical representative environments. A coarser-grained approach inspired by the Adaptive Toolbox may suggest better abstraction mechanisms to condense analysis permutations and inform modelling notations for StrA that can represent heuristic modes of human cognition.

The psychological study of bounded ecological rationality has developed greatly since CWA's fundamentals were set. We believe it is past time to improve CWA Strategies Analysis by drawing from the Adaptive Toolbox literature.

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