Using Cognitive Models in the Design and Evaluation of Team Structure

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The Navy is moving rapidly toward deployed systems that increase use of automation while dramatically reducing manning, as in the Surface Combatant of the 21st century (SC-21) ship. With more automation and fewer people, these future systems will place more emphasis on human cognitive performance. These changes will require new organizational designs that are optimized for the cognitive role of humans and their automated counterparts. Thus, new and more general methodologies for designing organizations and optimizing the allocation of functions to individual team members must be developed.

Organizational computational models deal with the organizational structure and its effects on decision processes and information flows within the structure. They characterize organizational decisions as the aggregate of individual agents characterized by demographic and psychological parameters (Carley & Behrens, 1999). Modeling at this level, while useful for high level analysis of organizational behavior, masks the processes that occur at the individual level. To study the relation between these high level processes and individual behavior, we have been extending the COGNET theory and computational model of individual cognition (Zachary, 1992) using concepts from team training research (Smith-Jentsch, Zeisig, Acton & McPherson, 1998). This new model of organizational cognition is termed ORGNET.

To use ORGNET for designing and evaluating new designs or redesigns, we developed the Process for Redesign of Organizations (PRO) methodology and associated toolset. PRO is a flexible environment for discovering the structure of organizations/teams already in place or for building new structures. The starting point of PRO is to build an aggregate ORGNET simulation model of the overall team as a set of interacting tasks and knowledge that can perform an overall job or mission. In addition to demonstrating the basic competence of the tasks to do the team's job, the team model provides a set of measures that are used to characterize the team's basic tasks and their interactions. The measures include complexity and workload of individual tasks, as well as the information flows and workflows that emerge from model runs against representative scenarios. The user can visualize and analyze these measures to discover the basic structure and relationships of the tasks to each other.

These measures are tied to a set of design principles, such as minimizing the overall levels of communication, or leveling workload. These design principles give the user guidance on how the measures should be used (i.e. minimized or maximized) to optimize the team structure.

The next step in PRO is to build candidate function allocations (i.e. cluster tasks into roles) based on design principles selected by the user. The user may do this manually through a graphical interface or through optimization algorithms. These algorithms find team structures that conform to the set of principles and other constraints on the organizational design defined by the user.

After an initial team structure is found, an iterative process is carried out. Tasks associated with separating the team into distinct members, i.e. communication to maintain situation awareness, task management, and backup, are added to the model and the measures are recalculated.

The user of the ORGNET software can iteratively refine the team structure either by changing the set of principles used in clustering the tasks, or by manually moving tasks between roles and seeing the results of those changes on the conformance of the design to the selected principles. We are in the process of testing various assumptions, including the efficacy of using measures from the monolithic model to predict team performance, and the use of low-fidelity aggregate models in finding an initial team structure.

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