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The effects of agent activeness and cooperativeness on team decision efficiency: A computational simulation study using Team-Soar

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Abstract

Within an organizational context, an agent type reflects the behavioral tendency that a member might employ across tasks. Until now, however, the impacts of agent types on team performance are not well understood. To address this issue, this study examines the relationships of agent activeness and cooperativeness with team decision efficiency at different degrees of information redundancy by using a team model consisting of four AI agents. This study presents the team model called "Team-Soar" and describes how the model implements agent activeness at two levels (active and passive) and agent cooperativeness at three levels (cooperative, neutral, and selfish). Then a computational simulation experiment is described. Results of the simulation indicate that the impacts of the agent type depend on the amount of information to be processed and active style boosts the effects of agent cooperativeness on team efficiency. The results also indicate that active agents do not always contribute team efficiency more than passive agents.

1. Introduction

Agent types are typically characterized by patterns of thought and behavior that are permanent or at least change very slowly (Moffat, 1997). Within a human organizational context, an agent type can be interpreted as interpersonal characteristics that a member might employ across tasks and settings.

The study of agent types is necessary because agent types are believed to affect the performance of human organizations (Driskell et al., 1988; Bradley and Hebert, 1997; Reilly et al., 2002). This is especially true for groups or teams where behaviors of members are interdependent on each other and outcomes the members receive are determined by their behaviors. Accordingly, agent types in human teams (or groups) have been considered as an important factor in determining how teams function and perform (Driskell et al., 1988; Bradley and Hebert, 1997; Reilly et al., 2002). However, little research has been reported investigating agent types and human team/group performance (Kichuk and Wiesner, 1997; Lucius and Kuhnert, 1997; Bonner, 2000), and until now the role of personality in team performance is not well understood (Reilly et al., 2002).

Recognizing the needs of research on the relationship of agent types with team performance, the present study examines the effects of two agent types, agent activeness and agent cooperativeness, on team efficiency under different information conditions by using a computational model of multi-agents called "Team-Soar." This study presents the team simulation model consisting of four artificial intelligent (AI) agents and describes how the model implements agent activeness at two levels (active and passive) and agent cooperativeness at three levels (cooperative, neutral, and selfish). Then a simulation experiment using Team-Soar will be provided. The simulation study will show which agent types perform better in what information conditions, and the findings can be used to design human teams and computer networks in which multiple human or AI agents interact.

The followings are the characteristics of this simulation study:

(1) In the study, agent activeness and agent cooperativeness are selected as research variables of agent types because both agent types are two of the most basic dimensions that

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describe human's interaction behavior; hence they are believed to affect team performance significantly. The study especially concerns the mixture of the agent types and how the two types interactively affect team efficiency.

(2) The study also tries to explore the relationship of agent types with information. The study models the agent types in terms of the attitudes of AI agents when they exchange information to fulfill their assignments. Unlike past studies that have focused on how agent types affect information processing behavior, this study examines how information redundancy controls the impact of agent types on team efficiency.

(3) Often agent types are uncontrollable or hard to control for experimentation. One way of overcoming the problems is to use computational models. Due to the advantage of control, computational models have been widely used for studying social natures of humans. The study uses a theory-based computational model (i.e. Soar) to represent the social attitudes of agent activeness and agent cooperativeness. In particular, the multi-agents Soar technique (Laird et al., 1993) is used to build the Team-Soar model because the modeling subject, which is a hierarchical decision making team with distributed expertise, is comprised of multiple intelligent human agents.

Before going to further, there is one thing to mention. Note that, in this paper, the terms "team(s)" and "organization(s)" are used with discretion. Orasanu and Salas (1993) define groups as just collections of people. That is, groups are small organizations of people. Teams are a special class of groups that consists of two or more people who share a common goal (O'Neil et al., 1992; Orasanu and Salas, 1993; Hollenbeck et al., 1995). In particular, a team is a small organization, where communication is a beneficial component of a task (Carley et al., 1993). Therefore, a team has special characteristics as a special group as well as general characteristics as a small organization. In this paper, the term "organization(s)" is used when it is relevant to small organizations in general, whereas the term "team(s)" is used when it is appropriate to the special class of groups specifically.

The later parts of this paper are organized as follows: The next section reviews theoretical background of the study. The third section describes Team-Soar that models a naval command and control team and how the model implements agent activeness and cooperativeness specifically. The fourth section introduces a simulation experiment using Team-Soar and discusses the results. The last section presents the conclusion.

2. Background

2.1. Computational models of multi-agents systems

2.1.1. Computational models for agent types

Researchers in various disciplines have studied agent types (Genesereth et al., 1986; Decker, 1987; Chaib-Draa et al., 1992; Carley et al., 1993). Nevertheless, literature regarding agent types is still relatively rare (Beggan and Allison, 1994). This is due to that humans are complex being whose agent types are not clearly determined and therefore researchers have difficulties in measuring and controlling agent types when the variables are used in experimental settings with human subjects. The use of computational models can be a solution to the problems in studying agent types of humans. Computational models, which are symbolic representation of reality on computer, have been widely used for studying social natures of human or AI agents (Prietula and Carley, 1994; Prietula et al., 1998). See Lin and Carley (1993) for an example of using computational models for studying agent activeness and see Carley et al. (1993), Glance and Huberman (1994), and Macy and Skvoretz (1998) for examples of using computational models for studying agent cooperativeness.

2.1.2. Multi-agents systems for agent types

Multi-agent systems (MAS) can be used to build computational models of agent types within a team context. MAS is a subfield of distributed artificial intelligence (DAI), which studies how a collection of AI agents in a problem solving situation can interact to achieve a common set of global goals (Chaib-Draa et al., 1992). Both human groups and MAS are arrangements of distributed intelligence for multi-agent problem solving (Masuch, 1992). Hence, research in MAS can provide modeling methodologies of human groups and valuable insights of them. Reversely, studies of agent types have important implications on improving MAS. In particular, studies of agent types can contribute the improvement of the cyber space where multiple electronic agents interact to achieve their assignments (e.g. Tambe et al., 2000). See Yen et al. (2001) for an example of using MAS for studying agent activeness and see Bicchieri et al. (1998) for an example of using MAS for studying agent activeness.

2.2. Soar

Human team members are intelligent, but bounded-rational beings. Here, intelligent means that members make decisions on the basis of all the task-based information available to them, and bounded rational means that information availability depends on the current problem and the member's position (Carley and Lin, 1997). Moreover, each member is an independent, goal-oriented problem solver that has its own knowledge about the world. Considering theses features, in Team-Soar individual team member is modeled by a computational model called Soar (Laird et al., 1993, 1987). As an exemplar of Newell's "Unified Theories of Cognition," Soar is a candidate of the computational model of humans, which has sufficiently detailed cognitive architecture (Newell, 1990). Employing single set of mechanisms as the cognitive architecture, Soar is capable of knowledge-based problem