A Constructive Approach to the Evolution of the Planning Ability

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ABSTRACT

Human beings have behavioral flexibility based on a general faculty of planning for future events. This paper describes the first stage of a study on the evolution of planning abilities. A blocks world problem is used as a task to be solved by the agents, and encode an inherent planning parameter into the genome. The result of computer simulation shows a general tendency that planning ability emerges when the problem is difficult to solve. When taking social relationships, especially in the collective situation, into account, planning ability is difficult to evolve in the case that the problem is complex because there is a conflict between personal and collective interests. Also, the simulation results indicate that sharing information facilitates evolution of the planning ability although the free rider problem tends to be more serious than the situation where agents do not share information. It implies that there is a strong connection between evolution of the planning ability and symbolic communication.

Keywords: Collective Situation, Ecological Pressure, Evolution, Mental Time Travel, Planning, Social Pressure, Symbolic Communication

INTRODUCTION

Future-directed behavior can be seen in many animals as well as humans. For example, some hibernators store food for the coming winter just like humans who start building a shelter already in summer preparing for cold winter. So what is the difference in future-directed behavior between animals and humans? It has been said that animal behavior is instinctive but human behavior is flexible. “Mental time travel” is one of the capacities that provide increased behavioral flexibility of humans. Mental time travel is a term to refer to the faculty that allows humans to mentally project themselves backward in time to relive, or forward to pre-live, events (Suddendorf & Corballis, 1997). The crucial selective advantage that mental time travel provides is the flexibility in novel situations and the versatility to develop and adopt strategic long-term plans to suit goals (Suddendorf & Corballis, 1997). In this paper, we focus on the mental time travel into the...
future, especially the evolutionary aspect of the planning ability.

In the sphere of the cognitive science, it has been proposed that episodic memory is part of a more general faculty of planning for future events (Tulving, 1993). Tulving (1993) argued that the owner of an episodic memory system can transport freely into the personal past as well as into the future, a capability not possible for other kinds of memory such as procedural or semantic memory. Baddely (2000) proposed episodic buffer in a working memory system as a function to play an important role in feeding information into and retrieving information from episodic memory. Also, recent studies using functional neuroimaging techniques indicate that the prefrontal cortex plays a crucial role in working memory (Curtis & Esposito, 2003) and episodic memory (Squire et al., 1992). Although distinct elements of information processing of the planning have been gradually elucidated, and several kinds of mental models were proposed, the mechanisms about how these mental models have been shaped through the autonomous developmental of evolutionary process is not fully known.

Natural selection has been considered as one of the most widely held mechanisms to explain the emergence of living creatures’ complex characteristics. Evolutionary psychology has attempted to explain psychological traits as adaptations as the functional products of natural selection or sexual selection. It has been proposed that the prefrontal cortex, known to be critically involved in planning abilities, has been especially enlarged through the human evolution than other brain areas (Deacon, 1997). Large brains are extremely costly both to maintain and evolve. Therefore, in a niche where there is little to use planning abilities, it might have a relatively small impact on evolution of it. Recent studies have indicated that ecological pressures drove the evolution of intelligence of human (Byrne, 1997; Darwin, 1871; Hill, 1982; Osvath & Gärdenfors, 2005; Potts, 1998; Tooby & DeVore, 1987). For example, with the global shift to cooler climate after 2.5 million years ago, much of southern and eastern Africa probably became more open and sparsely wooded, and it exposed the hominids to greater risk from predators and drove them into a cognitive niche (Tooby & DeVore, 1987).

Yet, common problems for these ecologically based theories include difficulties with explaining why humans evolved such extraordinary cognitive competencies, considering that many other species hunt, occupy savanna habitats, endured the same climatic fluctuations, and so forth (Flinn et al., 2005). A different approach to the problem of the evolution of intelligence of human involves the consideration of the social aspect (Alexander, 1971, 1990; Brothers, 1990; Dunbar, 1998; Humphrey, 1976; Jolly, 1999). Alexander (1990) argued that it (evolution of the intellect) was rather the necessity of dealing continually with our fellow humans in social circumstances that became ever more complex and unpredictable as the human line evolved (pp. 4-7). Co-operating with other people is considered to be one of the most important factors to deal with our fellows in social circumstances. Furthermore, symbolic communication seems to be indispensable to co-operate smoothly with other individuals. Brinck and Gärdenfors (2003) traced the difference between the ways in which apes and humans co-operate due to differences in communicative abilities, claiming that there is a strong connection between the evolution of planning and symbolic communication. However, there is little known about the specific mechanisms that underlie it.

Considering all of the above factors, this study explores the dynamics inherent in the mechanism of the evolutionary acquisition of the planning abilities, focusing on the benefits of the planning and the costs of it. The first goal is to elucidate the environment which drove the evolution of planning ability. The second goal is to explore the dynamics inherent in the mechanism of evolution of the planning ability in the social circumstances. Our main method consists of a constructive approach which attempts to create not only a symbolic model of a living system, but also a symbolic living object (Moreno, 2002). Accordingly, our models are elaborated without direct and precise reference...
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