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Joint determination of biological encephalization, economic specialization☆

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ABSTRACT

In this paper, we develop a paleoeconomic model of the co-evolution of economic specialization and encephalization—the common physiological measure of intelligence as reflected by brain mass relative to total body mass. Our economic analysis links ecological and social intelligence theories of increased encephalization in early hominins through a model in which both economic and ecological feedbacks jointly determined the evolutionary incentives. We focus on degrees of specialization affected by coordination costs with and without market exchange. Our results suggest encephalization would be a process characterized by diminishing returns to behavioral advances. In terms of the long-running debate in economics over whether specialization increases or decreases intelligence, our results suggest from an evolutionary perspective the answer depends on economic/social institutions and how these influence ecological interactions.

1. Introduction

A central theme of Tom Crocker's research is that economic and ecological systems are jointly determined (e.g., Crocker and Tschirhart, 1992)—the two systems are fundamentally linked through a series of feedback processes. As a consequence, risks to environmental health and ecosystem services

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are endogenous (Shogren and Crocker, 1999). Crocker has applied this concept to a diverse set of topics ranging from groundwater policy (Crocker et al., 1991), invasive species management (Settle et al., 2002), health care policy (Chen et al., 2002), and human capital formation (Agee and Crocker, 1998). Our paper serves to illustrate how the concept of joint determination is relevant even for the co-evolution of human economic behaviors, specifically specialization, and the most important of all human physiological traits—encephalization. Greater encephalization means increased brain mass relative to total body mass, and is widely seen as a measure of intelligence (Williams, 2002).

Our model builds on Agee and Crocker's (1998) results in the area of human capital formation, and it addresses a debate in the economic literature initiated by Adam Smith. Smith (1965) proposed that specialization and intelligence, two of the key drivers of economic growth, are fundamentally linked. He theorizes specialization and intelligence are substitutes, whereby specialization reduces (the need for) intelligence because an individual only requires knowledge about his or her specialized skill. More recently, Becker and Murphy (1992) find a complementary relation may hold in some instances: investments in specialization and human capital are reinforcing when specialization is limited by coordination costs. But these results are less clear cut when human choices generate environmental impacts affecting utility. Agee and Crocker (1998) show how incorporating environmental relations in a model of human capital development produces economic and ecological feedback processes that can lead to ambiguous results. They stop short of modeling the thickening of markets via specialization, but they do propose that more research is needed on the role of ecosystem interactions in this process. In effect, this earlier work focuses on human investments in knowledge as opposed to evolutionary investments in intelligence. Herein we take things one step further. We investigate the role of economic and ecological feedbacks at the evolutionary level, shedding light on fundamental processes of what makes us human—the co-evolution of human physiology, behavior, and our natural environment.

The origin of human intelligence is at the core of understanding human beginnings. Researchers measure a species' intelligence by the *encephalization quotient* (EQ): the ratio of actual brain size to the predicted brain size based on body mass (Williams, 2002). Human EQ is far greater than the EQ of any other known animal. For instance, Williams calculates the EQ for humans to be 62.9, almost three and one half times the largest EQ among all other extant primates −18.5 for *Gorilla Gorilla*.

Scientists generally accept that human intelligence is the result of runaway selection—a self-reinforcing selection process, often described as a co-evolutionary arms race, fueled by positive feedbacks between humans (or hominins) interacting with each other or with their environment (e.g., Ofek, 2001). Debate remains, however, on the processes involved. Theories generally fall into one of two categories. First, the *social intelligence hypothesis* posits that social interactions drive runaway selection (Robson, 2005).[1] For instance, Robson (2005) and Ofek (2001) describe various ways in which individuals gain from having improved rationality or intelligence relative to others, resulting in runaway selection for this trait. Alexander (1990, p. 4) argued humans had "become so ecologically dominant that they in effect became their own principal hostile force of nature." That is, the encephalization process came about from within-group and cross-group social competition and coordination. Competition and coordination enabled us to achieve such dominance over our ecosystem we were no longer subject to ecological pressures. Flinn et al. (2005, p.15) write, "In this evolutionary scenario, the primary selective pressures acting on hominins – particularly in regard to the brain – came from their dealings with other hominins rather than with climate, predators, and food directly." Only social pressures mattered and these spurred runaway selection for intelligence. These theories, however, do not address why hominin social environments developed differently and spurred unique outcomes as compared to our closest primate relatives (see Flinn et al., 2005). Moreover, if complex social interactions did spur encephalization, why has encephalization apparently ceased, or declined (Ruff et al., 1997) today when humans have developed the most complicated and ecologically dominant society the world has ever known?

[1] The label "social intelligence hypothesis" is used in economics, while other labels have been adopted in other fields. For instance, in human behavioral ecology, Flinn et al. (2005) use instead the label Ecological Dominance-Social Competition (EDSC) model, as proposed by Alexander (1987, 1990).