

## PSYCHOLOGY

# Rice, Psychology, and Innovation

Joseph Henrich

By the late 18th century, the earliest tremors of the industrial revolution were beginning to shake England. Fueled by a stream of innovations related to textiles, transportation, and steel manufacturing, this eruption of economic growth would soon engulf northern Europe, spread to Britain's former colonies, and eventually transform the globe. For the first time, humanity would be sprung from the Malthusian trap. The question of why this revolution first emerged in northern Europe remains one of history's great questions. If you stood overlooking the globe in 1000 CE, the most obvious candidates for igniting this engine were perhaps in China or the Middle East, but certainly not in Europe. Addressing this question, researchers have pointed to differences in geography, institutions, religions, and even genes (1, 2). On page 603 of this issue, Talhelm *et al.* (3) take an important step forward by fingering psychological differences in analytical thinking and individualism as an explanation for differences in innovation, and then linking these differences to culturally transmitted institutions, and ultimately to environmental differences that influence the feasibility of rice agriculture.

Decades of experimental research show that, compared to most populations in the

world, people from societies that are Western, Educated, Industrialized, Rich, and Democratic (WEIRD) (4) are psychologically unusual, being both highly individualistic and analytically minded. High levels of individualism mean that people see themselves as independent from others and as characterized by a set of largely positive attributes. They willingly invest in new relationships even outside their kin, tribal, or religious groups. By contrast, in most other societies, people are enmeshed in dense, enduring networks of kith and kin on which they depend for cooperation, security, and personal identity. In such collectivistic societies, property is often corporately owned by kinship units such as clans; inherited relationships are enduring and people invest heavily in them, often at the expense of outsiders, strangers, or abstract principles (4).

Psychologically, growing up in an individualistic social world biases one toward the use of analytical reasoning, whereas exposure to more collectivistic environments favors holistic approaches. Thinking analytically means breaking things down into their constituent parts and assigning properties to those parts. Similarities are judged according to rule-based categories, and current trends are expected to continue. Holistic thinking, by contrast, focuses on relationships between objects or people anchored in their concrete contexts. Similarity is judged overall, not on the basis of logical rules. Trends are expected to be cyclical.

People in wheat-cultivating areas of China are more individualistic and analytical than those in rice-cultivating areas.

Various lines of evidence suggest that greater individualism and more analytical thinking are linked to innovation, novelty, and creativity (5). But why would northern Europe have had greater individualism and more analytical thinking in the first place? China, for example, was technologically advanced, institutionally complex, and relatively educated by the end of the first millennium. Why would Europe have been more individualist and analytically oriented than China?

Talhelm *et al.* hypothesized that different combinations of environments and technologies influence the cultural evolution of different forms of social organization. Under

**Measuring analytical thinking and individualism.** To investigate the individualism and analytical thinking in participants from different agricultural regions in China, Talhelm *et al.* used three tests. They measured analytical thinking with a series of triads. Participants were given a target object, such as a rabbit, and asked which of two other objects it goes with. Analytic thinkers tend to match on categories, so rabbits and dogs go together. Holistic thinkers tend to match on relationships, so rabbits eat carrots. The authors also measured individualism in two ways. First, they asked participants to draw a sociogram, with labeled circles representing themselves and their friends. In this test, individualism is measured implicitly by how much bigger the "self" circle is relative to the average "friends" circle. Second, they assessed the nepotism (in-group loyalty) of participants by asking them about hypothetical scenarios in which they could reward or punish friends and strangers for helpful or harmful action.

Departments of Psychology and Economics, University of British Columbia, Vancouver, Canada V6T 1N5. E-mail: henrich@psych.ubc.ca

**Measuring analytical thinking with triads**

Does the rabbit go with the dog or the carrot?

**Measuring individualism**

Relationship between self and friends

Going into business with friends or strangers

The friend or stranger is honest and you make money. How much do you reward him?

The friend or stranger is dishonest. How much do you punish him?

some techno-environmental conditions, only intensely cooperative social groups can endure, prosper, and spread. Although potentially applicable to many situations, including territorial defense and whale hunting, Talhelm *et al.* focus on the different labor requirements of paddy rice and wheat cultivation. By demanding intense cooperation, paddy rice cultivation fosters and reinforces the social norms that govern patrilineal clans. Growing up in strong clans creates a particular kind of collectivistic psychology. In contrast, wheat cultivation permits independent nuclear households and fosters more individualistic psychologies.

To test these ideas, Talhelm *et al.* used standard psychological tools (see the figure) to measure analytical thinking and individualism among university students sampled from Chinese provinces that vary in wheat versus rice cultivation. Focusing on China removes many of the confounding variables such as religion, heritage, and government that would bedevil any direct comparison between Europe and East Asia. The prediction is straightforward: Han Chinese from provinces cultivating relatively more wheat should tend to be more individualistic and analytically oriented.

Sure enough, participants from provinces more dependent on paddy rice cultivation were less analytically minded. The effects were big: The average number of

analytical matches increased by about 56% in going from all-rice to no-rice cultivation. The results hold both nationwide and for the counties in the central provinces along the rice-wheat (north-south) border, where other differences are minimized.

Participants from rice-growing provinces were also less individualistic, drawing themselves roughly the same size as their friends, whereas those from wheat provinces drew themselves 1.5 mm larger. [This moves them only part of the way toward WEIRD people: Americans draw themselves 6 mm bigger than they draw others, and Europeans draw themselves 3.5 mm bigger (6).] People from rice provinces were also more likely to reward their friends and less likely to punish them, showing the in-group favoritism characteristic of collectivistic populations.

So, patterns of crop cultivation appear linked to psychological differences, but can these patterns really explain differences in innovation? Talhelm *et al.* provide some evidence for this by showing that less dependence on rice is associated with more successful patents for new inventions. This doesn't nail it, but is consistent with the broader idea and will no doubt drive much future inquiry. For example, these insights may help explain why the embers of an 11th century industrial revolution in China were smothered as northern invasions and climate change drove people into the southern

rice paddy regions, where clans had an ecological edge, and by the emergence of state-level political and legal institutions that reinforced the power of clans (7).

Cultural evolution arises from a rich interplay of ecology, social learning, institutions, and psychology. Environmental factors favor some types of family structures or forms of social organization over others. Honed and refined over generations, these institutions create the conditions to which children adapt developmentally, shaping their psychologies and brains. Long after their ecological causes have become irrelevant, these cultural psychologies and institutions continue to influence rates of innovation, the formation of new institutions, and the success of immigrants in new lands. As such, wheat farming may contribute to explaining the origins of WEIRD psychology and the industrial revolution.

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## NEUROSCIENCE

# A Price to Pay for Adult Neurogenesis

Lucas A. Mongiat<sup>1</sup> and Alejandro F. Schinder<sup>2</sup>

We tend to believe that plasticity is what makes brain circuits adaptable to continuous changes in environmental demands and that greater brain plasticity should result in a better ability to cope with the surrounding world. To adapt to everyday life, animals explore, learn, and remember, and these tasks make use of various cortical structures, including the hippocampus. The dentate gyrus, part of the hippocampus, is a remarkable structure in that it is one of two areas of the adult mammalian brain, including the human

brain, that continue to generate new neurons throughout postnatal life (1). It is well established that adult-born neurons integrate into preexisting neuronal networks and participate in information processing (2). Much evidence accumulated over the past decade supports the hypothesis that adult neurogenesis itself is a type of circuit plasticity required for hippocampus-dependent learning and memory recall. The work by Akers *et al.* on page 598 of this issue (3) now shows that adult hippocampal neurogenesis may also promote forgetting.

In the adult hippocampus, new-born granule neurons develop and establish synaptic connections within preexisting neuronal networks very slowly. Input and output

Newly formed hippocampal neurons participate in the encoding of new memories in adult rodents, but too much neurogenesis may jeopardize memory retention.

connections are refined during several weeks as neurons acquire a meaningful functional integration. The specific functional role of these new cells is not clear. Nor is it clear why the dentate gyrus requires freshly assembled neurons to perform its function. It has been proposed, based on its architecture, that the dentate gyrus may play a critical role in performing “pattern separation” of incoming inputs. Pattern separation is the process whereby similar pieces of information are represented by distinct (orthogonal) sets of neurons in the output network. It has been proposed that in a behavioral context pattern separation underlies the capacity to extract the subtle differences among environments or cues that are otherwise

<sup>1</sup>Research Institute for Biodiversity and Environment (INIBIOMA, CONICET), Bariloche, Río Negro, Argentina. <sup>2</sup>Laboratory of Neuronal Plasticity, Leloir Institute (IIBBA, CONICET), Buenos Aires, Argentina. E-mail: aschinder@leloir.org.ar