The Rice Theory of Culture

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Abstract

In this paper, I present evidence that rice agriculture makes cultures more interdependent. First, I review anthropological research showing that rice has much higher labor and irrigation requirements than other traditional staple crops such as wheat and millet, as well as evidence that humans solve these problems with reciprocity and coordination. Study 1 tests this with 1,162 Han Chinese participants in six sites from all over China. Participants who grew up in rice provinces had more holistic thought, lower individualism, and higher loyalty/nepotism toward close friends. Study 1 also finds that rice provinces have lower divorce rates and fewer patents for inventions, controlling for GDP per capita. Study 2 replicated the rice-wheat thought style differences and loyalty/nepotism differences in India, which also has a rice-wheat split. Study 3 tests the theory in a more fine-grained way by collecting a large sample in Anhui province, which sits on the rice-wheat border. Three of four tasks showed rice-wheat differences at the county level. Study 4 tests whether differences in analytic thinking extend to ability to solve logic problems or whether the differences in thought style are truly "styles" that come out only at times when problems do not have a clear right or wrong answer. The results showed that holistic thinkers did better on logic problems, suggesting holistic thought is not indicative of less logical ability.

Keywords: culture, rice, wheat, China, East Asia, subsistence theory, origin of cultural differences, agriculture, ecological psychology

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The rice theory of culture

"Rice is a highly productive crop, but this productivity is paid for with labor and water" (Fuller & Qin, 2009, p. 88).

The East Asian Paradox

Several years ago, I was hiking in southwest China with a couple of French travelers I had met on the way. When we stopped to eat in a small-town restaurant, one pointed out that we wouldn't have to tip in the restaurant because people in China do not tip waiters. Without pausing, she added, "But they'll get that soon enough, as they modernize."

The thought that modernization will automatically cause people to start the custom of tipping borders on the absurd. But I think the thought has a logic behind it that many people share, myself included. The logic is that modernization makes cultures more Western, more individualistic. Like my French traveling partner, many people have the intuition that modernization leads to the individualistic culture typical of the West. Researchers have that intuition too: anthropologists studying changes of modern Chinese villages (Yan, 2002), psychologists studying native Mayans' transition to the market economy (Greenfield, 2009), and political scientists running the World Values Survey (Inglehart, Basanez, & Moreno, 1998).

And there is no doubt that modernization affects how people live. Modernization gives people cars, supermarkets, computers, and apartment buildings. There is also evidence that modernization shifts people's values. For example, as countries become wealthier, people shift from a focus on material well-being to quality-of-life concerns like environmentalism and self-expression (Inglehart et al., 1998).

But how much does modernization change culture? One way to test that question is to study East Asia. Over the last 50 years, East Asia has experienced enormous modernization and wealth creation, making it a giant living experiment for the theory that modernization

makes cultures individualistic. Japan emerged first, growing astronomically from about 20% of Western Europe's GDP per capita in 1950 to neck and neck in the 1970s, and then finally surpassing Western Europe in the 90s. Hong Kong, Singapore, and Taiwan skyrocketed not long afterwards. By the year 2000, Hong Kong and Singapore had surpassed Western Europe. Taiwan is not far behind. Although Korea would still need to grow by 30% to catch up with Western Europe, its economy still managed to grow 10 fold from 1960 to 1996. China's economy launched much more recently, starting to take off in the 1990s, and it is still far behind (Figure 1).

If the intuition about modernization is correct, all of this economic growth should be making East Asia much more individualistic. Based on GDP alone, Singapore, Hong Kong, and Japan should be roughly as individualistic as Western Europe. But when you look at international studies of individualism, East Asia is still far lower than where it "should be" based on its GDP per capita. To illustrate this phenomenon, I plotted year 2000 GDP per capita against the average of three published measures of individualism and collectivism (Figure 2; Gelfand, Bhawuk, Nishii, & Bechtold, 2004; Hofstede, 2001; Suh, Diener, Oishi, & Triandis, 1998).

GDP per capita explains 51% of the variance in individualism (Figure 2). However, *all* of the wealthy East Asian countries are far less individualistic than nations that are just as wealthy. In fact, all of wealthy East Asia is below the 95% confidence interval predicted by GDP. This is the East Asian paradox.

Doesn't Change Take Time?

One way to explain the paradox is to make our theory a bit more sophisticated. We can build in the caveat that it takes time for economic growth to change a culture, and maybe East Asia's wealth is too recent to have changed its culture. Maybe wealth has just not had enough time to make East Asia individualistic. I'll call this the "change takes time" theory.

I find the change-takes-time theory plausible. However, including it in the model does not resolve the East Asian paradox. One rough way to test that theory is to look at other countries that have become wealthy in the last 50 years. If change takes time, these other countries should also be less individualistic than their current wealth predicts.

To illustrate this, I placed red dots on the seven other countries in Figure 2 that doubled their GDP per capita from 1969 to 2000: Greece, India, Turkey, Austria, Finland, Portugal, and Spain.[1] Of these seven countries, only Portugal is significantly less individualistic than GDP predicts. Four countries are on the regression line or very close to it (Greece, Spain, Turkey, and Austria), and two are *more* individualistic than their wealth would predict (Finland and India). Of course, this is a very rough way to test the theory, but at first glance, the change-takes-time theory does not seem to be able to explain the East Asian paradox.[2]

The Rice Theory of Culture

The rice theory of culture can help explain the East Asian paradox. Rice can explain at least partly explain why East Asia is so much more collectivistic than it "should be" based on its economic development. In Figure 2, GDP per capita explains 50.8% of the variance in individualism. However, adding a simple dichotomous "rice culture" variable[3] increases the explained variance to 73.7%.

[1] Some readers may guess that this comparison is unfair because the East Asian countries started off from a poorer base to begin with. This is not the case. In 1969, the East Asian economies made between $712 (China) and $8,800 (Japan) per capita. The non-East Asian countries made between $844 (India) and $9,000 (Austria).

[2] This paradox exists *despite* the fact that (in my opinion) some of the measures of individualism in international surveys are conflated with modernization (such as the "individualism" item asking about the importance of having "good physical working conditions." See Appendix 1.

[3] To categorize cultures as rice cultures, I analyzed rice output statistics and removed cultures that produce rice in the modern day, but not as a major part of the culture in pre-modern times, such as Australia, Italy, and the United States.

Yet this is large-scale data. Analyzing data at the country level is helpful, but it can be dangerous because there are many other variables that differ between countries. It is important to complement large-scale data with more careful comparisons of nearby areas and people who farm rice and wheat.

For me, the rice theory did not start with the East Asian paradox. Instead, it started with my observations living in China. While teaching at a high school in Guangzhou in the far south of China, I noticed that when people would accidentally bump into me in the supermarket, they would often tense up and shuffle away without saying anything. I also noticed that my Chinese friends put a lot of effort into thinking through what they would say to people so as to avoid offending them. People there seemed very focused on avoiding conflict.

A year later, I moved to Beijing in northern China, and I had almost as much culture shock as when I moved to China in the first place. The day I arrived and got out of the taxi from the airport, an elderly man on a bicycle started yelling at the taxi driver for parking in the bike lane (all while I was struggling to get my bags out of the trunk). Over my next year in Beijing, I found people were quicker to make friends and quicker to tell me like it is. Northern and southern China seemed to have very different cultures.

But the north and south have more than just a cultural divide. They also have an agricultural divide. The traditional line between rice-growing areas and wheat-growing areas essentially splits the country in two (Figure 3).

The Rice Theory

The rice theory of culture is based on the idea that paddy rice has different requirements from other staple crops such as wheat, corn, and millet. The two biggest features of rice farming are:

1. Paddy rice requires about twice as much labor as wheat.

2. Paddy rice often requires elaborate irrigation systems.

To deal with the labor demands, rice farmers often form cooperative labor exchanges (Bray, 1986; Fei, 1945). To make the irrigation systems work, rice farmers have to coordinate their behavior, making it more costly to have conflict with other people. In addition, traditional irrigation systems required extra manpower to build, dredge, and drain, which adds to the already burdensome labor requirements.

The rice theory is that, over time, cultures that farm rice build values and habits that are consistent with the behaviors required to farm rice. Furthermore, once that rice culture is established, it persists even after farmers put down their plows and move into cities and office jobs. Rice is very different from the other major staple crops of the traditional world, and this uniqueness can help explain why rice cultures are consistent outliers in international studies of individuals.

Rice Requires More Labor than Wheat

Perhaps the best evidence for the labor requirements of rice and wheat comes from anthropologists visiting pre-modern rice and wheat villages. Anthropologists Fei Xiaotong[4] and John Buck studied farming villages in China in the early 1900s and documented how many hours farmers spent on their plots. Their conclusions were the same, although their methods were quite different.

John Buck's method resembled that of statistics departments in modern governments. Buck trained a survey team and sent it to 12,076 farms in 22 Chinese provinces in the 1920s and 30s (Buck, 1935). They found that rice farmers on average were spending over 50 days per year per crop acre for a single crop of rice; wheat farmers were spending closer to 25 days per acre (Buck, 1935, p. 302).

[4] I'm observing the Chinese custom of putting the family name (Fei) before the given name (Xiaotong) because I find it jarring to hear the order switched from the original. We in the West seem to be inconsistent anyway. We still refer to Deng Xiaoping and Mao Zedong with their family names first.

Fei Xiaotong took a more micro approach. Fei trained at the London School of Economics, and his approach was a combination of anthropology and economics. He led a smaller but more in-depth study of three rice villages in Yunnan province (Fei, 1945). Similar to John Buck, Fei found that rice required about twice as much labor as wheat and barley (Fei, 1945, p. 214).

This is true even when it was the same farmer planting different crops (Fei, 1945). For example, in the Yunnan villages Fei studied, some rice farmers planted corn when they were short of labor, during the winter when the fields were dry, or on land that had soil that was too loose for rice.[5] Fei (1945) found that they spent an average of 165 days of labor farming rice, but only 85 days for corn (which is grown similarly to wheat).

Fei also took the study one step further. He created an accounting for the bare minimum amount of rice a single family would need to avoid starvation and barter for all of their basic needs, such as clothes and tools. He concluded that a husband and wife would not be able to farm a large enough plot of rice to support the family if they relied on their labor alone (Fei, 1945; Wong, 1971).

Historical evidence of rice labor. Fei and Buck were systematic, but they were not discoverers. It does not take careful observation to discover a difference so large. The difference between how much labor rice and wheat require was so large that it was apparent to the people farming it. For example, a Chinese farming guide in the 1600s advised, "If one is short of labor power, it is best to grow wheat…the reason for not planting rice is to economize on labor power" (quoted in Elvin, 1982, p. 30).

[5] Some land had sandy soil that was too loose to plant with rice, so farmers planted corn, beans, or other crops in those fields (Fei, 1945, p. 138). Perkins (1969) argues that water is the main limitation for where rice can be grown in China. "In fact, when water is adequate, rice can be grown almost anywhere in China" (Perkins, 1969, p. 43). This also includes the soil needed to retain that water (Elvin, 2006).

The labor burden of rice is also a theme in folk songs. The China historian Mark Elvin describes popular "mountain ditties" that farmers sang while working in the rice fields (Elvin, 2006). The songs speak about toiling in fields while exhausted, swatting away mosquitoes, working in the darkness, and keeping an eye on people starting to succumb to exhaustion. Throughout the songs is a theme of "the economic need to endure discomfort" (Elvin, 2006, p. 210).

One song talks about keeping the slowest workers motivated: "The lazy workers are put in front; some way further back, the diligent" (the poetic feel is lost in translation; Elvin, 2006, p. 210). Presumably people who were prone to slacking were put in the front so that the diligent workers could see them and put them back to work if they started relaxing. More examples come from the Chinese writer Qian Zai, who grew up in the rice areas around Shanghai and later became an artist and writer. As a writer, he extolled rice farmers' "stoical endurance of pain" (Elvin, 2006, p. 210).

To energize themselves for the hard work, rice farmers around Jiaxing (near Shanghai) held special festivals. After drinking alcohol, the farmers would "shout in drunken fashion and mutually encourage each other to endure the bitter work" (Elvin, 2006, p. 211). These festivals were fittingly called "Green Sprouts Gathering."

Other historical sources describe the toil this labor took on people's bodies. For example, an official gazetteer from Yunnan province in 1563 described the toil needed to repair irrigation systems. On top of the labor needed to farm their plots, the labor irrigation exhausted farmers, "their hair becoming grey because of their lack of rest" (quoted in Elvin, 2006, p. 125).

Of course the historical accounts are anecdotal. Anthropologists' observations of rice and wheat farmers are more authoritative because they are more systematic. However, the

historical records suggest that everyday Chinese people were aware of the large labor burden of rice—that it was a part of everyday life.

Was rice labor high outside of China? These examples all come from China, which raises the question: Were Chinese rice farmers just fervent farmers? Did they spend more time in their fields than they needed to? Anthropologists studying farmers in other countries have shown that rice requires more labor there too. Richards (1987) compared millet farmers and rice farmers in Sierra Leone, which is quite far from the cultural influence of East Asia. He found that millet required 593 hours per hectare, while rice required 1,360 hours.[6] Again, the result is roughly double the number of hours for rice.

Richards also came to a similar conclusion as Fei about the necessity of exchanging labor. "Even the largest farm households…are unable to meet all their labor requirements from within the group" (Richards, 1987, p. 173). This suggests that rice farmers needed to exchange labor.

Thus, evidence from two distant rice cultures both support the notion that rice requires much more labor than wheat. There is evidence from other cultures, such as India, Malaysia, Japan, and Indonesia. However, instead of listing that here, I will draw on studies in those cultures when I discuss the details of rice labor in the following sections.

Why does rice require so much labor? One reason rice requires so much labor is that rice is often transplanted. Wheat isn't. Or put another way: rice responds well to transplanting, but wheat does not. Transplanting is when farmers first grow rice in small plots (often near the home) and then later transplant the seedlings to the main field.

Transplanting has several benefits. When seedlings are small, they need less space, which frees up the main field for other crops. This makes it possible to grow two or even three

[6] However, Richards also says that West African rice did not often use intensive irrigation systems. Instead, rice is more often farmed on dry land or in swamps. If this is the case and if irrigation is an important mechanism between rice and collectivism, then rice farming may less of a cause of collectivism in West Africa than in East Asia.

crops a year. Starting the seedlings in small plots also makes it easier for farmers to monitor the water level, which is important for young rice plants (Fei, 1983, p. 74).

Transplanting also allows farmers to plant the seedlings more precisely in the field, maximizing the use of the land (Elvin, 2006, p. 168). The alternative to transplanting is usually "broadcasting," or throwing seeds into the field. Throwing the seeds into the field saves time, but it cannot ensure that the clumps are evenly spaced or that land use is maximized.

Thus, transplanting requires a lot of work, but it increases yield. Elvin (2006) estimated that it would take about 6 people 10 hours to transplant a *mou* of land (a *mou* is a traditional Chinese measure of land; about .07 hectares or 26.5 meters by 26.5 meters, Elvin, 2006, p. 209). Fei (1946) estimated that a single person could transplant a *mou* in two days (p. 163). In more familiar terms, it would take that person 11-12 days of full-time work to transplant a single acre (about 75% of a football field).

To make things more complicated, farmers had to finish transplanting and their other tasks in a prescribed window of time. This creates labor bottlenecks—times when a lot of labor is needed within a short amount of time. These bottleneck problems tend to be cumulative. Missing one task will cause more work down the line or make that work more urgent (Richards, 1987, p. 173). Richards (1987) describes why:

> If plowing is delayed too far into the rainy season, cleared farms become choked by weeds and excessive cloud cover and rainfall inhibit the growth of young rice plants…if the harvest is not gathered on time, the farm field is vulnerable to bird damage and theft. Tardy brushing leaves insufficient time for felled material to dry thoroughly before the first rainstorms (Richards, 1987, p. 173).

Beyond the absolute number of hours needed, labor bottlenecks raise the incentives to cooperation. That's because a single farmer might be able to complete a task, but it becomes much more difficult to do it if that task has to be finished in, say, a week. Strict time windows make it more necessary to trade labor with other people.

Of course, rice is not the only crop that has time windows. However, Fei (1945) argues that rice has stricter time windows than many other crops. For example, Fei observed rice farmers who would also grow beans and corn on some plots of land. In describing the schedule of farm work, Fei first describes the strict time windows of rice and says, "the same is true of the broad bean and of the corn, but these can be handled with less strictness" (Fei, 1945, p. 143).

Irrigation Requires Labor

A major difference between rice and the other major grain crops is that paddy rice grows best in standing water. Some parts of the world have precisely the right rainfall at the right time of the year, making it so they don't have to irrigate their fields. However, about 75% of the world's rice production is grown using human irrigation (IRRI, 2009). And even in areas where rice *could* be grown without human irrigation, irrigation can improve yields by giving farmers more tools to fight drought and more precise control over the water level.[7]

A modern farmer can irrigate huge fields by turning on a diesel pump, but many traditional farmers had to use their arms and legs to pump water, and this added to the labor requirements (Bray, 1986). To get the water in and out of the fields, many rice farmers in China used "dragon's backbones" (Figure 6 and 7).

To operate the dragon's backbone, farmers step on pedals, which spin a log. As the log spins, it pulls up a line of wooden pallets that pull water up and then eject it at the top. It was

[7] Having the appropriate water level can increase yields. Relying on the timing of rainfall can jeopardize productivity. Relying on rainfall alone also makes it harder for farmers to fight salinization (IRRI, 2009).

a slow process. Vermeer (1977) calculated that four laborers using a footpump could irrigate .0067 hectares in an hour (p. 170). If we multiply that by the average size of a paddy rice farm in Japan in the early 1900s (Bray, 1986, p. 116), it would take four men about 75 hours to irrigate a single field. That's almost two full weeks of labor from four men.[8] In 1909, rice farmers in Japan were spending 70 man-days of labor per hectare on irrigation—over two months of full-time labor for irrigation alone (Bray, 1986, p. 55; Ishikawa, 1981).

Putting water *into* the field is probably the most obvious task in irrigation, but farmers sometimes had the opposite problem. They had to prevent too much water from coming into the field. This happened when rains were heavy or when winter snow melted too quickly in the spring. To keep their fields from getting too much water, farmers had to drain the field, which often involved pumping water with their feet.

In sum, drainage is often a very large task. It is so large that farmers could not handle it alone. As Bray argues, drainage projects "cannot usually be carried out without the cooperation of a relatively large community" (Bray, 1986, p. 68).

Irrigation requires maintenance. The labor burden increases when you zoom out to include not just flooding the fields, but repairing the irrigation networks. Without modern machines, these projects take a massive amount of labor. Historical records from China's Yunnan province detail an irrigation project that required 90,000 men to rebuild embankments and 60,000 men to clear and dredge *each year* (Elvin, 2006 p. 126).

Many repair and maintenance tasks had to be repeated every year or so—an "unending labor" (Elvin, 2006, p. 128). One example is dredging. As rivers bring water to the ocean, they also bring dirt suspended in the water. Over time, this dirt settles on the bottom of the irrigation channels and can eventually cause the water level to rise and overrun the banks. It

[8] Some farmers used animals to pull the pump. However, animals bring their own labor costs because farmers have to buy or grow more grain to feed the animal.

can also clog irrigation paths, rendering them useless. Rice farmers had to dredge their irrigation networks frequently.

An official gazette from Yunnan province in 1563 described the irrigation maintenance that had to be done "constantly every year" (Elvin, 2006, p. 125). Similarly, the rice farmers in the village that Fei Xiaotong studied built irrigation ditches that "must be cleared and repaired every year" (Fei, 1945, p. 138). In sum, irrigation added a significant amount of labor for rice farmers every year.

Irrigation requires extra field preparation. Flooding the fields also made it so that farmers had to be more careful when they plowed their fields. In uneven fields, some soil will stick out above the water level and grow more weeds. Figure 8 demonstrates the weed growth that can occur without proper flooding (IRRI, 2007). Weeds compete with rice for nutrients and sunlight, so farmers with uneven fields have to spend more time weeding or sacrifice their yields.

Alternatively, farmers with uneven fields can flood their fields with even more water to make sure the entire field is covered with water (IRRI, 2007). However, this leads to its own problems. First, flooding with extra water raises the amount of labor needed to flood and drain the fields. Furthermore, many systems just don't have enough water to support extra flooding. Having level fields allows farmers to use less water.

Level fields are also important so that rice grows evenly in the field. If rice in one part of the field has too little or too much water, it will take longer to mature, which may decrease yield. It can also mean that sections of the rice field will not be mature when it is time for the harvest. Carefully controlled modern studies of field levelness have shown that uneven fields give lower rice yields (Figure 9).

The evidence above comes from Asia, but there is also evidence from outside of East Asia that irrigation networks added to labor requirements. Richards (1987) observed rice

farmers in West Africa repairing irrigation channels and embankments (p. 162). This is part of the reason rice farming in West Africa took about twice the number of hours as millet (Richards, 1987).

Wet fields are harder to work in. Finally, paddy rice can require more work because wet fields are harder to work in, particularly around harvest time (Hayami, 1978, p. 27). The wet mud in the bottom of the field makes it harder to move around and complete tasks such as weeding. That means that it can take rice farmers longer to complete the same tasks that wheat farmers have. In sum, paddy rice requires more work mainly because (1) it often uses irrigation and (2) it usually requires tasks that wheat does not, such as transplanting.

Cooperative Exchanges

To deal with the massive labor requirements, rice farmers form cooperative labor exchanges. Anthropologists have found cooperative labor exchanges in rice villages from China (Fei, 1945) to West Africa (Richards, 1987), Korea (Reed, 1977), India, Malaysia, Indonesia, and Japan (Bray, 1986). In the Chinese village Fei Xiaotong (1945) studied, labor exchanges were "common practice" (p. 144). In *The Rice Economies,* Francesca Bray (1986) says, "labor exchange systems have been found in almost every society where rice is grown" (p. 120).

Labor exchanges are common to rice farming, but they come in many different forms. In a rice village in Malaysia, farmers would gather in groups of 10 to 12 families (Bray, 1986, p. 120). The large group would plant one farmer's field at a time and then move onto the fields of other farmers. Because there is an advantage to having your farm planted first, the families would give the coveted first position to a different family each year. Anthropologists have found similar family-to-family exchanges in Japan (Bray, 1986, p. 120) and Korea (Reed, 1977).

One problem with labor exchanges is that, if everyone in the village plants their rice at the same time, it will all come ripe at the same time. In that case, it can be difficult to find people who are free to exchange labor. To solve this problem, some farmers stagger the time they plant their crops, allowing a group of farmers to plant one farmer's field first and then move onto another farmer's field. This was how rice farmers exchanged labor in parts of Malaysia and Thailand (Bray, 1986, p. 124; Tsuruta, n.d.). The staggered-exchange system is also an example of how paddy rice required not just extra labor, but coordination.[9]

Another way to coordinate labor is to plant different types of rice. Lewis (1971) found that farmers in the Philippines did so to make their fields come ripe at different times. That allows several farmers to help out when one farmer's rice is ready to be harvested, and vice versa.

Some farmers exchange labor within their extended family, but many farmers also exchange labor with neighbors. In Southwest China, Fei (1945) found that villagers preferred to exchange labor among extended family members because it helped ensure people repaid their labor debts. Fei saw this in a farmer named Wang, who needed help harvesting his rice. Wang enlisted his wife, his son, his son's wife, a niece, and two nephews from a neighboring village (Fei, 1945, p. 65).

In Sierra Leone, labor exchanges are more flexible. Families exchange labor, but acquaintances, divorcees, and even groups of children exchange labor. Richards describes what he saw in rice villages in Sierra Leone:

> I knew of cases where, for example, a man and a woman, both recently divorced, found it convenient to agree to share the responsibilities of a [rice] farm for a single season; where a woman trader, short of capital, proposed to join a former boyfriend

[9] Fei also argues that labor exchange leads to efficiency. I detail this argument in Appendix 2.

> and his wife in a farm; where a man and a female relative made a farm with the help of several foster children. At the end of the farming year temporary units of this sort might dissolve, never to form again (Richards, 1987, p. 170-171).

Richards also found labor groups of small children led by an older caretaker. When a father had several dependent sons, he might send one to work in a *gboto*, a youth labor group. In the *gbotos*, an elder manages the children by fining and punishing them if they fail to keep up with the group. When the rice teams would work in the field, drummers beat a rhythm to coordinate their movement (Richards, 1987, p. 174). In sum, rice farmers in many different cultures use labor exchange to deal with the labor burden of rice, although labor exchanges take different forms in different cultures.

Irrigation Requires Coordination

Rice farmers coordinated irrigation tasks. Irrigation networks require more labor, but they have a feature that is different from many types of labor. Many tasks in daily life—cooking, cleaning, fetching water—fall on individuals or single families. One person can decide to cook more one day and less another. You can wash your clothes today, and your friends can wash their clothes tomorrow. The tasks do not depend on each other.

Irrigation labor is different because many irrigation tasks fall on groups of people, rather than individuals (Aoki, 2001, p. 46). For example, farmers had to decide how to divide water resources. They also had to split up the labor required to maintain the irrigation systems. As one writer put it, “using water effectively required collective organization” (Blunden, 1983, p. 208).

One task farmers have to coordinate is the labor needed to maintain the irrigation networks. This leads to a classic commons dilemma. Everyone in the village benefits from the irrigation network because it helps them produce more rice, but no one individual farmer

wants to be stuck with the cost of building and repairing that system. Thus, rice farmers need to solve the commons problem through collective action.

Another type of coordination problem was deciding when to flood the fields. In some irrigation systems, farmers need to flood and drain their fields at the same time (Bray, 1986, p. 119). For example, Fei (1946) describes a rice village near Shanghai[10] that used human-powered pumps (p. 172). The fields of several families shared a single drainage ditch, which forced them to drain their fields at the same time.

One way to solve collective irrigation problems is with a central government, and this is certainly how *some* water problems were solved in China. However, many irrigation networks in rice areas were built and governed by villages (e.g., Aoki, 2001; Elvin, 2006). There are also examples of wealthy people using their personal fortune to solve irrigation problems. In India, temples and wealthy farmers sometimes donated money to build or repair irrigation networks so that they could gain religious merit (Stargardt, 1983, from Bray, 1986, p. 65).

My argument is that the need to coordinate irrigation raised the costs of being an individualist. If a single farmer decided he wanted to drain his field now and get started with his harvest, his neighbors would probably get angry because his decision affects how they farm their fields. Similarly, if an individual farmer neglected his shared duty to repair the irrigation networks, it is a good bet his neighbors would notice and be unhappy with him. In the case of Japan, Aoki (2001) describes the practice of *mura hachibu* or "80 percent separation from the village" (p. 46). Farmers could use this method to punish non-cooperative neighbors, excluding them from labor exchanges and local festivals. Contrast this with wheat farmers, who do not need to flood their fields. Individual wheat farmers have more say in when they harvest their wheat, with lower costs to being an individualist.

[10] The village Fei describes is actually near Jiaxing, which Elvin (2006) describes in detail.

Rice farmers coordinate water use. Once irrigation systems let farmers control how much water they use, they need to coordinate *how much* water they use. This is usually not a problem for wheat farmers because they usually rely on rainfall.

We can still see this problem in modern farming. Even with modern pumps and pipes, farmers today have to coordinate how much water they use with cities and governments. When rainfall is low, farmers and cities need to decide whether cities will cut down on their water use or whether farmers will let their crops die.

In the pre-modern world, cultures solved the water-coordination problem in different ways. For example, farmers in Bali, Indonesia formed organizations called *subaks* (Bray, 1986, p. 67; Suarja & Thijssen, 2003). In exchange for their water shares, *subak* members have to contribute a set amount of labor for maintenance. (Or they can pay for the right not to.)

Some early historians have argued that water control encourages despotic centralized governments, but *subaks* were far from large top-down autocracies (Wittfogel, 1956). In 1999, there were 1,500 *subaks* in Bali, and each *subak* had about 200 members (Suarja & Thijssen, 2003). Within the *subak*, a general assembly and a board help divide water resources, plan maintenance work, and decide when to plant crops (this example also illustrates how irrigation pushes farmers to cooperate seemingly individual decisions, like when to plant crops). The general assembly discusses these issues, votes, and elects board members. *Subaks* can also make decisions to grow crops that use less water than rice if there are water shortages (Suarja & Thijssen, 2003).

Some writers describe *subaks* as if they were utopian democratic systems, but irrigation does not have to be so egalitarian or democratic. Chinese villages sometimes used collective discussions to decide how to use irrigation systems (Elvin, 2006), but the Chinese government also organized irrigation projects from the top down (Bray, 1980).

Nor are the solutions always fair. For example, in one Japanese village, rich farmers had special rights to use water when it was scarce (Shimpo, 1976). In India, rice labor was often divided by caste lines. People coordinated with people of the same caste (Stargardt, 1983). Rice does not guarantee utopian socialism.

If Rice is So Much Work, Why Farm It?

Up to this point, paddy rice sounds like it's full of negatives—more work, less freedom, and complex tasks. That leads to the obvious question, if it's so much work, why farm it? The answer is simple: rice pays off. Paddy rice takes more labor and water, but it produces more tons per hectare than the other major staple crops (Fuller & Qin, 2009, p. 88).

We know this was the case historically because, even hundreds of years ago, farmers kept records of their yields in order to collect rent and pay taxes. We can use those records to compare the output of wheat farmers and rice farmers hundreds of years ago. One way farmers measured their output was yield per liter of seeds. From 1500 to 1750, European wheat farmers were reaping 3-4 liters of wheat for 1 liter of seeds (Elvin, 2006, p. 208; Maddalena, 1970). In China, rice farmers near Shanghai were getting an astounding 48 liters. Even the most industrious European farmers at that time never exceeded 9 liters (Elvin, 2006, p. 208).

Lest readers think this is because Chinese farmers were just more skilled than European farmers, studies comparing yields within China also show that rice yielded more than wheat. In his large-scale survey, John Buck found that rice yielded 446 catties per *mou* (about 223 kilograms per 666.5 square meters; Buck, 1935; Perkins, 1969, p. 267). Wheat yielded just 141 catties. A 1958 Chinese government survey found similar results: Rice produced more than three times the yield of wheat (Perkins, 1969, p. 267). The numbers are similar if you compare rice to other common staple crops in China—millet, corn, and soybeans. From the 1400s through the 20th century, records showed that rice areas were

consistently getting yields five times that of wheat areas (Perkins, 1969, p. 19). The extra work for transplanting and irrigation pays off.

Another benefit of rice is that it grows quickly. Rice can mature in 2-3 months, letting farmers plant two or even three crops a year (Bray, 1998, p. 50). Rice occupies even less field time if farmers transplant it (Bray, 1998, p. 50).

This can lead to incredible productivity per acre, but it adds substantially to the labor burden. For one, double cropping makes labor bottlenecks more urgent. That is because farmers have to complete one crop in time to plant the next crop (Richards, 1987).

Double cropping also creates entirely new tasks (in other words, tasks that are not required of crop A or crop B if planted in isolation). To illustrate this, let's assume that a plot of rice requires 150 man days of labor (by itself). Let's also assume that winter wheat requires 50 man days of labor (by itself). We might expect the yearly total to be 200 man days of labor.

But if a farmer double crops, the sum total may actually be more than 200 days. That's because adding wheat in the winter actually adds *extra* tasks that the farmers would not have had to do otherwise. For example, if they are going to plant winter wheat, rice farmers have to do extra work to make sure they pump their fields as dry as possible so that the fields would be ready for the winter wheat (Elvin, 2006, p. 170). If farmers aren't growing wheat, they won't need to be so fastidious about pumping water out of their fields at the end of the rice season.

Prior Subsistence Theory

The rice theory is not the first theory to argue that how our ancestors made a living affects culture today (e.g., Alesina, Giuliano, & Nunn, 2011; Barry, Child, & Bacon, 1959; Berry, 1967, 1979; Edgerton, 1971; Harris, 1989). Nisbett and Cohen (1996) gave evidence that settlers to parts of the American south were from herding cultures of Scotland and Ireland, and herding brings with it a culture of honor. They argue that herders have property that is

easier to steal than a field of wheat and thus presents a constant threat to herders' livelihood. Therefore, herders have to show that they will defend themselves against anyone who threatens them. Nisbett and Cohen (1996) document evidence that southerners are more likely than northerners (who are mostly descended from farmers) to use violence to defend threats to their honor. They also show that the south has higher rates of honor murders (e.g., killing the lover of a cheating wife), but similar rates of non-honor murders (e.g., during store robberies).

Nisbett has also argued that East-West cultural differences are due to subsistence style (Nisbett, 2003). Nisbett argues that farming is a more interdependent activity than herding (Berry, 1979). Herders are much freer to move around, and they do not have to share as many tasks with their neighbors. In contrast, farmers generally stay in one place and get enmeshed in stable social ties. Similarly, Berry argues that food accumulation makes people more interdependent because they have to decide how to distribute the harvest throughout the rest of the year (Berry, 1967; Barry et al., 1959).

Nisbett argues that the West (and particularly ancient Greece) more of a herding culture than the East (Nisbett et al., 2001, p. 303). In contrast, Eastern cultures like Han China and Japan were almost exclusively farming cultures. This could partly explain East-West differences, but it ignores the fact that much of the West has traditionally farmed wheat (and similarly grown crops such as barley).

Instead, the biggest East-West difference may not be herding versus farming, but rice versus wheat. Although the more mountainous parts of the West have traditionally herded (e.g., Scotland, Switzerland, and Greece), large parts of the West have traditionally farmed wheat. If all types of farming are created equal, then most of the West should be as collectivistic as the East.[11]

[11] However, farmers can cultivate the same crop in different ways, which is why the variable of *intensity* may be important. In brief, farmers may be more likely to have to share labor if they're farming intensively. They're less likely to need to share labor if they're, say, burning

The rice theory can improve on prior subsistence theory by differentiating between rice and wheat farming. If rice farming causes collectivism, it could explain why the East is still more collectivistic than farming areas of the West. By adding rice to subsistence theory, we get a more detailed spectrum of subsistence from herding (most individualistic) to wheat farming and then rice farming (most collectivistic; Figure 10).

Summary of the Rice Theory

In a nutshell, the rice theory of culture is this: Paddy rice requires irrigation and much more labor than crops like wheat, and these two factors increase the incentives for cooperation and avoiding conflict. Over time, this makes rice cultures more interdependent, with strong reciprocal ties. I focus on irrigation and labor as the links between rice farming and collectivistic culture, but there may well be other mechanisms. I discuss some of the other potential mechanisms in Part 6.

Basic Assumptions

In the rice theory, I make several basic assumptions that I will try to make explicit here. My hope is that, by listing the assumptions here, I can avoid burdening readers by repeating each caveat throughout the paper.

Cultural inertia. The data I report later in this paper shows that people from rice and wheat areas still have psychological differences, even people who have not farmed rice personally. In this way, my argument is similar to that of Nisbett and Cohen (1996), who showed that areas of the southern United States that have a legacy of herding also have higher rates of honor killings, even though very few people in their statistics actually herded animals (Nisbett & Cohen, 1996). Thus, subsistence theory relies on the idea of cultural inertia.

Of course, inertia is not really an explanation. Inertia must still take some specific form, whether it is parents teaching children, cultural norms, or something else. Culture is a

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their fields instead of plowing or if they're fallowing their fields instead of manually fertilizing them each year.

complex thing, and there are probably many mechanisms that help pass down rice culture. In another paper, I discussed possible mechanisms including parenting styles, values, mobility, feudalism, population density, and institutions (Talhelm, 2014). There are surely more variables than this, and future studies can build on this study by diving into them.

Intensity. Not all rice is farmed with irrigation or intensive labor. Some areas are blessed with just the right rainfall and geography to flood fields naturally. Furthermore, farmers can farm rice without the more labor-intensive tasks of leveling fields, weeding, and transplanting, although this severely limits crop yields. Thus, when I write "rice requires," I usually mean "most irrigated paddy rice."

Traditional agriculture, not modern. The rice theory is about how people farmed *traditionally*, not how they farm today. Irrigation is a good example of why this distinction is important. Traditional irrigation systems often required an intense number of man hours to operate. Irrigation ditches had to be dug with human power, and water often had to be removed using human-powered tools. For modern farmers, emptying fields is as easy as flipping a switch on a diesel pump.

For this reason, it is important to understand how crops were grown traditionally, before modern tools. Modern tools have changed the way we grow crops, so it would be unwise to use our understanding of how people grow crops now to understand our cultural heritage. For example, parts of Australia now grow rice with modern machinery, but it would be incorrect to predict that the process of growing rice is making them collectivistic. Instead of creating labor exchanges, Australian rice farmers use tractors and even planes to solve labor problems (Bray, 1986). Thus, when I say "growing rice requires," in more precise language I often mean "before modern machinery, growing rice traditionally required."

Rice paddies, not dryland Rice. In this paper, I often use "rice" as a shorthand for "paddy rice." Rice can also be grown on drylands without the use of paddies. This rice is

called "upland rice" and "hill rice," but I'll call it "dryland rice" because that seems to me the most direct wording.[12] Dryland rice is particularly common in hilly regions, and dryland rice is usually (but not always) a different variety of the rice plant (Bray, 1986, p. 11).

Irrigated rice is the most productive type of rice (Khush, 1997). Modern dryland rice produces 1.2 tons per hectare, whereas irrigated rice produces 5 tons per hectare (Khush, 1997; also: Bray, 1986, p. 15). Dryland rice only accounts for 4% of total rice production (IRRI, 2009).

The flipside of the low yield is that dryland rice requires less work. Dryland rice isn't irrigated, and it does not require farmers to transplant or carefully level their fields. For that reason, I suspect that dryland rice does not cause collectivism as strongly as paddy rice (although I do not have evidence for this suspicion).[13]

Bray (1986) argues that dryland rice can only be farmed with shifting cultivation, which is very different from paddy rice farming. In shifting cultivation, farmers often burn a patch of wild land, farm it until the soil is exhausted, and then move on. Shifting cultivation uses much less labor and produces much lower yields than intensive paddy rice farming. For that reason, Bray argues that dryland rice does not lead farmers to develop complex technical or social systems that arise from paddy rice (Bray, 1986, p. 12).

Why I use the term "staple crops." When I make comparisons about rice in this paper, the point of comparison is *other staple crops*, mainly wheat, corn, millet, barley, and sorghum (and perhaps potatoes and beans). The world has a huge spectrum of crops that have unique requirements. For example, cotton tolerates salt water particularly well, so people who

[12] "Upland rice" is a common term. For example, the International Rice Research Institute uses the term. However, I prefer the term "dryland rice" because "upland rice" does not require elevation. Plenty of "upland" rice grows at low elevations. Instead, the most important feature is that this rice grows on fields that are not flooded.

[13] One way to test this is to compare farmers that grow dryland rice and farmers that grow paddy rice. However, we must be careful in comparing these two groups because most dryland rice is grown by subsistence farmers (IRRI, 2009), and thus it is probably correlated with poverty.

live near the sea in eastern China sometimes grow cotton (Elvin, 2006, p. 214). Some researchers have suggested the properties of sugar cane may be particularly suited to the plantation model of farm labor (Paige, 1975).[14]

However, I am excluding these crops from this review. This paper focuses on cultural differences writ large, and staple crops are where most of the action is. For example, many parts of the world grow apples (including my homestate of Michigan), but I suspect no major culture on Earth has been predominantly shaped by it. Some regional cultures have definitely been shaped by non-staple crops: Colonial sugar cane farming shaped Caribbean island nations, and cotton farming shaped the slave-holding American south. These crops are worthy of study, but they are not my focus here. Instead, the comparisons in this study are relative to other staple crops.

How Rice Farming Started and Why It Matters

It may seem overly rote to lay out the archaeological beginnings of rice agriculture. I'm reminded of a teacher who told me that, if I wanted to learn to write, I needed to learn Latin first. I'm reminded of an old expat English teacher in China who told me Chinese people moving to the US need to learn Spanish and Native American languages because so many place American place names are derived from these languages. Understanding the origins of things is not always useful. However, I think going back to the very beginning of rice agriculture helps explain why rice is different from other major staple crops.

Going back to the beginning helps tests three intuitions that I had when I started thinking rice could explain the cultural differences I was seeing in China:

[14] Paige argues this is because sugar requires substantial "bulk reduction"—processing in which bulky sugar cane is turned into the more easily shipped forms of sugar. At the same time, sugar cane can be harvested year round, so it provides incentives for having year-round laborers, as opposed to migrant laborers who are needed only once a year to harvest crops like tomatoes. Paige analyzes 135 export sectors in 70 developing nations and shows a .60 correlation between crops' need for bulk reduction and plantation frequency (r = .53 between long harvest period and plantation frequency; Paige, 1975, p. 84).

1. Rice is so fundamental to Chinese culture that it must have been grown first (before other crops).

2. If farming causes collectivism, the areas of China that have been farming the longest should be the most collectivistic. (And if #1 is true, how do we know that rice areas aren't more collectivistic than wheat areas simply because they've been farming longer?)

3. Paddy rice methods took historic people the same amount of time to develop as other crops.

Why the Incentives for Farming Were Bigger in the North (at First)

When I first started thinking that farming could explain the differences I was seeing in China, one intuition I had was that the more collectivistic regions had been farming for longer. I guessed that farming had developed in the south and then spread to the north.

I knew little about the history of farming, but I suspect I'm not the only person to have had this mistaken intuition. To people who live in China today, it probably seems normal to think that southern China started farming first because southern China is the breadbasket. To take one year's statistics at random, in 1981, the 13 provinces below the Yangtze river produced about 64% more tons of grain than the 13 provinces above the Yangtze river (Statistical Yearbook of China, 1981).[15] The south even manages three crops a year in some places. Meanwhile, northern China has harsh winters and much less rainfall, which make it seem less natural to farm there.

But scholars have come to believe that farming started not in the world's most productive areas, but the more marginal areas (Price & Gebauer, 1995, p. 7). To understand why, it helps to think about the tradeoffs early people faced when they decided to start

[15] As in the data I report later, I'm excluding the non-Han provinces of Xinjiang, Tibet, and Inner Mongolia. I'm counting provinces that the Yangtze crosses as southern because Chinese people often think of these provinces as southern (Sichuan, Hubei, Jiangsu, and Anhui). Note that Chongqing and Hainan were still parts of other provinces at that time.

farming. We need to think about the *relative* payoffs for farming versus foraging, rather than the *absolute* payoff (i.e., how many tons of food could we grow from this patch of land?).

In early China, people's alternative to farming was hunting and foraging (collecting wild food). In the most fertile areas, foraging was so productive and reliable that the extra work of farming was not attractive.[16] However, in colder and drier areas, foraging was less reliable. This probably made farming more appealing in the north—not because it produced more in absolute terms, but because the alternative (wild food) was less reliable. This was especially true as the population grew, and people put more strain on the natural resources around them (Fuller, Harvey, & Qin, 2007).

In China, archaeological samples show that wild plants made up less and less of people's diet as the human population grew (Tao, Chen, & Xu, 2006). By studying the food remains in prehistoric villages, archaeologists know that early Chinese people ate lots of acorns. However, pollen records show that oak trees declined around the time that Chinese people domesticated grains (Tao et al., 2006). Oaks may have declined because the human population was growing, and people were over-exploiting the trees. It could also be due to shifts in climate. In either case, the weakness of the natural environment probably struck northern China earlier than southern China, and as wild food became less reliable, farming became more appealing (e.g., Winterhalder & Goland, 1993; Kelly, 1995; Piperno & Pearsall, 1998).

Chinese People Farmed Millet Before They Farmed Rice

For that reason, the first established farming appeared in northern China, where farmers grew millet around the Yellow River (Fuller, Harvey, & Qin, 2007). As a reference, Confucius lived sometime around 500 BC, and he probably would have been more familiar

[16] We think of farming as leading to abundance, but human body size and health actually went *down* after humans started farming (Cohen, 1989). One reason for this is that farmers probably had a less diverse diet and ate less meat.

with millet than rice (Elvin, 1982, p. 16). In fact, the famous *wugu bufen* (五谷不分) passage from the *Analects* mentions a farmer serving broomcorn millet to one of Confucius's disciples.[17]

As agriculture expanded in the north, the Yellow River became the center of Chinese culture. From around 200 BC to 300 AD, the majority of the Han Chinese population lived along the Yellow River valley and farmed dry fields (Elvin, 1982, p. 15).[18] Northerners farmed millet because (1) it is much easier to grow than rice and thus easier to develop the techniques to grow it, (2) it is more suited to the loose soils of the north, and (3) it is more drought resistant than rice and thus suited to northern China's dry climate (Elvin, 1982).

Thus, widespread farming in China developed in the north before the south (Figure 11). And when I say "before," I do not mean "a few generations before." Rice was not established in China until 2,000-3,000 years after millet (Fuller et al., 2007). Even wheat did not become an important crop in China until around 500 AD (Elvin, 1982).

While millet was the main mode of subsistence in northern China, farming was still underdeveloped in southern China. As late as 300 AD, the Chinese military was sending in troops to colonize the areas around Shanghai (Elvin, 2006, p. 181). Even after the Han army moved in, farming did not take root decisively. A rebellion and 14 years of warfare in the 700s left less than one in 100 people farming the land (Elvin, 2006, p. 181). Once again, the government moved settlers in to farm the area. In short, over a thousand years after the millet-farming culture of northern China had produced many of the classics of Chinese civilization, farming was still not completely settled around Shanghai—areas that later became the heart of China's rice production.

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[17] Similarly, the legendary founder of the Zhou Dynasty (1045BC-221BC) was Houji (后稷) "Lord Millet" (Elvin, 2006). This is not to say that early Chinese people were unfamiliar with rice, just that millet was more common.

[18] In other words, not the flooded fields of rice paddies.

I think the "which came first" question is important because it actually works against the rice theory. The fact that northern China started farming first and has been farming longer than southern China are reasons to think that we should find more collectivism in "the old north" (Elvin, 2006, p. 167).

Did Rice Farming Take as Long to Mature?

In its most basic form, rice farming can be as simple as farming wheat or millet. Farmers can burn their fields instead of plowing them. They can rely on seasonal rains to flood the fields and not worry about making the field level. They can throw the rice seedlings into the plot rather than carefully transplanting them.

Yet the rice plant has characteristics that allow for much more complicated methods. To give a metaphor, dogs have more receptiveness to training than cats, which leads humans to spend much more time developing dog training than cat training. A simple search on Amazon attests to this fact. A search for books about "dog training" resulted in 15,718 books. A search for "cat training" resulted in 2,010 books. Rice's receptiveness to advanced farming methods led humans to develop more complicated ways to farm it.

The case of Jiaxing. We can see the long process of this development in the historical records of an area called Jiaxing, which Elvin (2006) documents in rich detail. Jiaxing ("Jah-sheeng") is near Shanghai on the Yangtze River, which cuts across the middle of China. Jiaxing represents some of the earliest major rice-farming sites in China. The region around Shanghai now devotes over 80% of its farmland to rice, which is the highest in China (Figure 3).

Historical records from Jiaxing show that rice farmers in the south were using very basic techniques even after millet farming was widespread in the north. Government officials' written documents suggest that Chinese rice farmers around Shanghai in the 700s were planting rice without fertilizing, transplanting, or double cropping (Elvin, 2006, p. 182).

If farmers use crude methods, they get low yields, and they need large plots of land to grow enough food to survive. Getting that much land around Shanghai was evidently not a problem when farmers were using these basic methods. In the Tang Dynasty (618-906 AD), undeveloped land was still fairly common south of the Yangtze River, and farmers left their rice fields fallow every other year—a practice that later farmers would consider wasteful (Elvin, 2006, p. 180). Farmers burned their fields instead of plowing them, and they still hunted and fished for a significant portion of their food (Elvin, 2006, p. 168).

But land became more scarce over time. People's changing attitudes toward land size can be seen in the historical records of land disputes. In the 1200s, documents described land disputes over smaller and smaller fields (Elvin, 2006, p. 182). These small fields were now more meaningful because farmers were getting more and more out of each field. Farming was intensifying.

As land became more scarce, Chinese people developed the most important pre-modern techniques for rice farming and started using them widely (Elvin, 2006, p. 180). People in Jiaxing started building elaborate canals and irrigation systems, and rice made up a much higher portion of the diet.

It was in this period that Chinese farmers started transplanting their fields, which can increase yield by 40% (Bray, 1986). Chinese people at this time also started using techniques that allowed stop fallowing. Now they could farm the same field every year.

With these new techniques, the rice areas of China started getting yields that were much closer to the peak of what rice can produce without modern technology. Soon southern China started outproducing the wheat and millet areas of northern China (Bray, 1998, p. 51).[19] From AD 1000-1700, the south was growing so much more grain than the north that the northerners started diverting a large amount of tax (in the form of rice) from the south. The

[19] Bray estimates this happened sometime between the Tang Dynasty (618-907) and the Song Dynasty (960-1279).

north used these crops to support the northern capital and to raise armies to defend against nomadic tribes, such as the Mongols. The famous Great Wall was built around the northern limits of farming in this period.

Yet "south" here means "the areas along the Yangtze River," which is not the most southern part of China (Figure 11). The Yangtze River is actually central China. If we're talking about China's true south, farming developed even later (modern day Guangdong, Guangxi, and Hong Kong). When Confucius was teaching in the northern millet areas, far southern China was still "barbarian" land. The Han people did not conquer the far south until about 2,000 years ago (Elvin, 2006).

Even in the 1100s, a visitor from the Yangtze region complained about southerners' sloppy rice-growing techniques: "They [don't] transplant the rice seedlings. Nothing is more wasteful of seed! Furthermore, after sowing they neither weed nor irrigate, but simply leave nature to take care of the crop" (quoted in Bray, 2000, p. 38). Even in the early Ming dynasty (around 1400 AD), Guangxi was considered a backwater, "where people scarcely knew how to farm" (Bray, 2000, p. 25). China's far south is now a major rice producer, and farmers there manage to fit in three crops a year.

The fact that rice farming took so long to develop hints at how complex it is. Rice yields more when it's transplanted and flooded—two tasks that require sophistication and labor. Millet does not. For this reason, developing millet farming is simpler than developing rice farming.

Exceptions to the Rice Theory

In any attempt to create a theory to explain human culture, there will inevitably be examples that don't fit and complexities that muddy the neat picture of the theory. In this section, I describe some of the complexities and exceptions to the neat picture I gave above.

The Rice Theory is not Ecological Determinism

One over-simplification would be to say that the rice theory is a pure ecological theory. Paddy rice is certainly an ecological variable. For example, it can hardly be grown in deserts or in very cold climates. Yet, if a region has the right ecology for rice, it does not mean the people there will definitely grow it. The environment is not an iron-clad determinant of culture.

A slightly better over-simplification would be to say that areas that farmed rice are more collectivistic, but this has flaws too. I agree with Aoki (2001) when he argues that having the ecology for rice is not sufficient by itself to create collectivism. He argues that collective norm enforcement is an effective way to coordinate the irrigation systems that make rice so productive. However, he points to the case of Korea in the 1600s, where collective irrigation networks did not fit with the social hierarchy of powerful nobles and an underclass of slaves (or "serfs," depending on the translation). It was only outside of these villages—in more egalitarian communities—that irrigation flourished.

Similarly, he argues that Japan's rice irrigation networks flourished when the emperors forced the samurai class to leave their villages and reside in Tokyo. Once Japanese villagers were freed from the hierarchy of the nobles, they were able to start collective norm-enforcement systems to maintain their irrigation networks. Here again, the ecology is the same over time, but it takes a social change to develop intensive rice irrigation.

These examples explain what the rice theory is *not*. It is not that having the ecology for rice causes collectivism. It is not that growing rice always causes collectivism. Instead, the argument is that (1) collectivism is a common solution for growing paddy rice, and (2) people who live in areas with the right environment to grow rice have incentives to build cultural practices that support higher rice yields. In the next section, I describe two places that have the right environment to grow rice, but chose to grow it without a cooperative system.

Rice does not Always Cause Collectivism

Cooperation is a solution to the massive labor requirements of rice, but it is not the only solution. The most obvious alternative solution is to use machines. Modern machines and irrigation pipes have brought much more rice to China's cold northeast. Now many Chinese people consider rice from Heilongjiang to be the tastiest rice in China. Similarly, modern rice farmers in Australia plant large fields using tractors and even airplanes. Yet, Australian rice farmers don't have to cooperate with other farmers to plant their rice like traditional Chinese rice farmers did. Thus, it would be incorrect to predict that modern Australian rice farmers are collectivistic because they farm rice.

Even before planes and tractors, white Americans solved rice's labor problem by forcing slaves to plant it. Historically, parts of coastal South Carolina and Georgia farmed rice, but my guess is it would be incorrect to say people there are more collectivistic because they farmed rice. Even the slaves (the ones who actually farmed the rice) may not be pushed toward collectivism by their experience farming rice because they were forced to work, rather than to cooperate with others out of reciprocity. At the very least, it's an open question whether forced rice labor leads to collectivism.

However, slaves in rice areas may have been more collectivistic not because of their work on plantations, but because they were systematically selected to be different from slaves on sugar and cotton plantations. Slave owners paid more for slaves from the rice-growing parts of West Africa (Wood, 1975). Slave advertisements touted some slaves by saying they were "well acquainted with the culture of rice" (Sale of Africans from the Windward Coast, n.d.). American slave owners knew that rice required more detailed skills than crops like cotton, so they paid more for slaves who came from this specific region—yet more evidence that rice is a unique crop. This is in stark contrast to slaveholders in other parts of the United States, who cared far less about where slaves were from (Opala, n.d.).

Does the Intensiveness of the Rice System Matter?

Not all rice is grown intensively. For example, some rice is grown on hills without irrigation systems, usually on patches of land that cannot be made into rice paddies because the land is too steep or because the soil is too loose to hold water (IRRI, 2009). Where rainfall and terrain are right, farmers can rely on rain at the right times of year to flood their fields naturally, instead of irrigation interventions (Tsuruta, 2001).[20] Finally, some farmers may not irrigate because the relative payoff of the extra work is too low (perhaps because of low population pressure, abundant land, or plentiful wild food).

This raises the question: does the extent of the development of rice farming matter? Less-intensive rice farming might put less pressure on people to be collectivistic because it has lower labor requirements and does not need to be irrigated. However, less-intensive rice cultures may still be more collectivistic than cultures that rely entirely on hunting and gathering (Berry, 1967). It would be useful to test this hypothesis by comparing nearby cultures or small regions that farm intensively and less intensively.

There is some anecdotal evidence that less-intensive rice farming puts less pressure on cultures to be collectivistic. Remember that farmers can throw rice seeds into plots ("broadcasting") rather than transplant them, although broadcasting is less productive (Bray, 1986). In Thailand, Tsuruta found that when villagers practiced broadcasting rather than transplanting, they did not exchange labor (Tsuruta, n.d.). But later, when they started using transplanting, it created a new labor peak, which was probably the reason why more farmers started using *ao raeng* (cooperative labor exchange; Tsuruta, n.d.). This suggests that intensiveness is an important condition for rice to lead to cooperation, although a single case history is insufficient.

[20] This is the case for much of the rice grown in Thailand (IRRI, 2009).

How Equivalent were Chinese and European Wheat Farming?

When I describe the rice theory in its simplest form, it sounds like I am claiming that wheat leads to one type of culture and rice leads to another. Yet the real picture is probably more complicated. Intensity may also be an important variable for wheat, and the cases of European and Chinese wheat farming are useful for illustrating how intensity can vary widely for the same crop.

Chinese and European wheat areas are similar in some ways. Both used much less irrigation than rice areas, and both had lower yields than rice areas. However, there are reasons to conclude that the Chinese wheat areas were much more intensive than European wheat areas. Elvin goes so far as to say "the way Chinese farmed in late-traditional times (1350-1900) was so different from United States and European agriculture today that an effort of imagination is needed to understand it" (Elvin, 1982, p. 13).

One major difference was fallowing. Most European farmers fallowed their fields, letting them grow wild every other year or so in order to return nutrients to the soil. In China, farmers rarely fallowed their fields after medieval times (Elvin, 2006). Instead, they intensively fertilized their fields by burning stalks, collecting animal manure, and even paying for human feces from nearby cities (Elvin, 2006).

Another important difference is that Europeans used more animals than the Chinese did. Europeans herded animals and raised cows for milk more frequently. Han Chinese did not herd in a major way, especially as farming became more intensive and ate into pasture lands during medieval times (Elvin, 1982, p. 16). Raising livestock is generally less labor intensive than farming, and livestock fertilize farmers' fields naturally, without the need for the labor-intensive fertilizing that many Chinese farmers practiced.

Finally, Chinese farmers practiced much more double cropping. This raises the labor burden in obvious ways, but also in less obvious ways. For example, double cropping shrinks

the time windows for certain tasks and creates tasks that would not otherwise be required to farm the first or the second crop in isolation (see Part 2). In sum, even though European and Chinese wheat farmers were growing the same crop, Chinese farmers were growing it more intensively.

We can hypothesize that intensive wheat farming leads to more collectivism than less-intensive wheat farming. For example, Chinese farmers were not letting their fields go fallow, so they had a higher labor burden, stricter bottlenecks, and added tasks (see Part 2). This would make labor exchanges more likely (although still not as likely as in rice areas).

Not Just Farming and Herding: The Spectrum of Subsistence Style

Rice and wheat are not everything. Humans practice many other types of subsistence, and each style probably tilts the incentives for and against certain behaviors. If we're looking at individualism and collectivism, I suspect we can create a spectrum from subsistence styles that tilt toward collectivism to styles that tilt toward individualism (Figure 10). We could just as well make spectrums for other cultural traits, such as Hofstede's power distance.

I suspect there's even a spectrum within rice and wheat cultures. Among all types of rice, low-intensity rice is probably on the less-collectivistic end of the spectrum. The highly "interventionist" rice along the Yangtze River is probably on the collectivistic side of the spectrum.

To illustrate this, I've created a spectrum of subsistence style in Figure 10. It is missing a lot of detail because we don't have enough evidence comparing the cultural effects of different subsistence styles, although we have enough detail to get a rough picture. A handful of studies have shown that herding cultures are more individualistic than farming cultures, so we can place herding on the individualistic side of the spectrum (e.g., Edgerton, 1971; Uskul et al., 2008).

We can also put hunting on the spectrum because there is evidence that some hunting cultures are more individualistic than farming cultures (Barry, Child, & Bacon, 1959). Back in the 1960s, Berry (1967) showed that a group of African farmers conformed more on the Asch social suggestion task than "Eskimo" hunters. Berry argued that hunting cultures raise their children to function individually, whereas farming cultures expect their children to be more dependent.

These individual comparisons hint at a spectrum, but they don't give enough information to fill in all of the details. For example, hunters and herders tend to be more individualistic than farmers, but are hunters more individualistic than herders? Does it depend on the type of hunting or herding?

One example illustrates the complexity that can exist within a single category of subsistence. The Lamalera people of Indonesia are hunters, so a simplified model would predict they are individualistic. However, they hunt whales, and it takes a team of people working together to kill a whale. So perhaps it's not surprising that the Lamalera people gave unusually generous offers in the classic ultimatum game (Henrich et al., 2005). In the ultimatum game, stingy givers give less than half. Generous givers split the money equally. Yet the Lamalera actually gave *more* money to the other person on average. My point is that even subsistence styles that have the same title ("hunting" or "farming") can differ in important ways.

We must be careful in the titles we give to different subsistence styles, and we should expect plenty of variation within large categories like farming. I don't mean to say that it is important to find a precise place on the spectrum for each subsistence style, just that there does seem to be a spectrum. Ecological theories of culture have a tendency to be simplified into caricature, so it is important to remember that there will always be variation within any single type of subsistence.

Rice Farmers are not the Only Ones who Share Labor

Rice farmers exchange labor, but it would be wrong to think that *only* rice farmers share labor. Examples are easy to find. My Midwestern ancestors held "barn raisings" in which several families would get together to take on the large task of building a barn. In Africa, Congolese shifting farmers[21] organize work parties when they have to clear the brush from new sites that they want to farm (Suehara, 2006). Afterwards, the host gives the guests a meal and home-brewed banana beer (for men).

Thus, it would be wrong to say that *only* rice farmers share labor. Instead, my argument is that rice requires more labor than most other crops, which makes labor exchange more likely and more necessary for survival in rice cultures.

Several anthropologists studying rice villages have argued that rice farmers would not have been able to farm enough rice to survive if they limited the size of their farm to the size they could farm with labor from within the family (Fei, 1945; Wong, 1971). If true, rice labor exchanges may have been more consequential than labor exchanges in other types of farming.

There is some evidence that rice labor exchanges took on a more serious tone. Suehara (2006) studied labor exchange among shifting farmers in Congo and rice farmers in Japan, and he found the exchange customs in the Congo were more festive. Suehara (2006) describes the labor exchanges in the Congo as "beer parties." These parties were more optional, more like festivals. But in Japan, "such a strong interest in the festive aspect of labor exchange cannot be found" (Suehara, 2006, p. 57).

[21] Shifting farmers clear a plot of land, farm it for a year or more, and then move onto another plot of land, letting the original plot grow over. One common type of shifting farming is slash-and-burn agriculture.

Rice farmers seemed to take reciprocity very seriously. For example, Fei (1945) noticed that farmers who were for some reason unable to reciprocate would pay for laborers to work in the other farmer's field.[22] Participation was far from optional.

Furthermore, if labor exchange were just a social nicety, we might expect rice farmers to practice it in the relative slack periods, when labor demands are less urgent, such as tilling or weeding (Suehara, 2006, p. 56). However, Suehara found that Japanese families used their household labor for these less-demanding tasks, and only used labor exchange for the more demanding tasks of transplanting and harvesting. In contrast, labor exchange in the Congo was designed less out of necessity and more to bring "an atmosphere of joy and conviviality into their otherwise lonely and tedious routine work" (p. 61).

Other Theories of Regional Differences in China

Wittfogel's Theory of Oriental Despotism

German-American historian Karl Wittfogel (1956) put forth his theory of oriental despotism to explain East Asia's strong centralized governments. He argued that East Asia's strong centralized governments grew out of the need to control water. The reasoning is that (1) East Asia had a stronger need to control water, and (2) controlling water requires a strong centralized government. (3) Over time, this led East Asian countries to have despotic rulers.

It can be easy to draw an equivalence between Wittfogel's theory and the rice theory because both talk about water control. However, there are two crucial differences: First, Wittfogel's theory predicted despotism, not cultural collectivism. The rice theory does not make a prediction about strong central governments. These are different variables.

Second, Wittfogel focused on the need to control flooding. Yet floods are more common in northern China along the Yellow River. The Yellow River is sometimes called "China's sorrow" because it unleashed devastating floods so frequently. Therefore, even if we

[22] There are exceptions to strict reciprocal exchange. For example, Suehara (2006) found that villagers in one Japanese village did not expect physically weak old people to reciprocate.

were to say that despotism is equivalent to cultural collectivism, Wittfogel's theory predicts the highest values in the north, whereas the rice theory predicts the highest values in the south.

Another problem with drawing a line between the two theories is the idea that all types of water control require centralized power. After Wittfogel put forth his theory, historians and anthropologists pointed to evidence that rice irrigation was usually coordinated at the local level (Bray, 1986; Elvin, 2006). Most scholars now believe that rice irrigation was usually done at the local level—as a village or even between families.

For example, Fei (1983) outlined in detail how several families in a rice village coordinated filling, draining, and dredging their irrigation network. The farmers even had rules set up to punish people who did not show up for their allotted work. If anything, rice irrigation seems to push in the opposite direction from Wittfogel's theory.

Skinner's Centers of Regional Urbanization

G. William Skinner (1977) split China into nine regions based on drainage basins (Figure 12). He argued that these basins defined transportation and trade efficiencies (p. 212). He argued that these regions differed in how and when they developed. In the late 1800s, the most urbanized regions were the Lower Yangtze, Lingnan, and the Southeast Coast. These areas still have some of the highest per-capita GDPs today.

According to Skinner (p. 219), these boundaries also tended to contain upheavals and natural disasters within their borders. For example, the Taiping rebellion in the 1800s was mostly contained within Skinner's Lower Yangtze region and part of the Middle Yangtze region. Serious droughts were usually limited to the Northwest and North regions.

If economic systems and disaster types were generally contained within these regional borders, cultural differences should fall along these borders too. These borders provide a clear hypothesis to test on datasets of regional differences. Dialect differences are also a variable that should fall along these borders if the divisions are correct. However, Shepherd (1993, p.

438) points out a difficulty with analyzing Skinner's regions: the divisions cut across province borders, which makes it hard to analyze data that is often available at the province level and not broken down further.

One of the best tests would to test for abnormally large cultural divides between nearby areas that happen to fall in one region versus another. To use a metaphor, rain that falls just a few meters west of America's continental divide ends up flowing hundreds of miles to the Pacific Ocean. Rain that falls a few meters to the east flows even farther to the Gulf of Mexico. If Skinner's regions were really separate systems, each region could have developed down a different path and ended up miles apart on cultural variables. If so, we should find larger differences (1) between nearby counties on two sides of his borderlines than (2) between similarly close counties that fall within a single region.

It is interesting to note that Skinner's division in Anhui province falls along the rice-wheat border. This is particularly relevant for Study 3, which tests rice-wheat border differences in Anhui province. Skinner's Anhui border falls along the rice-wheat border despite the fact that he created his borders based on drainage basins, not agriculture. However, Skinner's borders are different from the rice-wheat border farther to the west. For example, his Upper Yangtze region covers all of Sichuan, even into Gansu, even though rice does not extend throughout northern and western Sichuan. Thus, Skinner's borders are not the same as the rice-wheat border, and they can be tested independently.

Study 1

Rice can at least partly explain why East Asia is so much more collectivistic than it "should be" based on its economic development. In Figure 2, GDP per capita explains 50.8%

of the variance in individualism. However, adding a simple dichotomous "rice culture" variable[23] increases the explained variance to 73.7%.

Yet this is large-scale data. Analyzing data at the country level is helpful, but it can be dangerous because there are many other variables that differ between countries. It is important to complement large-scale data with more careful comparisons of nearby areas and people who farm rice and wheat.

China as a Natural Test Case

China is an excellent test case because it is probably the biggest natural rice-wheat experiment. I argue that China is natural test case, but let me be clear about what I mean. First, in the studies I present here, when I say "China" I mean "Han China." This excludes Tibet, Xinjiang, and Inner Mongolia.[24] I exclude these areas because (1) they are predominately herding areas, which muddies the comparison of rice and wheat; (2) they have different ethnicities, languages, and religions from Han China (e.g., Islam and Tibetan Buddhism); and (3) these areas have been under Chinese political control for much less time. Thus, when I talk about China as a natural experiment, I'm referring to Han China, not China's current political boundaries.

Within Han China, there are 1.3 billion people in a cultural region that comes from a single language family and has been under a national government for the better part of at least a thousand years. Furthermore, the vast majority of Han China has subsisted on farming rice, wheat, and other grains. Extensive herding and dairying "began only where the Han Chinese culture area stopped" (Elvin, 1982, p. 16). Thus, Han China offers a large sample of people who have been predominately farming rice or wheat. It has a large number of people (large

[23] To categorize cultures as rice cultures, I analyzed rice output statistics and removed cultures that produce rice in the modern day, but not as a major part of the culture in pre-modern times, such as Australia, Italy, and the United States.

[24] I also exclude other non-Han participants who live in the predominately Han provinces (for example, Hui Muslims).

sample size) that have been growing rice and wheat for a long time (enough time for the subsistence style to affect the culture) under more or less the same political, ethnic, economic, technological, and religious background (naturally controlling confounding variables).

This case is even stronger in comparisons of Han people in the provinces located on the rice-wheat border. Finding differences between nearby wheat and rice regions in China offers more convincing evidence than comparing differences between the East (mostly rice) and the West (mostly wheat and herding). China also provides a better test case than we could find within the other major East Asian nations (Japan, Korea, Taiwan, Hong Kong, and Singapore) because these nations are all essentially unified rice cultures[25] or settled by people from rice areas.

Methods

A total of 1,162 participants were tested in six provinces in both north and south China. Beijing is oversampled because universities in Beijing draw students quite evenly from all over China, giving samples that represent each province. The sociogram and loyalty/nepotism tasks were given to subsets. See Table 1 for detailed sample sizes for each task and demographics by site.

Participants in Yunnan, Guangdong, Fujian, and Beijing winter 2010/2011 were students in large lecture classes who participated on a voluntary basis. Participants at Beijing's Minzu University were in a large lecture class and were compensated in the form of a donation to the class activity fund. Participants in Beijing in the summers of 2007, 2010, and 2011 were recruited through advertisements on campus bulletin boards and online message boards and paid 15 RMB (approximately US$2.30). Participants recruited via message boards

[25] Most of China's wheat provinces devote less than 20% of farmland to rice paddies. None of Japan's 9 regions or South Korea's 16 regions has that little rice (except for two outlying islands). Similarly, Singapore was settled mostly by Chinese people from the rice regions, which explains why Cantonese and the Fujian dialect are so prominent in Singapore.

took the surveys in small groups in a laboratory. All procedures were approved by institutional review boards.

Participants from Liaoning and Sichuan were recruited via snowball sampling in order to increase the sample from underrepresented provinces. All tasks were on paper, except for the Liaoning and Sichuan supplements, which were done online. Because the snowball sampling and online procedures could affect those sub-samples, I repeated the analysis of rice and thought style without these supplements, and the results were similar.

The triad task was chosen as the primary task because it is easy to administer and score, and it takes less time than the other tasks. The sociogram task was added when time permitted. Because the sociogram does not have an electronic version, the Sichuan and Liaoning subsamples could not take the task.

Participants reported the city and province they were born in, where they grew up, and where their father and mother were from. To deal with cases where people moved while growing up, I worded the question as "Where did you mainly grow up?" (*Zhuyao zai shenme difang zhangda de*?) I assigned people to provinces using this question—not where they were currently in school.

As a large, national university, Beijing Normal University has by far the most representative sample of any of the sites. In the Beijing samples, no single province ever made up more than 12% of the sample. By contrast, in the Fujian sample, 73% came from Fujian province; in Guangdong, 93% came from Guangdong province. The Yunnan sample was also quite evenly spread, with only 10% coming from Yunnan province, although few from the north.

A weakness of student samples is that they are not representative of the whole of society. However, student samples have an advantage for studying regional differences. As other researchers have pointed out, homogenous samples decrease the risk of Type II errors

(*43*). The samples in this study have the advantage that the students are almost all within a couple years in age; all are currently students; all live in the same small part of the same city; and all were selected by the same university based on the same standardized test. Student samples in China naturally control for these differences and make us more confident that variation on many confounding variables is limited.

I did not analyze data from ethnic minorities (e.g., Tibetans and Mongolians) because this study's focus is to compare rice and wheat cultures and many of these cultures are not farming cultures. For example, Mongolians have traditionally herded. Ethnic minority groups also often have obvious differences in language, ethnicity, religion, and historical political system that would make it more difficult to determine whether cultural differences are due to subsistence style. The largest sample (the triad task) had 174 ethnic minorities. Minorities came from over a dozen disparate groups, leaving the sample without enough representatives of any one minority group to give a reliable estimate of any one culture's thought style (the largest sample for a single minority group was $n = 30$ for Hui Muslims, followed by $n = 12$ Tibetans).

I also excluded anyone who grew up in the provinces of Tibet, Inner Mongolia, and Xinjiang ($n = 35$ Han from these provinces for the triad task) because these provinces are home to traditionally herding cultures of ethnic Tibetans, Mongolians, and Uyghurs. These areas have had a significant presence of different ethnicities, language families, and religions that may confound our comparisons of rice and wheat. Future studies with larger samples from these regions may compare China's herding cultures (e.g., Mongolians) and farming cultures (e.g., Han).

All measures in this study were selected because they are non-self-report tasks (i.e., they do not ask participants to rate their own perception of themselves). Studies have found flaws in the use of self-ratings scales across cultures (Heine, Lehman, Peng, & Greenholtz,

2002; Peng, Nisbett, & Wong, 1997). Instead, I use a measure of cognitive style (the triad task), an implicit measure of individualism (the sociogram), and a scenario task (the loyalty/nepotism task), which asks people to respond to a hypothetical situation.

Triad Task

As a starting point for testing rice-wheat differences, I used measures that have been used in the past to document East-West differences. I started with the triad task, a test of how people categorize objects (Ji, Zhang, & Nisbett, 2004). In the triad task, participants see three objects (e.g., *monkey, banana, panda*) and have to choose two to categorize together. Americans are more likely than East Asians to categorize items based on abstract categories (*monkeys* and *pandas* are mammals); East Asians are more likely to choose items that share a functional relationship (*monkeys* eat *bananas*; Figure 13).

An early version of the triad task was used back in the 1970s in studies of how American and Chinese children categorized objects (Chiu, 1972). Since then, psychologists have shown that East Asians and people in many other interdependent cultures choose more relational pairings than Westerners (Henrich et al., 2010).

The triad task is an example of a larger category of tasks that measure what some psychologists term "analytic" and "holistic" thought (Nisbett et al., 2001). Westerners tend to think analytically, using more abstract logic, splitting wholes into smaller parts, much like scientists who chop up the world into smaller isolated pieces that are divorced from context and easier to understand on their own. In contrast, people from East Asian and other interdependent cultures tend to think holistically, using intuitive and contextual reasoning, thinking about problems as a whole, stressing the relationships between different objects, and sometimes arguing that it objects cannot be understood when isolated from the context.

Sociogram Task

I also tested subsamples (n = 515) on the sociogram task, a measure of implicit individualism (Kitayama, Park, Sevincer, Karasawa, & Uskul, 2009; see Appendix 5 for a note on site effects in the sociogram task). In the sociogram task, participants draw circles representing themselves and their friends. Unbeknownst to them, researchers then measure the size of the self circle and the size of the friend circles to get an implicit measure of individualism.

Previous research has found that Americans draw the self much bigger than they draw their friends, whereas Japanese people draw the self slightly smaller than friends (Kitayama et al., 2009). Europeans scored in between Japan and the US (Kitayama et al., 2009). Men self-inflated more than women B(485) = -0.06, p = .02, so I included gender in all models.

Loyalty/Nepotism

I also tested subsamples (N = 174) on the friend-stranger distinction because people in collectivistic cultures tend to treat friends much better than strangers, whereas people in individualistic cultures tend to make a smaller distinction between friends and strangers (Triandis, 1995). In the task, participants imagined going into a business deal with a friend or a stranger (Figure 14; Wang, Leung, See, & Gao, 2011). Then the participants learn that the friend lied, which caused the participant to make less money on the business deal. Participants can then use a portion of their money to punish the friend (or the stranger in the stranger condition).

Divorce

I also analyzed national statistics for two variables related to individualism. First, I analyzed divorce rates because individualistic cultures tend to have higher divorce rates (Lester, 1995). In addition, the rice theory argues that rice farming raises the costs of conflict, making people more avoidant of conflict. I gathered divorce rates from the same statistical yearbook as the rice statistics (1996), as well as the year 2000 and 2010 to test for change over time. I calculated the divorce rate as the number of divorces per marriage.

Patents for Inventions

I analyzed the number of successful patents for new inventions in each province because research has shown that analytic thinkers are better at measures of creativity and thinking of novel uses for ordinary objects (Witkin, Moore, Goodenough, & Cox, 1997). Even within the United States, immigrants from individualistic cultures hold more patents for inventions (Shane, 1992).

The patent statistics reported are the number of patents granted (as opposed to merely submitted) for new inventions. I divided the number of patents by the population of each province to get the number of patents per capita. I did not include patents for other categories, such as patents for utility models. Patent rates for categories other than new inventions may not be as theoretically related to analytic thought. Other patent rates showed no clear difference between rice and wheat regions. I tallied gathered statistics from the 1996, 2000, and 2010 yearbooks.

Patents per capita were skewed (skewness = 4.74; kurtosis = 24.07), so I log-transformed the variable. After transformation, skewness was within the acceptable range (skewness = 1.63; kurtosis = 3.49). There were two outliers of greater than 2 SD: Beijing and Shanghai. Therefore, I repeated the analysis excluding these outliers. Results were largely similar.

Rice Statistics

Because some rice is grown with less labor on dry land (without paddies), I used statistics on rice paddies, rather than rice output. The statistic I use is percentage of sown farmland devoted to rice paddies. I wanted to assess the crop that Chinese people farmed traditionally, rather than figures affected by recent advances in irrigation and mechanization. Therefore I used rice statistics from 1996, the earliest available on the Bureau of Statistics website (State Statistical Bureau, 1996).

However, rice statistics are fairly stable over time. The percentage of sown farmland devoted to rice paddies in different provinces in 1996 and 2011 are strongly correlated $r(27) = .89$, $p < .001$. The largest changes were reductions in provinces that have become much wealthier, such as Shanghai. Shanghai's production fell from 88% to 27%. In contrast, technology has brought more rice to cold northeastern Heilongjiang, which rose from 10% to 23%. I argue that the earlier rice figures are more reflective of traditional farming, rather than recent changes due to technology and urbanization.

GDP Per Capita

To test the rice theory against the modernization, I gathered statistics on GDP per capita for each province. I divided the 1996 statistical yearbook's GDP by population size to get GDP per capita.

Because economists often use log-transformed GDP per capita, I re-ran the analysis using log-transformed GDP per capita. The results were virtually identical. For example, with the triad task, log GDP per capita still correlated with holistic thought in the wrong direction $\gamma(25) = 0.31$, $p = .03$, $r = .45$.

Disease Statistics

To test the pathogen prevalence theory, I used disease statistics from a retrospective study of the causes of death over a three-year period from 1973 to 1975 for people aged 0-64 years (Junshi, Campbell, Li, & Peto, 1990). Studies on pathogen prevalence have used both modern prevalence and historical prevalence, with historical prevalence often as more significant. This data from the 1970s are probably an adequate (although not perfect) representation of pre-modernization disease prevalence. Although many world economies could be considered to have modernized by 1976, the Chinese economy was still tiny, with a GDP per capita of less than 1% of the United States. Furthermore, China's widely varying disease rates make it a suitable place to test the pathogen prevalence theory. The 1976 study found that disease rates there varied "more widely than in any other country for which useful mortality data were available" (Junshi et al., 1990, p. vii).

The death rates are cumulative. The researchers in the study determined cause of death "using medical records from clinics and hospitals and by questioning relatives and close friends of the deceased person as well as people such as the team leader, woman leader, accountants, or others who lived in the local area for a long time and who knew much about births, ages, sicknesses and deaths of people within the district" (Junshi et al., 1990, p. 4). The survey was conducted by the China National Office of Cancer Control and Research.

The 1976 study surveyed 49 villages. I used these village rates to estimate rates for the province. In cases where the disease study sampled more than one village in a province, I averaged the scores for different villages. The study reported five types of infectious diseases: pulmonary tuberculosis, non-pulmonary tuberculosis, infectious disease other than tuberculosis, schistosomiasis (a blood disease commonly carried by snails), and parasitic diseases other than schistosomiasis. I calculated *z* scores for the rates of three human-transmitted diseases (pulmonary tuberculosis, non-pulmonary tuberculosis, and infectious disease other than tuberculosis). I then averaged these three *z* scores for each province.

Because the 1976 study did not cover 10 provinces, I also looked at the earliest statistical yearbook data I could find on death rates from infectious disease. Different provinces had statistics available from different years, from 2001 to 2008. For example, Jiangxi province reported rates in 2001; Fujian reported rates in 2008. This could lead to bias because disease rates may go down over time, as China modernizes. To correct for this, I calculated each province's score as deviations from the national average of that year (national averages were available for each year). The Census reports rates as deaths from "infectious disease and parasites." This categorization is similar to the categorization used by the original pathogen prevalence article (Fincher et al., 2008), although it is does not list all of the specific diseases included.

I converted the deviations from the national average into *z* scores. Adding the Census statistics to the 1976 study increased the sample by 4 provinces. Because 10 provinces had data from both sources (the 1976 study and the Census), I estimated the stability across the two measures. The Census statistics correlate moderately with the 1970s village studies, despite a small number of overlapping provinces $r(9) = .43$, $p = .25$, suggesting that the measurements are consistent. Both sources gave similar pictures: higher disease in the south and the highest in the southwest. I then averaged all available *z* scores for each province to give a final measure of pathogen prevalence.

Even with these two data sources, the disease sample still covers a smaller number of provinces than the rice and GDP statistics ($n = 28$ vs. 21), which could unfairly handicap the disease model. Therefore, I repeated the analyses of GDP and rice with the smaller subset of provinces that also had disease statistics (Table 3). Rice still predicted the cultural variables in the predicted direction, although the reduced sample size led to reduced significance.

I note one difference between this measure of pathogens and those of Fincher and colleagues' (2008) study linking pathogen prevalence and collectivism. The available

measures for China report *death rates* of infectious disease, whereas Fincher and colleagues used "prevalence," which is presumably the number of cases of the disease rather than the number of people who die from those cases. In this regard I was limited by the statistics available. Fincher and colleagues do not say whether the distinction between deaths and cases matters.

Hierarchical Linear Modeling

To analyze the data, I used hierarchical linear modeling (HLM) because it takes into account the fact that the data was nested, with individuals in provinces. It also takes into account the fact that some provinces have larger samples, which makes the data points for those provinces more reliable.

I ran HLMs using linear mixed effects models. I ran these models using the LMER and GLMER functions in the program R. The GLMER used a binomial link for the triad task, which is most precisely analyzed as a series of binary choices (analytic versus holistic). To control for gender, I also ran models with gender as a level-1 predictor. To control for site effects, I also ran models with site dummy coded (Beijing = 0, reported below). In LMER and GLMER, formulas were written in the format of:

$$Y \sim Gender + Rice + (1|Province)$$

where gender varies at the individual level and rice varies only at the province level. Similarly, GDP and pathogen prevalence vary only at the province level (except for in the county-level analyses).

To compare effect sizes across variables, I used the change in the province-level variance (pseudo-R^2) of the model with and without the key predictor. It should be noted that it is more common for effect sizes calculated this way to be equal to 0 than with ordinary least squares correlation coefficients. I took the square root of this to get the correlation r, which is

a more familiar effect size. The unstandardized regression coefficients are presented in the regression tables.

It should be noted the *r* effect sizes are describing province-level variance. Both individual-level and group-level variance are valid scientific questions. Because the rice theory is a cultural-level theory, I report standardized effect sizes at the group level.

Results

Triad Task

If rice and wheat is behind East-West differences in cultural thought style, people from the rice parts of China should think more holistically, and people from the wheat parts of China should think more analytically. Women chose more holistic pairings on the triad task than men B(990) = 0.21, $p < .001$, $r = .06$, so I controlled for gender in all analyses.

The rice theory was the only model that fit the data (Figure 15). People from provinces with a higher percentage of farmland devoted to rice paddies chose more holistic pairings $\gamma(25) = 0.56$, $p = .007$, $r = .51$. (γ represents province-level regression coefficients.) Table 2 presents the full regression output.

I tested the modernization hypothesis by testing whether people from wealthier provinces thought more analytically. People from wealthier provinces actually thought more holistically $\gamma(25) = 0.52$, $p = .03$, $r = .46$. This is the opposite of what the modernization hypothesis predicts. Controlling for rice, wealthier provinces thought marginally more holistically $\gamma(24) = 0.37$, $p = .11$.

I tested pathogen prevalence theory by testing whether provinces with higher rates of disease thought more holistically. Provinces with higher disease rates actually thought *less* holistically $\gamma(18) = -0.22$, $p = .04$, $r = -.44$.

The large-scale disease study from 1976 included statistics for 31 counties across China (Junshi et al., 1990), which let us test the pathogen theory more precisely. Thus, I tested whether the 198 people in our sample who came from these 31 counties had different thought styles based on the historical disease prevalence in their county. Even with this finer precision, pathogen prevalence predicted thought style marginally in the wrong direction $\gamma(28) = -0.43$, $p = .08$, $r = -.33$.

Individualism

On the sociogram task, men self-inflated more than women $B(485) = -0.06$, $p = .02$. Therefore, I controlled for gender in all analyses.

People from rice provinces were more likely than people from wheat provinces to draw the self smaller than they drew their friends $\gamma(24) = -0.20$, $p = .03$, $r = -.17$ (Figure 16). On average, people from wheat provinces self-inflated 1.5 mm (closer to Europeans), and people from rice provinces self-inflated -0.03 mm (similar to Japanese).

Pathogen prevalence did not predict self-inflation on the sociogram task $\gamma(17) = 0.003$, $p = .95$, $r = .04$. GDP per capita also failed to predict self-inflation $\gamma(24) = 0.04$, $p = .81$, $r = 0$.

Loyalty/Nepotism

I computed loyalty/nepotism as the amount they rewarded their friend minus the amount they punished their friend. People from rice provinces were more likely to show loyalty/nepotism $\gamma(25) = 2.45$, $p = .04$, $r = .49$. People from rice and wheat provinces did not differ in their likelihood to reward strangers more than they punished strangers $\gamma(24) = -0.09$, $p = .90$, $r = 0$.

Pathogen prevalence was not related to loyalty/nepotism $\gamma(19) = -0.13$, $p = .84$, $r = -.08$. GDP per capita did not predict loyalty/nepotism $\gamma(25) = 1.66$, $p = .36$, $r = .33$.

Differences along the Rice-Wheat Border

Testing China's rice and wheat provinces has the advantage of a large sample size of rice and wheat areas, but it also has a downside in that there are also other systematic differences between northern and southern China. For example, the north has had more contact with Mongolian and Manchurian herding cultures, and subsistence style theory holds that herding cultures are more individualistic (e.g., Nisbett et al., 2003). The north is also colder than the south, and some researchers have argued that climate is related to collectivism (Hofstede, 2001).

Besides statistically controlling for these variables, one way to minimize the effect of third variables is to test the counties along the rice-wheat border. Nearby counties have only minor differences in temperature, latitude, and dialect, and virtually no difference in contact with herding cultures.

However, nearby counties *do* differ drastically in the amount of rice and wheat they grow. For example, in Anhui province, Bozhou county farms 2% rice, but neighboring Huainan county farms 67% rice (Figure 17). Differences between these neighboring counties are much less likely to be due to contact with historical herding cultures or climate differences.

To test differences along the rice-wheat border, I analyzed the results from our largest task (cultural thought style). With over 1,000 participants from all over China, the data from this task had the detail necessary to compare 224 people from the counties in the five rice-wheat border provinces (Anhui, Sichuan, Chongqing, Hubei, and Jiangsu). I then categorized counties as rice versus wheat with the earliest statistics I could find for each province—the 2002 yearbooks. (For group comparisons, "wheat province/county" is defined throughout as < 50% farmland devoted to rice paddies, "rice" as > 50%.)

People from the rice side of the border thought more holistically than people from the wheat side of the border $B(221) = .54$, $p < .001$ (Figure 18; Table 4). To compare the border effect size with the effect size for rice and wheat in all of China, I compared effect of a

categorical rice-wheat variable. The effect sizes were similar (rice-wheat border B = 0.54; all China: B = 0.43).

Divorce

I controlled for GDP per capita because wealthier provinces had higher divorce rates B(26) = 0.10, p = .01, β = .48. Rice provinces had lower divorce rates B(26) = -0.11, p = .005, β = -.49, with an effect size similar to GDP per capita (Figure 19). Pathogen prevalence did not predict divorce B(20) = -0.01, p = .80, β = -.07 (controlling for GDP).

In 1996, wheat provinces had a 50% higher divorce rate than the rice provinces. Although divorce rates have almost doubled in the last 15 years, the raw divorce rate gap between the wheat and rice provinces has remained the same in the 2000 and 2010 Censuses.

Patents for Inventions

I controlled for GDP per capita because wealthier provinces had more patents B(26) = 2.22, p < .001, β = 0.73. Controlling for GDP, rice provinces had fewer successful patents for new inventions than wheat provinces B(25) = -1.27, p = .003, β = -0.39. Pathogen prevalence did not predict patents B(19) = -0.34, p = .29, β = -0.22.

In the case of patents, GDP per capita had a larger effect size than rice. This probably reflects the fact that economic development more clearly affects patents than divorce rates, since patents are a part of economic activity.

Next, I tested whether the differences have persisted over time. In 1996, wheat provinces had 30% more patents for inventions than rice provinces. This difference persisted through the 2000 yearbook, but not the 2010 yearbook.

Discussion

In sum, people from rice provinces scored differently on all three cultural variables. There were also rice-wheat differences in divorce and patents for inventions. GDP per capita and pathogens did not consistently predict the cultural variables. In fact, the wealthier rice

provinces actually scored *more* holistic. This offers preliminary evidence for the rice theory. However, from a big picture view, China is a single test case of the rice theory. Study 2 increases the cultural sample size by testing the rice theory in India.

Study 2

Why India is a Valuable Test Case

Study 3 tests for rice-wheat differences in India. India is another country of over a billion people that has a rice-wheat split. Thus, India offers a replication test for the findings from China. However, beyond replication, India is a valuable test case because its rice-wheat split is from east to west, rather than north south (Figure 20). In fact, northern India grows a significant amount of rice along the Ganges River, which flows out of the Himalayan Mountains in the north.

The fact that India is an east-west split is important because it compensates for the biggest disadvantage of China as a test case—temperature. In China, latitude and temperature are both correlated with rice because rice is grown in the south and wheat is grown in the north (rice and latitude $r = -.70$, $p < .001$). The rice-wheat border analysis in China provides one data point to suggest that rice-wheat differences are not confounds of temperature, but India provides a much stronger natural experiment in terms of temperature and latitude.

In India, rice is not correlated with latitude or temperature. At the state level, rice and average temperature are not correlated $r(25) = -.06$, $p = .76$. In fact, wheat states in India have a slightly *higher* average temperature than the rice states (wheat = 23.9 degrees Celsius, rice = 23.1; again, "rice state" defined as > 50% rice). Thus, we can use the data from India to test whether rice-wheat differences are confounds of temperature and latitude.[26]

[26] It should be noted that India is an outlier in this regard. Rice and temperature are correlated in the world as a whole. This raises the intriguing possibility that some earlier correlations between temperature/latitude and collectivism may be due to rice agriculture and other forms of subsistence (Kashima & Kashima, 2003).

Methods

To test for rice-wheat differences in India, I gave the same measures of cultural thought style and loyalty/nepotism to 500 people in India (triad task: n = 300, 20 states; loyalty/nepotism n = 300). Because 32% of the users of Amazon's MTurk platform are in India, it offers a convenient way to test for cultural differences (Ross, Irani, Silberman, Zaldivar, & Tomlinson, 2010). Although MTurk is not a random sample, it does offer a more diverse sample than the Chinese college samples. The India sample is more diverse in age, occupation, and education, allowing us to test for differences in a broader swath of society.

The sample was 65% male and 75% Hindu (the majority religion in India). The average age was 32, and 32% were from a large city. Because the India sample was diverse, I measured lots of control variables: age, gender, caste, income, education, religion, city size, and SES. I also collected data on GDP per capita at the state level.

Results

Cultural Thought Style

The results from India echoed the results from China. People from the rice parts of India chose more holistic pairings on the triad task than people from the wheat parts of India (r = .61, p = .003, Figure 21). This held controlling for the two individual-level demographic variables that were related to thought style: income and education. GDP per capita was not related to thought style p = .88.

Loyalty/Nepotism

As in China, people from rice provinces were more likely to punish strangers more than friends for the same behavior, showing more loyalty/nepotism (γ = 3.8, p = .01, r = .48). The results held for controlling for individual-level demographic variables and GDP per capita.

Discussion

The data from India makes three important contributions beyond the China data. First, it replicates the Chinese laboratory results with data not limited to universities. Second, it replicates the Chinese results in an environment where rice is not confounded with temperature or latitude. Finally, the data shows similar effect sizes as the Chinese data, suggesting a stable effect size.

Study 3

In Study 1, I analyzed people who grew up in neighboring counties along the rice-wheat border. However, that analysis has two drawbacks. First, the comparison includes people all along the rice-wheat border, which extends about 2,000 kilometers from Chengdu to Suzhou. Analyzing differences over such a large area has the benefit of large coverage, but it makes for a less-controlled comparison of nearby counties.

Study 3 improves upon this by drawing a larger sample focused within a single province. This focused sample lets us compare counties that are more similar on third variables (such as dialect and temperature), and it allows us to more clearly isolate rice-wheat differences. This can give us more certainty that rice caused the cultural differences and not third variables.

Second, in Study 1, only the thought style task had a large enough sample to test for rice-wheat border differences. It would be more convincing to widen the test to include other measures of culture. Therefore, Study 3 broadens the measures to include the loyalty/nepotism task, the sociogram task, and a new measure of social style relational mobility.

Relational Mobility

Relational mobility is a feature of social environments (Schug et al., 2010). In high-mobility environments, people have lots of opportunities to meet new people, make new friendships, and leave unsatisfying relationships. In low-mobility environments, people have

tighter social networks; it's hard to exit unsatisfying relationships; and there are fewer chances to meet new people. Americans rate their social environment as having higher relational mobility than the Japanese (Schug et al., 2010).

Why would rice farming lead to lower relational mobility? For one, rice farming had higher startup costs than wheat. Building irrigation systems for rice was probably beyond the ability of a single person or even a single family. Furthermore, the strict emphasis on reciprocal labor exchanges may have made it more difficult to break relationships. It is hard to break a relationship if you depend on that person to put food on the table.

Furthermore, the fact that relationships came bundled with labor exchanges would have made it costly to make too many friends. Therefore, it is reasonable to hypothesize that people from rice cultures will report lower relational mobility than people from wheat cultures. This would also fit with the common perception in China that northerners are more likely to talk to strangers.

Methods

Testing Site

Study 3 focuses on people in a single province on the rice-wheat border. I chose Anhui province because the rice-wheat divide in Anhui is particularly stark. For example, Jiangsu province is on the rice-wheat border, but even its northernmost counties grow 30% rice. (The true rice-wheat border may be Jiangsu's provincial border with Shandong province, where rice drops off to between 0 and 10%.) In contrast, Anhui has a starker divide. Anhui's Bozhou county devotes 2% of farmland to rice paddies, and neighboring Huainan grows 67% rice. This gives us a more stark rice-wheat split.

When sampling for county differences in Anhui, not all universities are ideal. Large national universities in Anhui such as the Chinese University of Science and Technology draw students from all over the country, but not enough to represent all the counties in Anhui.

Smaller universities such as Hefei College often draw a majority of their students from one or two counties. Thus, I sampled at Anhui University, Anhui Agricultural University, and Anhui Normal University, which are large enough to represent the entire province, but small enough that most students have grown up in Anhui.

Tasks

I included three tasks from Study 1: the triad task (thought style), the loyalty/nepotism task, and the sociogram task (implicit individualism). I also added a new measure of relational mobility (Schug et al., 2010). The 12-item relational mobility questionnaire asks participants to rate how easy it is to meet new people and leave undesirable friend groups. A previous study found that Americans rate higher relational mobility than Japanese (Schug et al., 2010).

Most psychological scales ask people to rate themselves, but the relational mobility scale asks participants to rate whether the statements apply to the people in their society (for example, people at their school, their neighbors). This is because researchers conceptualize relational mobility as a quality of a social group, rather than an individual trait. For example, one item reads, "It is common for [people in the community] to have a conversation with someone they have never met before."

Participants rate the items from one (*strongly disagree*) to seven (*strongly agree*). I analyzed the sum relational mobility scores. Researchers translated the scale into traditional Chinese for a previous study (Wang et al., 2011). I changed it to simplified characters (used in Mainland China).

Analysis

HLM. Study 3 replicates the analysis Study 1, which used a variable to represent rice counties versus wheat counties. Because students were tested in five different classes, I analyzed responses using hierarchical linear models with students nested within classes. I also ran hierarchical models nesting students within counties, and the results were similar.

Control Variables. Analyses included control variables from previous studies: gender and urbanization of the area where students grew up (measured here as self-reported 1 = rural, 2 = rural town, 3 = medium city, 4 = large city). As a test of the modernization hypothesis, I also tested whether the 2009 GDP per capita of the counties predicted cultural differences, but GDP predicted so little variation that I excluded it from the final models.

Enculturation. Finally, I tested a variable representing the number of years since the students had moved to college. I tested this because in Study 1, I found that participants from the rice region who moved to the wheat region enculturated to the thought style of the wheat region, becoming more analytic over time (although that data is cross-sectional and cannot prove change over time). Thus, I tested whether rice-wheat differences were smaller for students who had been living in the rice region (where the universities are located) for longer than one year.

Results

Participants

A total of 223 students participated in Study 3. To minimize extraneous variance, I removed 6 graduate students for a final total of 217 participants. Seventy-eight participants did not complete the sociogram task, giving a sample of 139 participants for that task.

Although this sample is fairly large, one weakness is that only 27% of participants were from the wheat area. Rice counties make up 71% of the province, and all of the sampled universities are located in the rice area. This limits the statistical power of this sample. Another limitation is that the sample leaned heavily female. Women made up 79% of the sample.

Holistic Thought

People from rice counties thought marginally more holistically B = 0.29, $p = .10$ (Table 5). However, there was a significant interaction between rice and the number of years

they had lived at school B = -0.74, p = .005. Among participants who had lived at school for a year or less, participants from the rice area chose more holistic pairings on the triad task B = 0.65, p = .02 (Figure 23). This effect size is comparable to the rice-wheat border county effect size in Study 1 (B = .54). Yet this difference shrank for participants who had been at school longer. Since the sample universities are located in the heart of the rice area, this result suggests that students from the wheat area are enculturating to the rice culture.

Implicit Individualism

Participants from rice counties showed marginally less self-inflation B = -0.24, p = .10. However, there was also an interaction between rice and the number of years at university B = 0.35, p = .046. Again, the pattern was the same: participants who had arrived recently from the wheat areas showed more self-inflation, but differences disappeared for participants from the wheat area who had lived in the rice area for longer B = 0.11, p = .26.

Loyalty/Nepotism

Loyalty/nepotism differences were not in the predicted direction and actually fell in the opposite direction, with people from rice counties showing less loyalty/nepotism B = -1.12, p = .046. The interaction with years spent at college was not significant B = 1.8, p = .19.

Relational Mobility

People from rice counties reported less relational mobility, although the trend was not significant B = -2.14, p = .05. There was no interaction between rice and years at college B = -1.00, p = .69.

Discussion

Overall, there was moderate support for differences between people from rice and wheat counties. Although I did not find the hypothesized differences in loyalty/nepotism at the county level, the rice-wheat border difference in thought style from Study 1 replicated. There were trends in the predicted direction for implicit individualism and relational mobility ($ps \leq .10$).

Enculturation

Study 3 provides new evidence of enculturation between rice and wheat areas. This echoes a pattern in the large dataset from Study 1. In Study 1, participants who moved from the south to the north showed less holistic thought if they had been in the north for longer. Movers are showing signs of enculturating to the local thought style.

There are many barriers to enculturation. For example, a Chinese immigrant to the United States has a large cultural gap to bridge and carries obvious markers of foreignness such as ethnicity and accent. Yet despite that gap, researchers have found evidence that people who have moved from China to the United States enculturate (for example, Hynie, Lalonde, & Lee, 2006).

Compare the case of a Chinese immigrant to the students in this study. Students crossing between rice and wheat cultures in Anhui face fewer of these obstacles. Students from nearby counties have no obvious gaps in ethnicity and citizenship, and they have smaller gaps in dialect. Even compared to students who move from southern China to northern China, enculturation should be more likely among students in Anhui because the cultural gap between counties in Anhui are much smaller than between northern and southern China as a whole. If enculturation is really happening, it would suggest that we would find larger rice-wheat differences if we compared students who had not moved between rice and wheat areas.

Limitations

Study 3 has limitations worth noting. First, the sample from the wheat counties was relatively small (n = 53). Of those, 60% came from a single wheat county (Fuyang). Future studies can improve on this by collecting larger samples and by sampling from a university in the wheat area. Sampling in the wheat area would also allow us to test for enculturation in the opposite direction—in people from the rice area who move to the wheat area. Finally, the sample was 79% female, which limits the representativeness.

Study 4

Is Relational Mobility a Mechanism for Rice-Wheat Differences?

Study 4 extends the prior studies by testing two questions. First, Study 4 tests whether relational mobility mediates rice-wheat differences (Figure 25). In essence, this asks whether rice agriculture lowers relational mobility, which then causes many of the other cultural differences between rice and wheat areas.

Some researchers have argued that relational mobility is a mechanism behind cultural differences (Schug et al., 2010). In other words, some cultural differences may be a strategy or a response to the fact that the social environment has low relational mobility. For example, if it is hard to make new friends and not socially acceptable to leave your current friends, it is rational to try hard to maintain current relationships. This could explain Japanese culture's emphasis on politeness and the "not offend others strategy" (Yamagishi & Suzuki 2009).

Another cultural difference that might be explainable is low rates of sharing personal information. Prior studies have found that people in Japan express less willingness than Americans to disclose personal information to other people (Asai & Barnlund, 1998; Schug et al., 2010; Ting-Toomey, 1991). At the same time, psychologists have found that self-disclosure is a tool for building new relationships—it increases feelings of affiliation (Laurenceau, Barrett, & Pietromonaco, 1998).

Later researchers have argued that self-disclosure is a strategy suited for social environments with lots of opportunities to exit old relationships and meet new people (Schug et al., 2010). Schug and colleagues (2010) tested this theory by (1) first replicating the finding that Japanese people report less willingness to self-disclose than Americans, (2) then finding that relational mobility can explain these cross-cultural differences.

Study 3 found that rice counties had lower relational mobility. Study 4 will test (1) whether there are relational mobility differences between the wheat and rice provinces and (2) whether relational mobility can explain variation in analytic thought and loyalty/nepotism between rice and wheat areas. There is some evidence that relational mobility can explain cultural differences in analytic thought (San Martin, Schug, & Maddux, submitted). Study 4 will test whether this explanation extends to rice-wheat differences. If so, it would suggest that relational mobility helps perpetuate rice and wheat cultures in China.

If relational mobility helps perpetuate cultural differences in China, it would also fit with the social orientation hypothesis (Varnum, Grossman, Kitayama, & Nisbett, 2010). The social orientation hypothesis argues that social style differences cause differences in thought style. Varnum and colleagues argue that people think analytically if their culture endorses "self-direction, autonomy, and self-expression" and views the self as "bounded and separate from social others" (Varnum et al., 2010, p. 9). In contrast, people think holistically if their culture endorses an interdependent, connected view of the self and emphasizes fitting in.

However, it should be noted that much prior research has used individualism to explain thought style differences. Relational mobility is distinct from individualism, although the two are likely correlated. Furthermore, "self-direction" and "autonomy" are closer to individualism than relational mobility.

What is Analytic Thought?

The second question Study 4 tests is whether cultural analytic thought is the same thing as logical thought. Studies 1-3 used the categorization task to measure analytic thought, but it's not clear what that means for the real world. To some people, "analytic" implies that people would be better at logic problems.

However, most cultural psychologists have not used problems with clear right and wrong answers, perhaps out of a concern that these tests have value judgments (although there is an exception in the logical syllogisms used in Study 3 and Study 4 from Norenzayan, Smith, Kim, & Nisbett, 2002). Study 4 tests whether cultural analytic thought is the same thing as right-and-wrong logical thought or whether it is truly a thought style used for occasions where there is no clear right answer

Possibility 1: Analytic Thought is a Style. It is possible that analytic and holistic thought are truly "styles." That is, people may think holistically in situations where it is ambiguous what thought style is best. The triad task might fit that description because it does not have correct answers. (Is it correct to pair monkey with panda? Is it correct to pair monkey with banana?)

If holistic thought is a style rather than an ability, then people with holistic thought styles should be just as likely to use analytic thought when the situation clearly calls for it. In the same way, Michael Jordan was very competitive, but he knew to tone down his competitiveness when playing driveway basketball with his two young sons.

There is some evidence that holistic thought style is a situational preference rather than an ability. A large-scale international study of IQ found that five typically holistic nations lead the list: Hong Kong, South Korea, Japan, Taiwan, and Singapore (Lynn & Vanhanen, 2002 using published reports of Raven's Progressive Matrices mostly with children). The United States may be the most analytic nation on earth, but it is tied for 19th

place in IQ. At least among developed Western and Eastern cultures, holistic thought does not seem to correlate with IQ at the national level. If that is true, it would be incorrect to map analytic thought style onto abilities like logic problems.

Possibility 2: Analytic Thought is an Ability. However, there is some evidence that thought styles are not just styles. One study tested students in Korea and the United States with logical syllogisms (Norenzayan et al., 2002). Korean participants were more likely to fall for the trap of flawed syllogisms that have believable conclusions. For example, participants saw two premises and were told to assume these premises are true:

Premise 1: All animals which feed their young are mammals.

Premise 2: Birds are not mammals.

Conclusion: Birds feed their young.

Then they had to judge whether the conclusion logically follows from the two premises. In this case, "birds feed their young" is an intuitive conclusion, so many people's gut response is to say this syllogism is valid. However, the premises do not logically lead to the conclusion, so the syllogism is actually invalid. Korean participants were more likely to commit these types of errors than Americans. Yet, on syllogisms that were not influenced by believability, both groups performed equally well.

Methods

Study 4 will test whether analytic thought is related to people's ability to solve logic problems by having participants complete tests of logic and cognitive ability.

Cognitive Reflection Test. The Cognitive Reflection Test has three puzzles that pit strong intuitive responses against correct, thought-out responses. For example, one question asks, "A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?" Many people have the strong intuition that the ball costs .10, and the bat costs $1.00. However, the bat costs $1.00 more than the ball, so the bat would could $1.10.

Add .10 to that and you get = $1.20. The correct answer is .05. The cognitive reflection test correlates moderately with IQ as measured by the Wonderlic Test (*r* = .43; Frederick, 2005).

Logic Syllogisms. Participants took 14 logical syllogisms (Morley, Evans, & Handley, 2004). Five of the syllogisms lead participants are "belief bias" syllogisms, like the syllogism listed above. In belief-bias syllogisms, the logic is false, but the conclusion seems intuitively true. These problems pit people's intuition against their logical ability.

Five of the syllogisms are free from belief bias because the logically correct answer is set up to fit with most people's intuition. For example, the following syllogism is wrong, *and* the conclusion seems intuitively wrong:

Premise 1: All living things grow.

Premise 2: Computers do not grow.

Conclusion: Computers are not living things.

Another four syllogisms are stated in abstract forms that have nothing to do with believability. For example, the following syllogism is valid and has no real-world components that would influence intuition:

Premise 1: All As are B.

Premise 2: C is an A.

Conclusion: C is B.

Analytic Thought and Loyalty/Nepotism. As in Study 1, participants took the triad task and the loyalty/nepotism task. These tasks will be the dependent variables that may be predicted by relational mobility.

Relational Mobility Scale. Participants also took the 12-item relational mobility scale (Schug et al., 2010). For Study 4, I modified the instructions to ask about the social ties in the areas where people grew up, rather than where they are currently. This is because all participants are now in the same university, in presumably the same social environment

(although people from rice and wheat areas may very well have different perceptions of the university environment).

Demographics. Participants reported the same demographic information as in prior studies, including the key variable of their hometown and home province.

Participants

Participants were recruited from large lecture classes at East China Normal University in Shanghai. Only 94 Han participants (86 female) were recruited, including only 25 participants from the northern wheat areas. This limits our ability to test for rice-wheat differences, but it does allow us to test for individual-level correlations between holistic thought and logic scores. With 94 participants and 80% power criterion, this sample size can reliably detect correlations of $r = .29$ and larger. Future studies with larger samples are needed to get more stable estimates, particularly for smaller effect sizes.

Results

Replicating Prior Rice-Wheat Differences

With the small sample size makes it less likely to find significant effects, but the same patterns held as in the earlier studies (Table 6). Participants from rice areas chose more holistic pairings on the triad task $\gamma = 0.65$, $p = .13$, $r = .46$, rewarded friends more than they punished them on the loyalty/nepotism task $\gamma = 2.15$, $p = .26$, $r = .60$, and rated their social environments as having lower relational mobility $\gamma = -5.80$, $p = .08$, $r = .55$. However, the relationships were not significant.

Does Relational Mobility Mediate Rice-Wheat Differences?

Next I tested whether relational mobility mediates the rice-wheat differences. It's important to note one weakness of these mediation models at the outset. Because the baseline relationships between rice and the cultural variables were not significant, it harder to test for

mediation. However, the pattern of the results can offer preliminary evidence for or against mediation.

I used the Onyx program to compare (1) a model using rice to predict holistic thought and (2) a model with a path from rice to relational mobility to holistic thought (Figure 26). I then ran identical models with loyalty/nepotism as the dependent variable. To test for mediation, I compared the regression coefficient for rice across the models by converting the differences to z scores. If adding relational mobility makes the rice coefficient smaller, it would suggest that relational mobility mediates the relationship between rice and thought style.

I also compared overall model fit using the Akaike Information Criterion (AIC) and -2 log likelihood. For both criteria, lower numbers indicate better model fit. The major difference between the two is that the AIC penalizes models for added complexity, whereas -2 log likelihood does not. If adding a path from rice through relational mobility to cultural thought improves model fit, it would support the idea that relational mobility mediates rice-wheat differences.

Holistic Thought. Comparing a base model and mediation model for holistic thought, the coefficient for rice was unchanged (base B = .03, mediation B = .03). The coefficients were not different $p > .99$. Model fit indices gave a similar result. The AIC was poorer for the mediation model (base AIC = 675.5, mediation AIC = 679.2). The -2 log likelihood was virtually unchanged (base = 661.5, mediation = 661.2, $p = .84$). Thus, there was no evidence that relational mobility mediated the rice-wheat differences in thought style.

Loyalty/Nepotism. Results were similar for loyalty/nepotism. The rice coefficient was similar in the base model and mediation model (base B = 1.28, mediation B = 1.11). The coefficients were not significantly different ($p = .93$). The AIC showed poorer model fit for

the mediation model (base AIC = 1223.8, mediation AIC = 1224.4). The -2 log likelihood improved slightly (base = 1209.8, mediation = 1206.4, $p = .18$).

In sum, there was little to no evidence that relational mobility mediated rice-wheat differences. Although there was virtually no evidence of mediation, it should be noted that the sample is fairly small, with only 25 participants from the wheat area. This limits the statistical power of these mediation tests.

Rice-Wheat Differences in Logic

People from rice provinces performed better on the logic problems. These group-level differences mirror the differences at the nation level, with holistic nations in East Asia scoring near the top on IQ tests (Lynn & Vanhanen, 2002). On the Cognitive Reflection Test, people from rice provinces answered more questions correctly $\gamma = 1.27$, $p = .03$, $r = .82$. The differences were the most stark on the bat-and-ball question, which 83% of people from rice provinces answered correctly compared to only 56% of people from wheat provinces. These differences remained in models controlling for province GDP per capita, urban-rural, and gender.

Results were similar on the logic syllogisms. Summing all syllogisms together, people from rice provinces answered more items correctly, although the difference bordered significance $\gamma = 0.63$, $p = .08$, $r = .52$. The same pattern held two of three sub-categories: the belief-conflict items, which pit intuition against logic $\gamma = 0.63$, $p = .08$, $r = .23$, as well as the non-conflict items problems $\gamma = 0.99$, $p = .17$, $r = .75$. There were no differences on the abstract logic problems $\gamma = 0.007$, $p = .99$, $r = 0$.

Is Holistic Thought a Style?

In general, participants who thought more holistically performed better on the logic tasks (Figure 27, Table 7). People who thought holistically were more likely to answer the logic syllogisms correctly, although it did not reach significance B = 0.50, $p = .08$, $r = .19$.

This same trend appeared for all sub-types of syllogisms: belief-bias syllogisms B = 0.28, p = .56, r = .07, non-belief-bias syllogisms B = 0.41, p = .46, r = .09, and abstract logic problems B = 0.91, p = .10, r = .21. Thus, the distinction between abstract logic and logic problems that pit intuition against logic did not seem to matter. In each case, holistic thinkers answered more items correctly. The one exception was the Cognitive Reflection Test. Answers on this test were not related to holistic thought B = -0.07, p = .89, r = -.02.

Discussion

Overall, the results support the idea that holistic thought is truly a style. On tasks that had clearly defined right and wrong answers, holistic thinkers were perfectly able to think logically. In fact, they did better on the logic syllogisms on average. People who thought more analytically (in a cultural sense) did not do any better on logic tasks that had clear right and wrong answers.

These results raise an intriguing question: Is the key cultural fit? Perhaps holistic thinkers have better cognitive performance in countries like China and Japan, where holistic thought is more the norm. But in countries like the United States, perhaps the relationship is the opposite. In a previous study colleagues and I completed with 182 Americans, holistic thinkers did significantly worse on the Cognitive Reflection Test. This offers at least preliminary evidence that people who fit their cultural thought style have the highest cognitive performance.

The results gave virtually no support for the idea that relational mobility is the direct cause of rice-wheat differences, even though rice areas did in fact have lower relational mobility. This leaves the door open for other potential mediators, such as individualism, other cultural values, parenting style, institutional differences. In the end, culture is a complex phenomenon, and it is unlikely that large cultural differences will have a single mechanism underlying them.

Conclusion

The rice theory of culture has the potential to make empirical and theoretical contributions. First, it advances theory on culture by giving evidence that historical subsistence style can continue to affect cultures in modern times. These findings also advance earlier subsistence theory (e.g., Berry, 1967; Nisbett & Cohen, 1996; Uskul et al., 2008). Earlier subsistence theory mostly treated farming as a single category and contrasted it with herding. The rice theory holds that not all farming is the same. Rice farming is a particularly collectivistic type of farming.

At the same time, it is important to not oversimplify the rice theory. The rice theory is not ecological determinism. Around the world, not everywhere that has the rain and soil to grow rice actually grows rice. And not all places that grow rice grow it as intensively as in China. Even among people who grow rice, many grown it in ways that do not lead to collectivism. For example, modern-day farmers in California solve rice's labor problem with modern technology. White Americans in Georgia used slaves to "solve" rice's labor problem. Collectivism is a solution to the problems rice presents, but it is not the only solution.

The rice theory also helps bring different fields together by incorporating research from anthropology, agronomics, history, archaeology, and psychology. In fact, the discovery that historical practices are still influencing culture today speaks to the importance of incorporating history into our understanding of modern-day culture (Alesina et al., 2011; Dell, 2010). It also speaks to how little we know about how these cultural differences are being passed down over time (Dell [2010] gives one example of how this can be done).

The rice theory has also led to several empirical findings. First, it helps demonstrate East Asia's cultural diversity. Cultural psychologists have sometimes treated East Asian cultures as interchangeable, but the rice theory attests to the important cultural diversity

within East Asia (Kitayama, Ishii, Imada, Takemura, & Ramaswamy, 2006). Simply put: East Asia is not all the same.

Understanding Han China's two very different cultures is also important for anyone interested in China's rise as a global superpower, such as global businesses and politicians. If for no other reason, China's sheer scale means it is important to understand its two cultures. Han China has over 1.3 billion people. That means the rice and wheat regions are each larger than the United States. If I were marketing products to China or managing employees in a Chinese business, I would want to know about these cultural differences.

The rice theory can also help us understand other Chinese cultural regions, such as Hong Kong, Singapore, and Taiwan. These three areas were all predominately settled by people from the rice areas of China, and that has implications for their psychological cultures. For example, Singapore is a highly urbanized country with a GDP per capita higher than Western Europe (Figure 1). Yet Singaporeans still score highly on loyalty/nepotism (Wang et al., 2011) and collectivism (Figure 2).

The rice theory also has implications for cultures outside of East Asia. This paper focuses on East Asia, but rice farming is not just an East Asian phenomenon. Cultures from India and Pakistan to Indonesia and the Philippines to West Africa have farmed rice. I have tested the theory in China and India, but there is much work to be done in other countries. There is also much potential for fruitful research on the historical legacies of the economies of other crops, such as sugar cane and corn.

Next Steps

Despite these advances, the rice theory is still missing important pieces. Perhaps the biggest missing piece is that I have not tested the specific mechanisms of irrigation and labor exchange. In addition, we know very little about how rice culture is perpetuated at a time

when so few people are still farming. These missing pieces leave the door open for much further research.

The rice theory can also give researchers a new canvas on which to test theories in cultural psychology. For example, some researchers have been interested in the idea that cultural differences are partly genetic (Chiao & Blizinsky, 2010). Other researchers have argued that genes continued to evolve along with human culture, which would mean that selection has been changing human genes far more recently than scientists used to think (Richerson & Boyd, 2008). Were rice villages' strong social norms and shaming of free riders enough to alter the genes of people in rice cultures (Aoki, 2001)? I do not know the answer.

Finally, the rice theory has the potential to at least partly resolve a long-standing question: why are there such large psychological differences between the East and West? Rice agriculture can help explain at least some of why East Asian rice cultures are so much more collectivistic than the West.

Rice agriculture also helps explain the East Asian paradox, and China's northern wheat heritage helps explain why I felt more at home living in Beijing than Guangzhou. However, I can't guarantee it will ever be able to explain why my French traveling partner and I did not have to leave a tip in that small-town Chinese restaurant.

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Figures

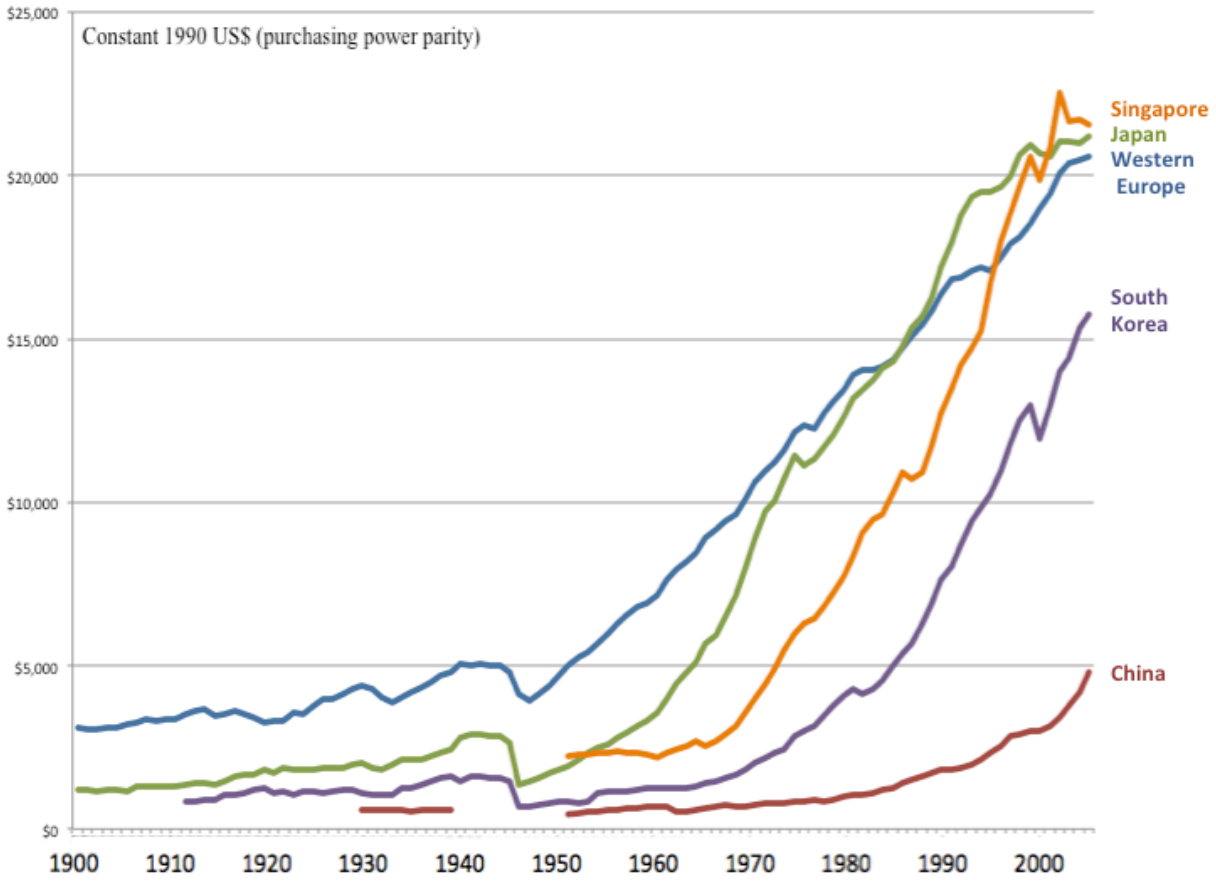

Figure 1. Historical GDP per capita in Western Europe and East Asia from 1900. The currency is constant 1990 US dollars adjusted for purchasing power parity (Maddison, 2003). Maddison defines Western Europe as Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Sweden, Switzerland, and the United Kingdom.

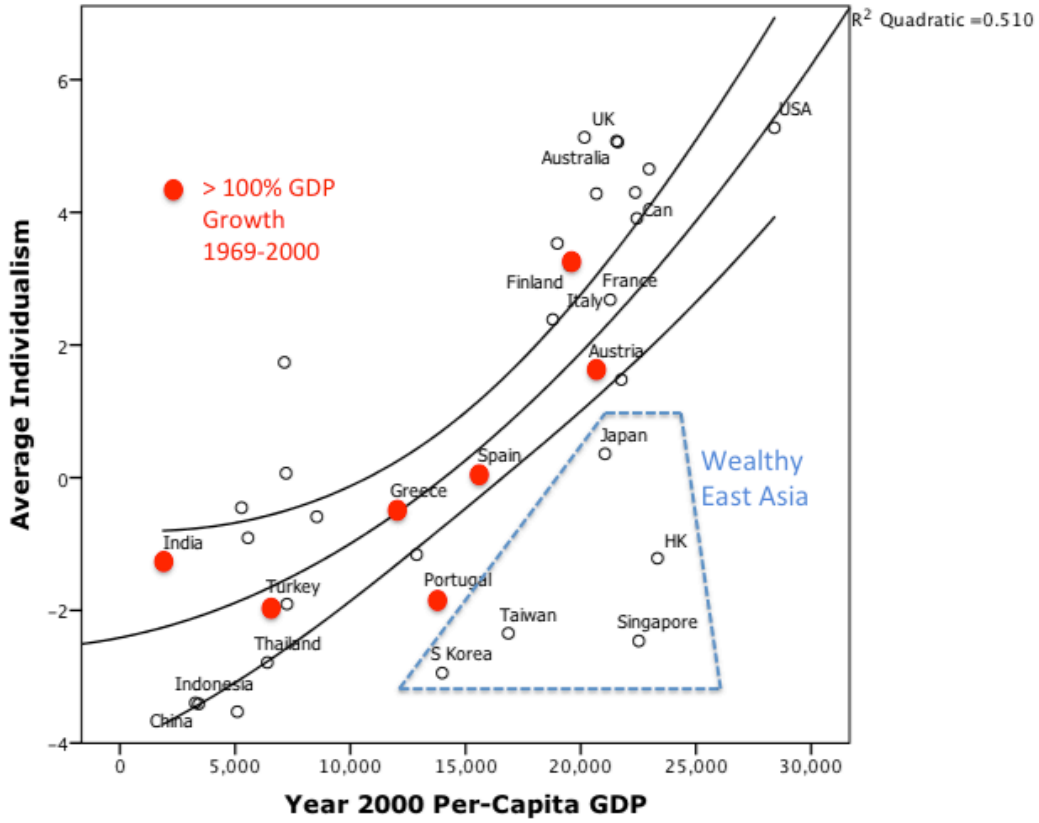

Figure 2. Per-capita GDP and individualism. The central line is a quadratic regression line, and the lines bordering it are 95% confidence intervals. To calculate individualism, I converted two published individualism scores (Hofstede, 2001; Suh et al., 1998) into *z* scores, added them together, and subtracted the *z* score of another published study of collectivism (Gelfand et al., 2004). All three individualism and collectivism scores are highly correlated in the predicted direction, |*r*|s ranging from .76 to .91. Per-capita GDP is from a dataset of historical GDP that uses 1990 international dollars and takes purchasing power parity into account (Maddison, 2003).

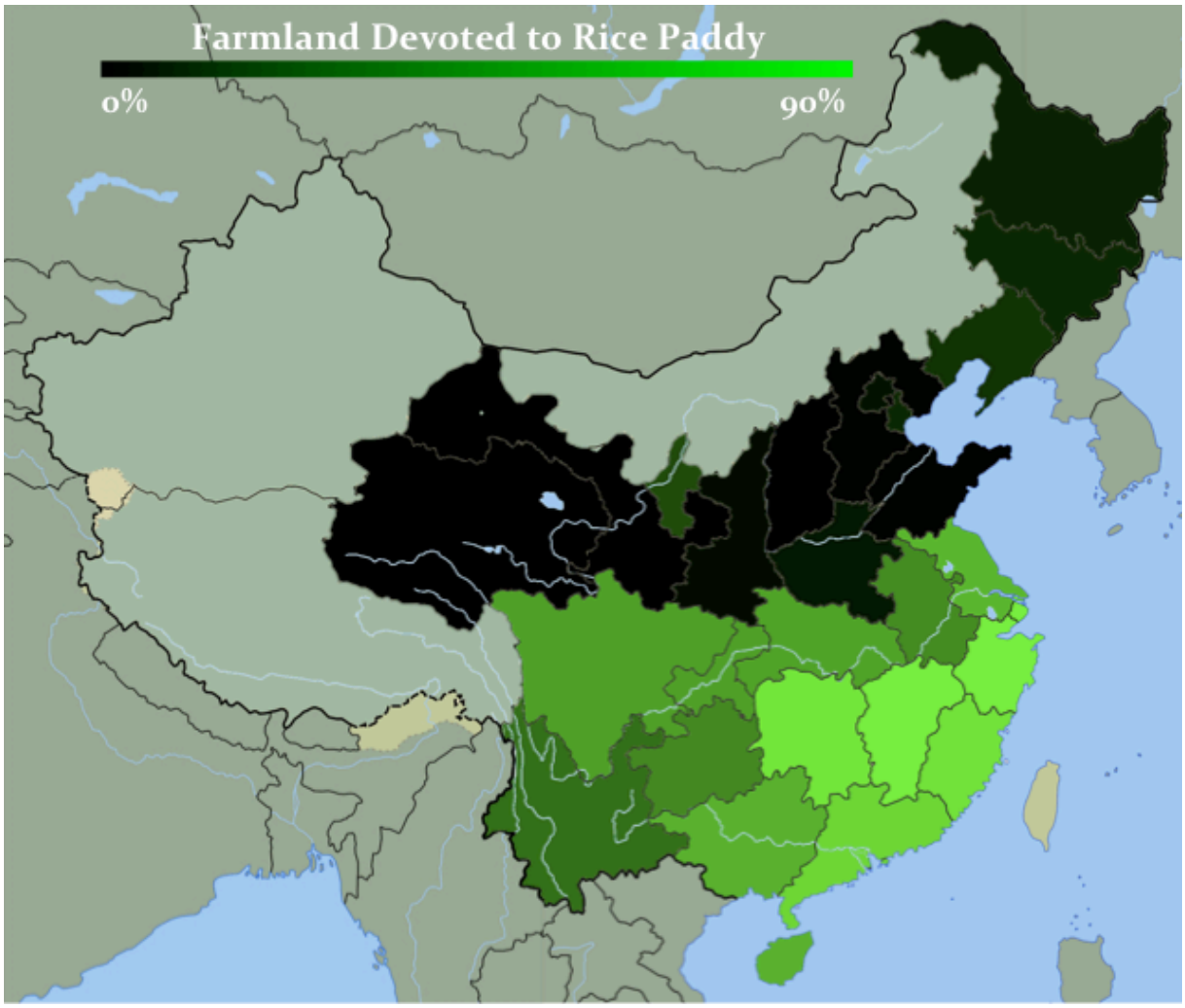

Figure 3. Percent of cultivated land devoted to rice paddies per province in 1996. Three major herding provinces are not shaded: Tibet, Xinjiang, and Inner Mongolia.

Figure 4. Percent of cultivated land devoted to wheat, corn, and soybeans per province in 1996. Three major herding provinces are not shaded: Tibet, Xinjiang, and Inner Mongolia.

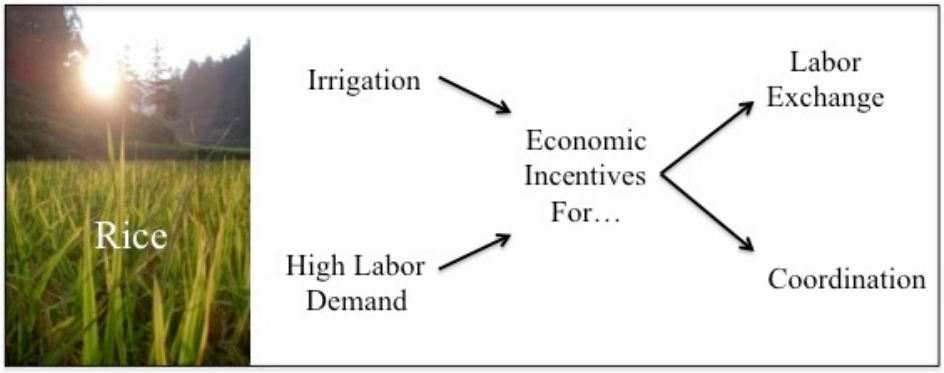

Figure 5. Simple schematic of the rice theory of culture.

Figure 6. A dragon's backbone tool for irrigation, commonly used in China. It is also known as a square-pallet chain pump. Pumps like these helped farmers reap more rice, but they also increased the labor requirements.

Figure 7. A dragon's backbone pump in Sichuan, China 1943. Photo by Joseph Needham.

Figure 8. Researchers placed the common weed found in rice fields (*echinochloa colona*) in containers with different levels of flooding. Less flooding is on the left. More flooding is on the right. Proper flooding decreases weed growth (IRRI, 2009).

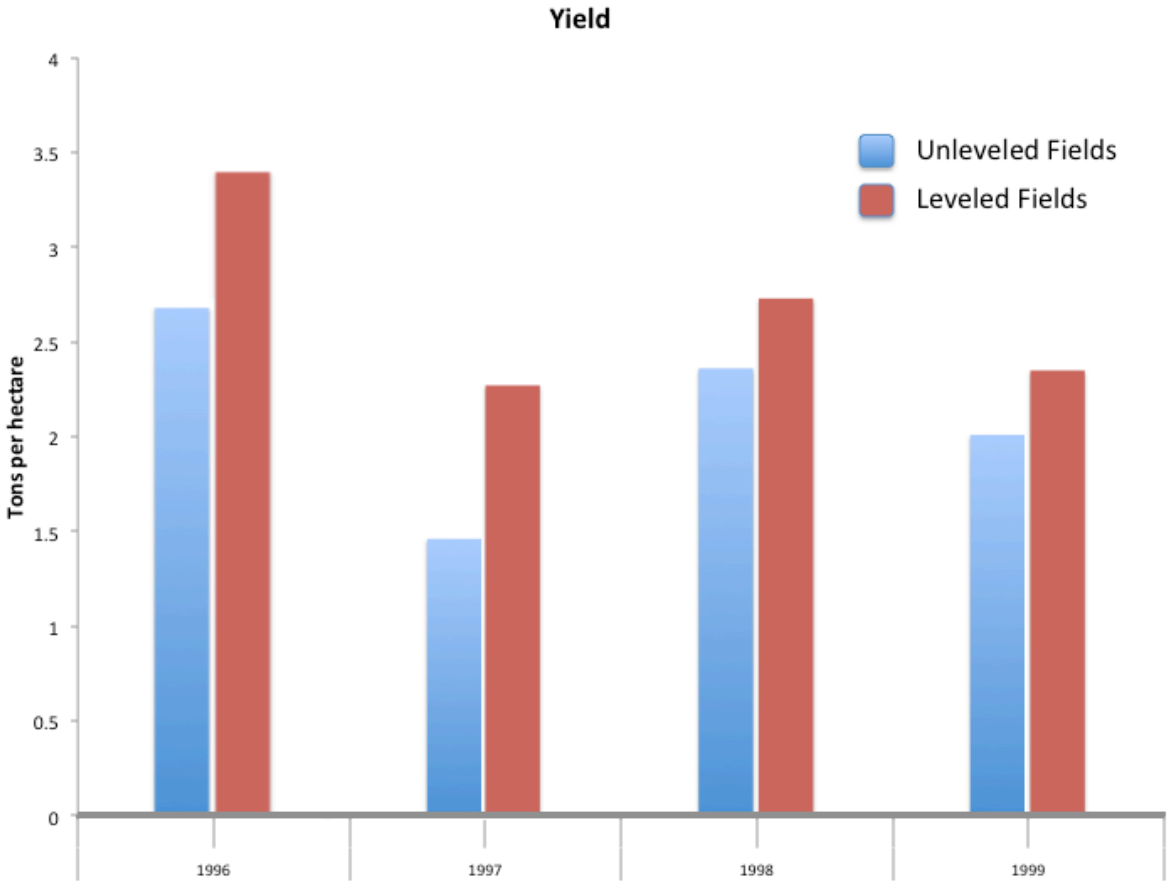

Figure 9. Land-leveling experiments conducted in Cambodia by the Cambodia-IRRI-Australia Project. The experiments covered a total 102 rice fields.

Figure 10. A spectrum representing the extent to which different subsistence styles encourage individualism or collectivism. This spectrum is clearly oversimplified and does not include other types of subsistence, such as hunting and foraging.

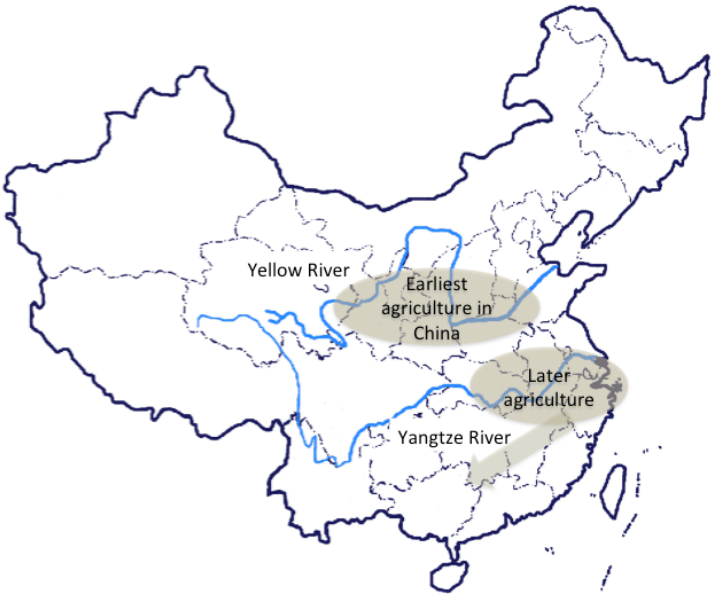

Figure 11. The historical spread of widespread intentional agriculture in China. Regions are gross approximations.

Map 1. China's macroregional systems in relation to provinces, showing metropolitan cities, 1990

Figure 12. Skinner's nine regions based on drainage basins.

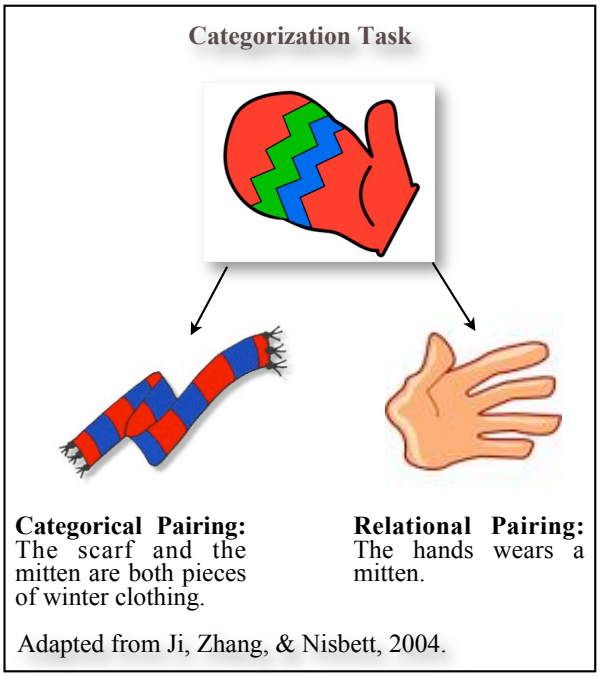

Figure 13. The triad task presents series of three objects to participants and asks them to choose the two objects that are most closely related. Each triad has two objects that share a functional relationship (hand and mitten) and two that belong to the same abstract category (mitten and scarf).

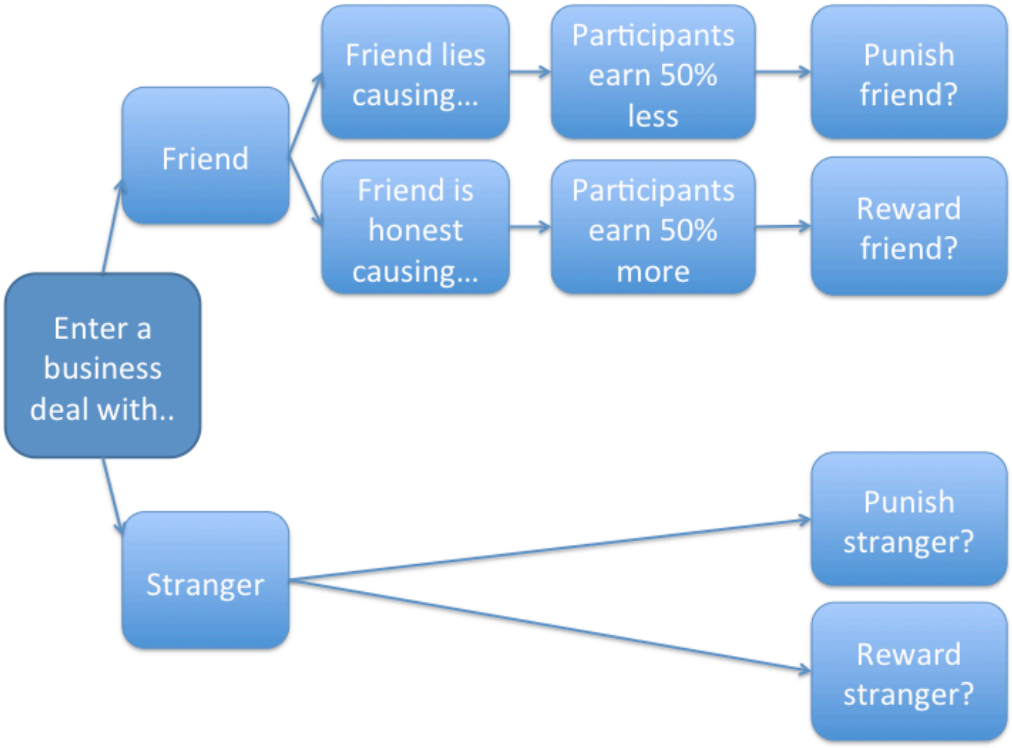

Figure 14. Schematic of the loyalty/nepotism task measuring people's distinction between friends and strangers (Wang et al., 2011). People from collectivistic cultures tend to punish the stranger much more harshly than the friend for the same behavior.

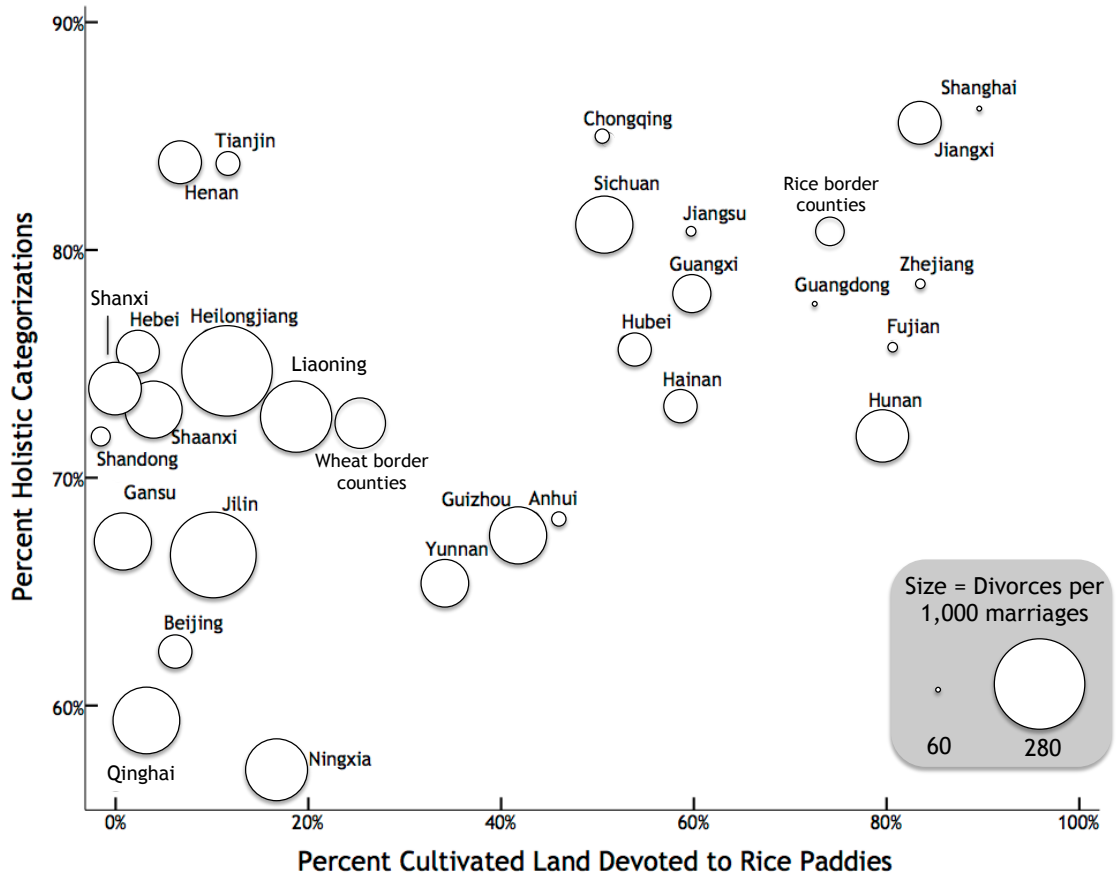

Figure 15. Cultural thought style by percentage of cultivated area devoted to rice paddies. Each dot represents a province. Dot size represents divorce and controls for effect of GDP per capita. To illustrate cultural differences along the rice-wheat border, dots represent the rice and wheat border counties.

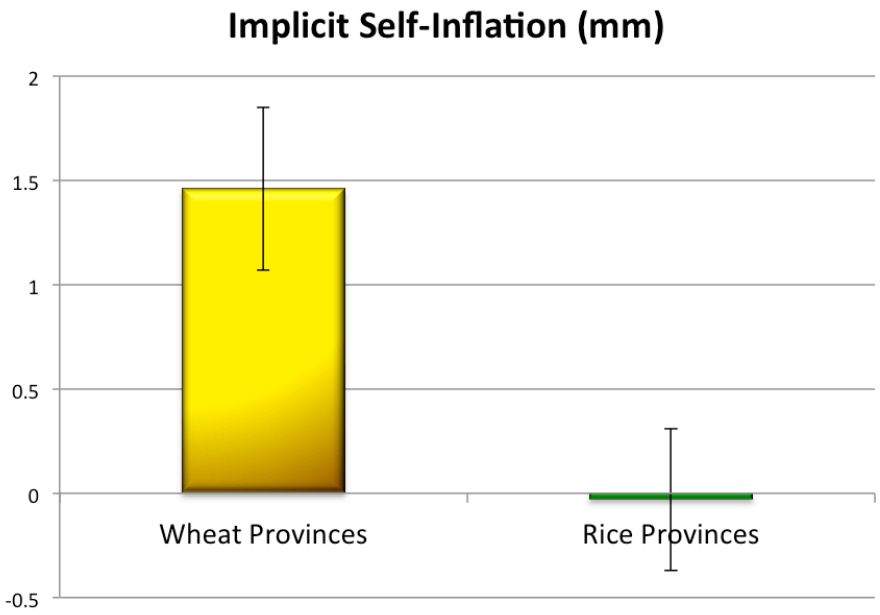

Figure 16. Implicit individualism in wheat and rice provinces. Values above 0 represent symbolic self-inflation (drawing self bigger than friends), characteristic of Western cultures. Error bars = 1 SEM. Values control for the potential confound of site effects. "Rice" is defined as > 50% cultivated area devoted to rice paddies.

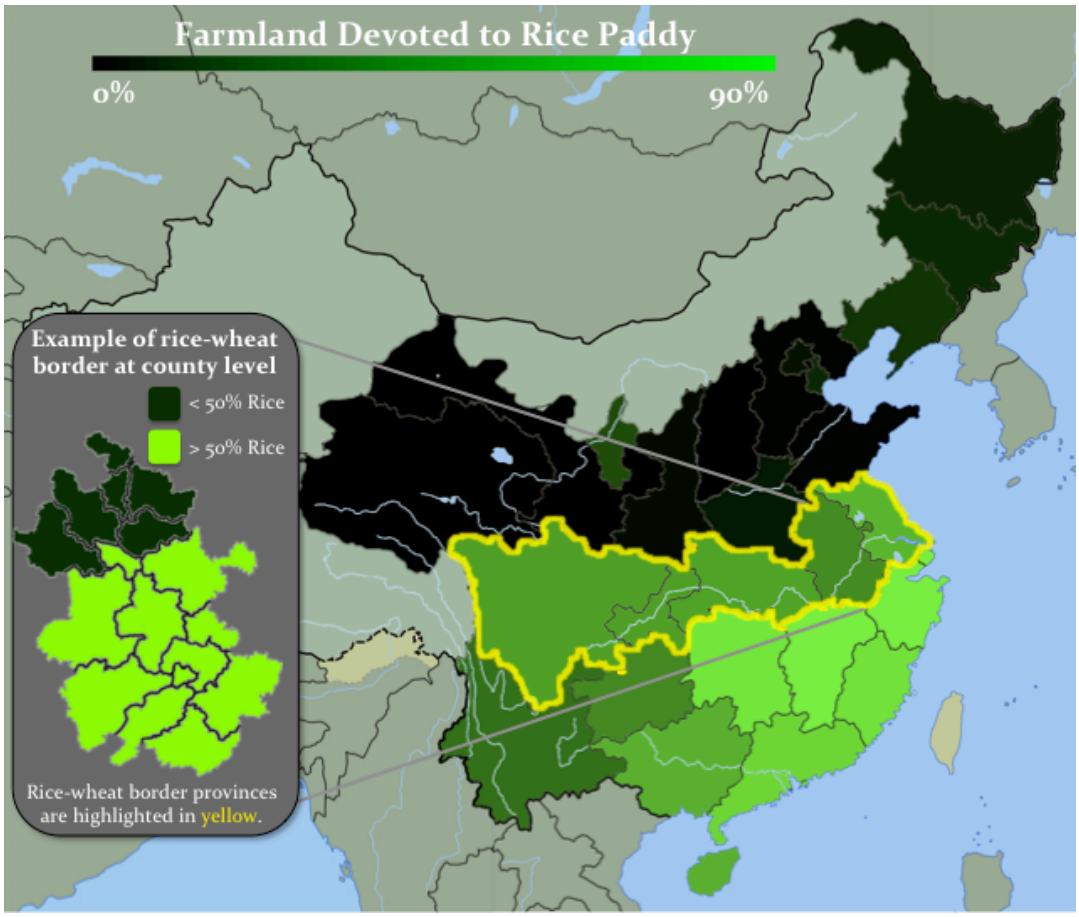

Figure 17. An illustration of the rice-wheat border at the county level in Anhui province.

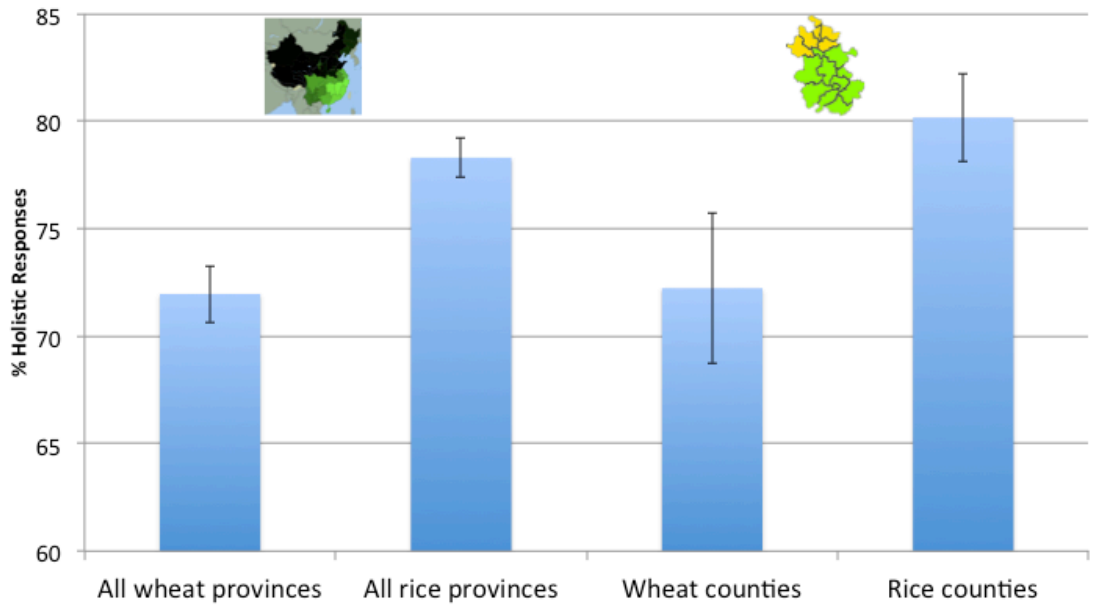

Figure 18. Thought style differences in China as a whole (left) and in the counties near the rice-wheat border. Error bars = 1 SEM.

Figure 19. To control for the effect of GDP, divorce rates are unstandardized residuals from a regression predicting divorce from GDP per capita. The relationship between rice and divorce is robust to the three outliers in the upper left. Excluding these three provinces (the *dongbei,* northeast), rice predicts divorce $\beta = -0.41$, $p = .015$.

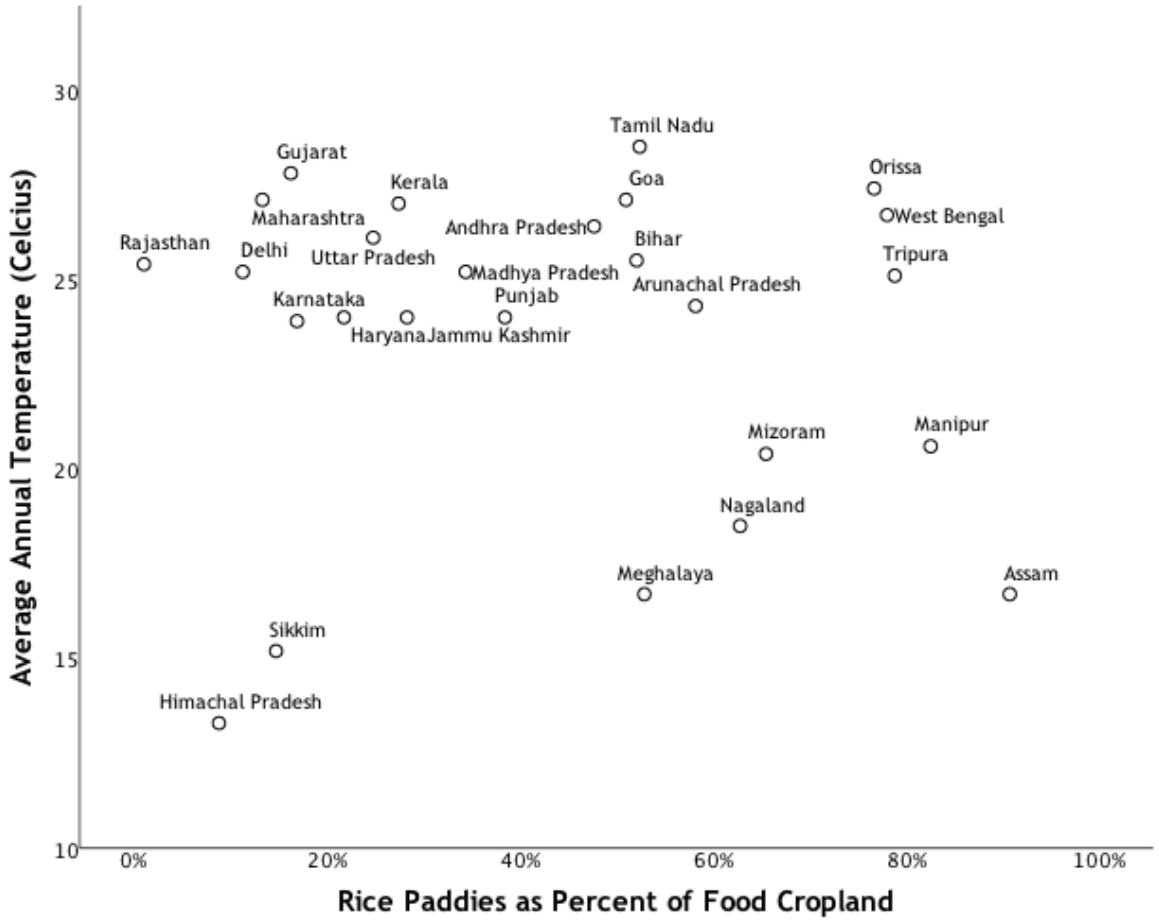

Figure 20. One advantage of India as a natural test case is that rice is not correlated with temperature. Each dot represents a state.

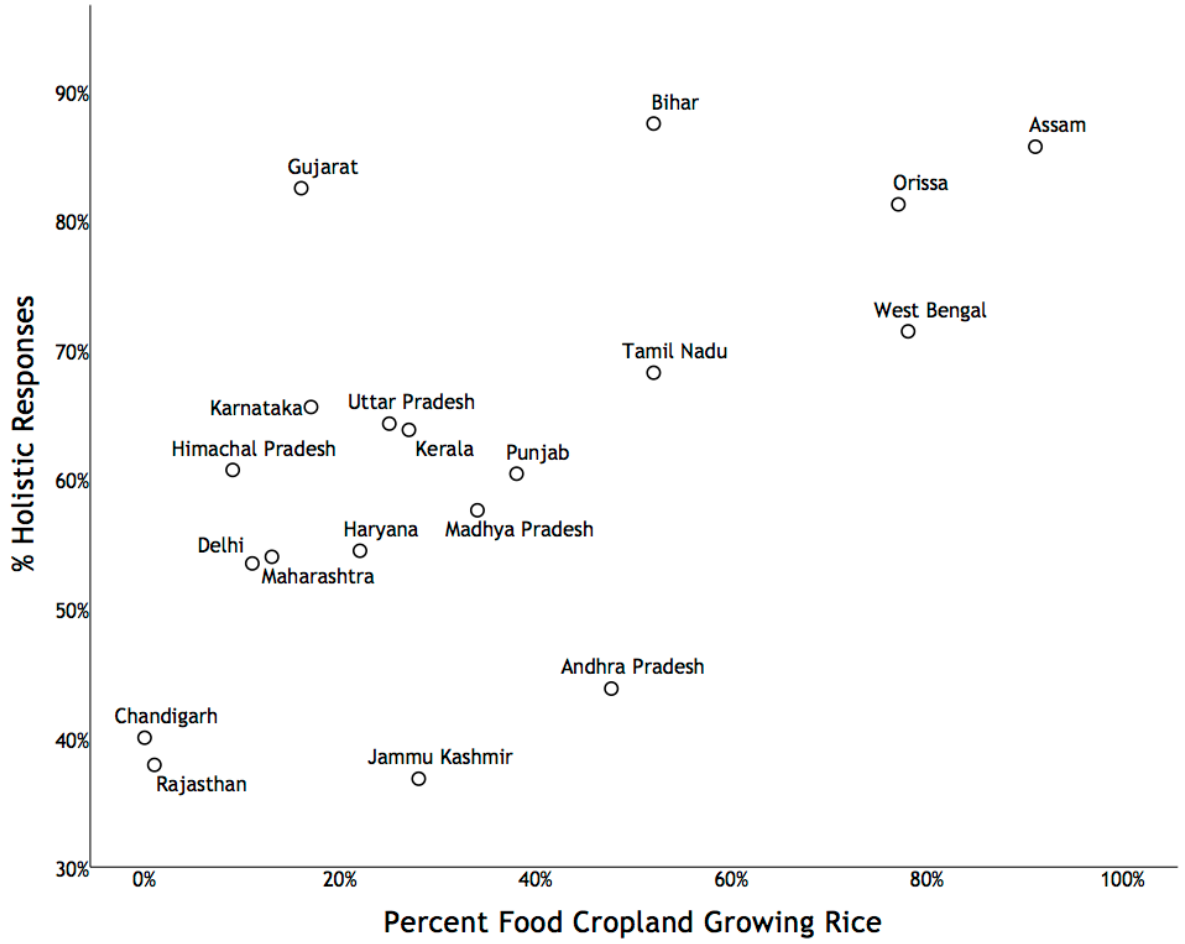

Figure 21. Holistic thought and rice agriculture in India. Each dot represents a state.

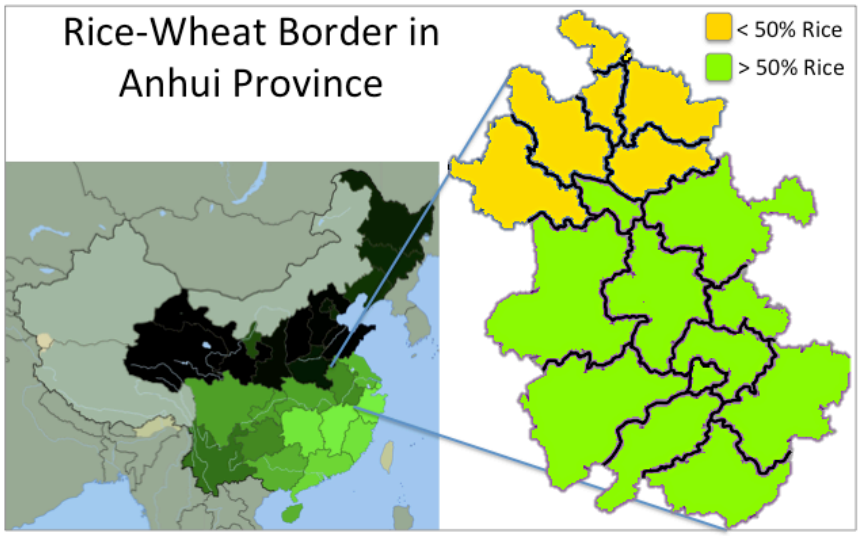

Figure 22. Rice-wheat split at the county level in Anhui province.

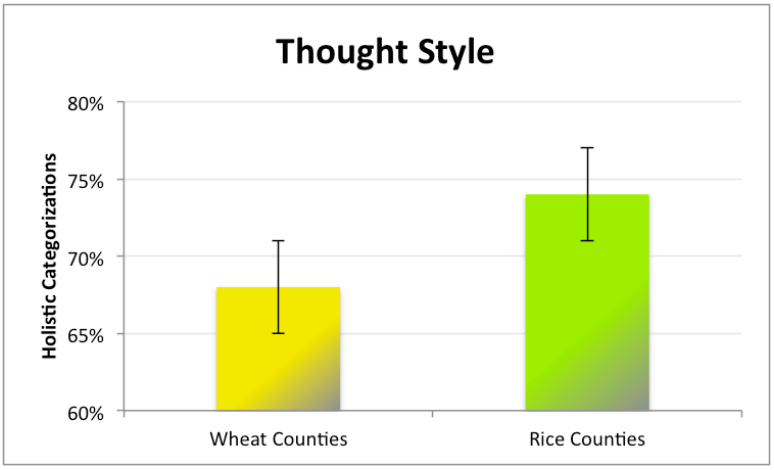

Figure 23. Rice-wheat county differences in Anhui among students who had been at university for one year or less. The values controls for urbanization and gender. Bars = 1 SEM.

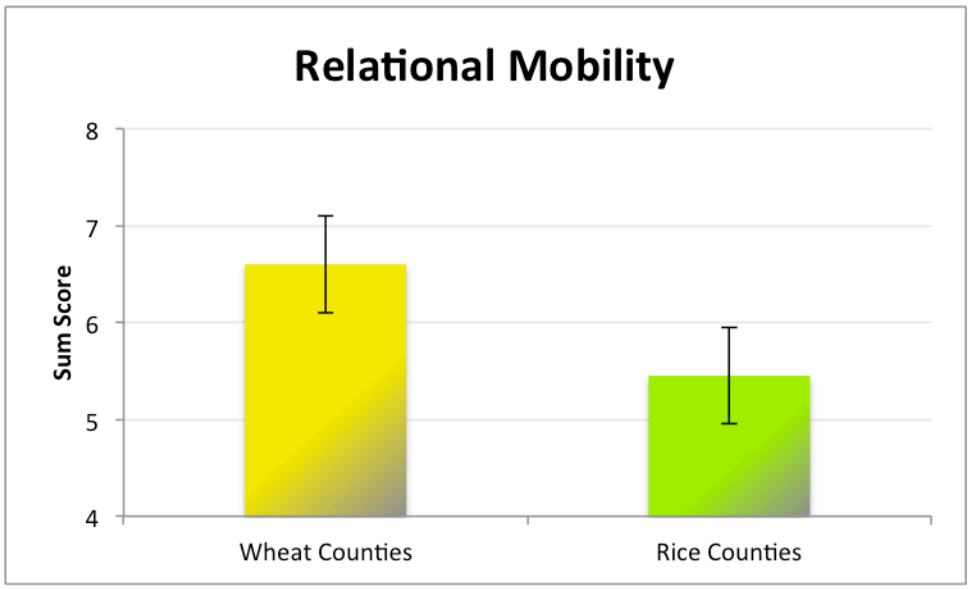

Figure 24. Rice-wheat differences in relational mobility at the county level in Anhui. The values control for urbanization. Bars = 1 SEM.

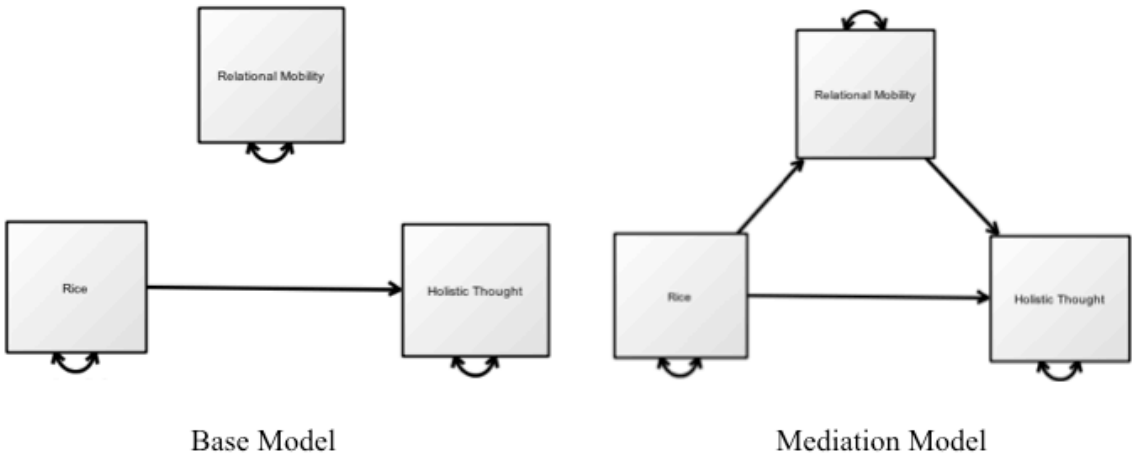

Figure 25. Potential mediation model. Study 4 tests whether relational mobility mediates rice-wheat cultural differences in China.

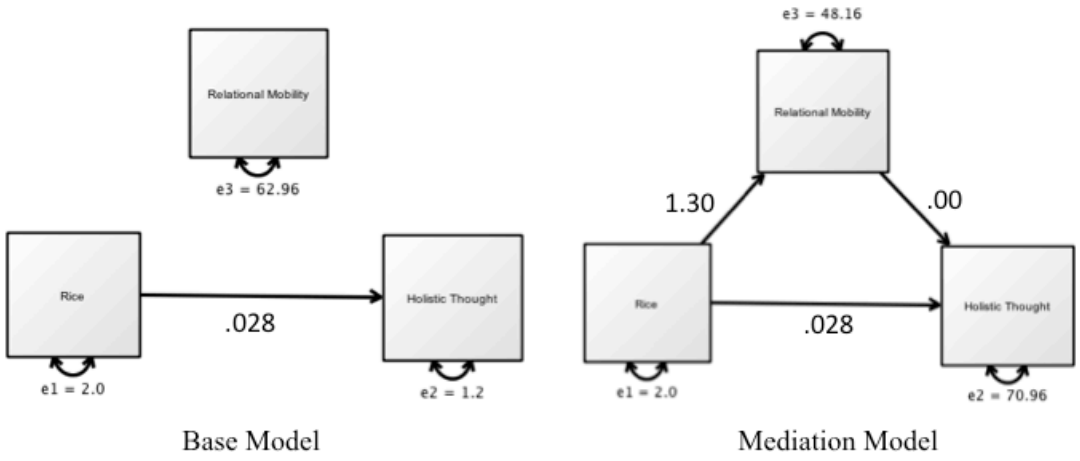

Figure 26. Mediation results for holistic thought. Results showed no support for the idea that relational mobility mediates rice-wheat differences.

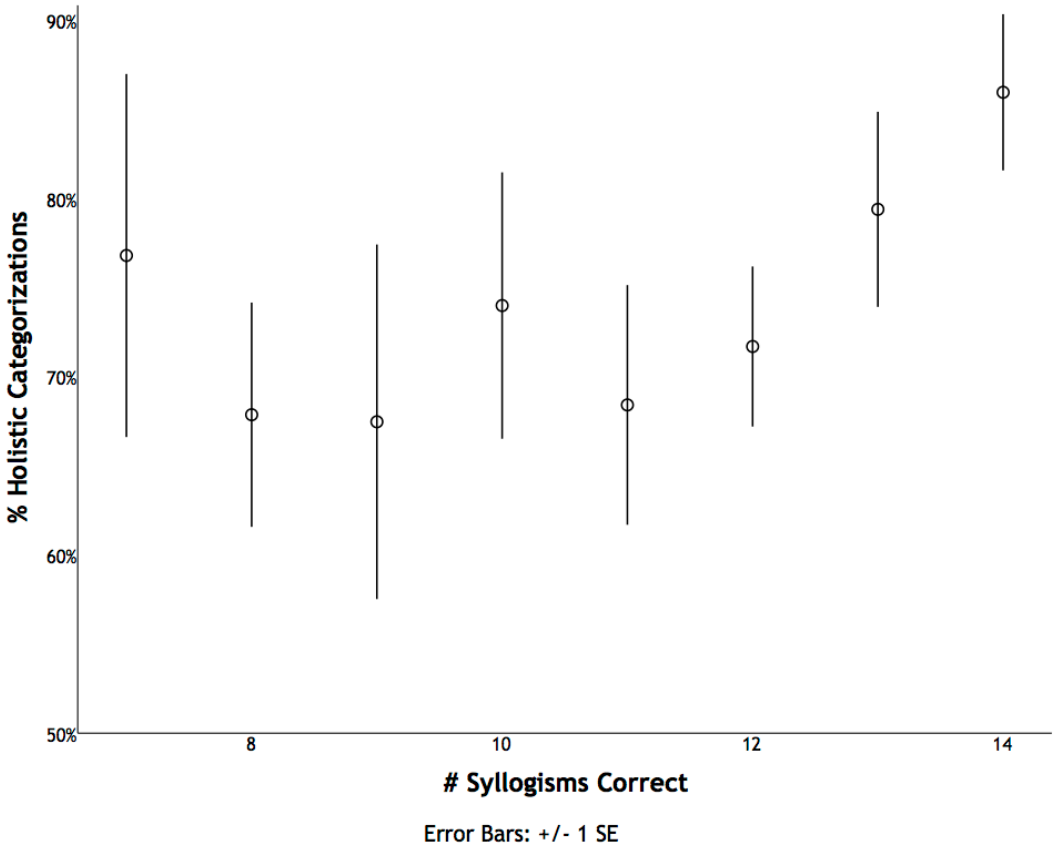

Figure 27. Holistic thought and performance on logic syllogisms. People who answered more syllogisms correctly tended to think more holistically.

Tables

Table 1. Demographic information and sample sizes for individual tasks

Site	Batch	*N*	% Female	% Growing up in Rice Provinces	% Growing up in Urban Area	Triad Task	Sociogram Task	Loyalty/ Nepotism
Beijing	BNU2007	91	53.3	51.1	13.2		X	
	BNU2010	93	72.2	35.6	10.8	X		
	BNU2011 Winter	239	71.3	33.5	22.2	X	X	
	BNU2011 Summer	87	88.5	52.3	18.4	X		X
	Minzu	45	77.3	45.5	22.2	X	X	X
Fujian		190	70.9	87.4	38.9	X	X	
Guangdong		193	65.8	96.4	15.0	X	X	
Yunnan		52	65.4	16.7	7.7	X	X	
Sichuan		107	50.5	94.2	72.0	X		X*
Liaoning		65	65.2	51.6	60.0	X		
Total		1162	68.0	63.2	27.9	1026	742	174

Note: Sample sizes for specific tasks vary slightly because of missing data. For example, among the triad sample, seven participants did not report gender. "Urban area" defined as provincial capital + the largest 50 cities by population size. "Rice province" defined as > 50% of cultivated land devoted to rice paddies. BNU = Beijing Normal University. Minzu = Central University for Nationalities. *In the Sichuan sample, the loyalty/nepotism was sent out as a follow-up task, resulting in a smaller sample size ($N = 36$).

Table 2. Basic regression models for rice, GDP per capita, and pathogens.

	Rice				Per-capita GDP				Pathogens			
Holistic Tht.	**B**	**SE**	***z***	***P***	**B**	**SE**	***z***	***P***	**B**	**SE**	***z***	***P***
$Gender_{(M=0;F=1)}$	.20	.06	3.55	< .001	.20	.06	3.53	< .001	.13	.07	1.97	.05
$Site_{Fujian}$	-.34	.11	-3.21	.001	-.33	.11	-3.07	.002	-.36	.12	-3.09	.002
Rice	.56	.21	2.72	.007								
Per-capita GDP					.52	.23	2.24	.03				
Pathogens									-.22	.10	-2.08	.04
Province $N = 28$, participant $N = 1019$									Prov. $N = 21$, part. $N = 725$			
Implicit Indiv.	**B**	**SE**	***t***	***P***	**B**	**SE**	***t***	***P***	**B**	**SE**	***t***	***P***
$Gender_{(M=0;F=1)}$	-.06	.02	-2.51	.01	-.05	.02	-2.34	.02	-.05	.02	-2.04	.04
$Site_{BeijingW2011}$	-.27	.05	-5.18	< .001	-.25	.06	-4.40	< .001	-.18	.05	-3.44	.001
Rice	-.20	.08	-2.57	.016								
Per-capita GDP					.01	.15	.07	.95				
Pathogens									.01	.04	.33	.74
Province $N = 28$, participant $N = 515$									Prov. $N = 21$, part. $N = 452$			
Loyalty/Nepot.	**B**	**SE**	***t***	***P***	**B**	**SE**	***t***	***P***	**B**	**SE**	***t***	***P***
$Site_{Sichuan}$	2.04	.83	2.47	.01	1.63	.87	1.88	.06	1.91	.85	2.25	.03
Rice	2.45	1.16	2.12	.04								
Per-capita GDP					1.66	1.69	.98	.34				
Pathogens									-.13	.62	-.21	.84
Province $N = 27$, participant $N = 166$									Prov. $N = 21$, part. $N = 146$			
Divorces	**B**	**SE**	**β**	***t***	***P***	**B**	**SE**	**β**	***t***	***P***	**B**	**SE**	**β**	***t***	***P***
PC GDP	.10	.04	.48	2.71	.01	.13	.03	.61	3.89	.001	.11	.05	.52	2.04	.06
Rice						-.11	.04	-.49	-3.11	.005					
Pathogens											-.01	.03	-.07	-.26	.80
Province $N = 27$						Province $N = 27$					Prov. $N = 21$				
Inventions	**B**	**SE**	**β**	***t***	***P***	**B**	**SE**	**β**	***t***	***P***	**B**	**SE**	**β**	***t***	***P***
PC GDP	2.22	.41	.73	5.37	< .001	2.55	.37	.84	6.98	< .001	1.78	.59	.60	3.00	.008
Rice						-1.27	.39	-.39	-3.28	.003					
Pathogens											-.34	.31	-.22	-1.10	.29
Province $N = 27$						Province $N = 27$					Prov. $N = 21$				

Note: Rows shaded gray correlate in the opposite direction from what the theory predicts. See the SOM for details on the site effects. Divorces are calculated as divorces per marriage. Inventions are successful patents for new inventions.

Table 3. Rice regressions using the reduced sample set with and without pathogens.

	Reduced Sample Set				Reduced Sample with Pathogens				Rice Change
Holistic Thought	**B**	**SE**	***z***	***P***	**B**	**SE**	***z***	***P***	
Gender	.13	.07	1.94	.05	.13	.07	1.90	.057	
$Site_{Fujian}$	-.37	.12	-3.16	.002	-.39	.11	-3.41	.001	
Rice	.46	.24	1.93	.05	.47	.23	2.06	.039	Stronger
Pathogens					-.20	.12	-1.67	.10	
Per-capita GDP					.11	.29	.39	.70	
Province $N = 21$, participant $N = 728$									
Implicit Indiv.	**B**	**SE**	***t***	***P***	**B**	**SE**	***t***	***P***	
Gender	-.05	.02	-2.09	.04	-.05	.02	-2.02	.04	
$Site_{BeijingW2011}$	-.20	.05	-3.75	< .001	-.21	.06	-3.56	< .001	
Rice	-.11	.09	-1.31	.20	-.14	.09	-1.59	.13	Stronger
Pathogens					.06	.06	1.09	.29	
Per-capita GDP					.19	.17	1.14	.27	
Province $N = 21$, participant $N = 452$									
Loyalty/Nepotism	**B**	**SE**	***t***	***P***	**B**	**SE**	***t***	***P***	
Sichuan Site	2.21	.86	2.57	.01	2.30	.89	2.59	.01	
Rice	1.73	1.28	1.36	.19	1.45	1.36	1.06	.30	Weaker
Pathogens					.18	.80	.22	.83	
Per-capita GDP					1.41	2.13	.66	.52	
Province $N = 21$, participant $N = 138$									
Divorces	**B**	**SE**	***t***	***P***	**B**	**SE**	***t***	***P***	
Rice	-.07	.03	-2.52	.01	-.07	.03	-2.44	.03	
Per-capita GDP	.13	.04	3.70	.002	.13	.05	2.70	.02	No change
Pathogens					-.004	.03	-.15	.88	
Province $N = 21$									
Inventions	**B**	**SE**	***t***	***P***	**B**	**SE**	***t***	***P***	
Rice	-1.60	.41	-3.88	.001	-1.58	.45	-3.51	.003	
Per-capita GDP	2.46	.36	6.90	< .001	2.40	.50	4.83	< .001	Weaker
Pathogens					-.05	.26	-.19	.85	
Province $N = 21$									

Note: Gender coded female = 1; male = 0. See the SOM for details on the site effects. Columns are shaded gray if the direction of the effect is the opposite of what the theory predicts. The "Rice Change" column reports the change in regression coefficient of rice after adding pathogens and GDP per capita.

Table 4. Rice-wheat border analysis at the county level.

Holistic Thought				
Individual Level	B	SE	*z*	*P*
Gender	.12	.12	1.02	.31
$Site_{Fujian}$	-.64	.21	-2.98	.003
Rice-Wheat	.54	.13	4.05	< .001
Participant $N = 224$				
Hierarchical Model	B	SE	*z*	*P*
Gender	.04	.14	.30	.76
$Site_{Fujian}$	-.60	.32	-1.89	.06
Rice-Wheat	.53	.29	1.81	.07
Province $N = 5$, County $N = 60$, Participant $N = 224$				

Note: Rice-wheat border is coded 0 = wheat county; 1 = rice county. As at the province level, "rice" is defined as > 50% of farmland devoted to paddy rice. Rice-wheat border provinces: Sichuan, Chongqing, Hubei, Anhui, and Jiangsu (Fig. 1). See the SOM for details on the site effects.

Table 5. Rice-wheat border analysis at the county level in Anhui province.

Holistic Thought				
	B	SE	*z*	*p*
Female	-.03	.14	-.22	.83
Urbanization	-.20	.06	-3.17	.002
Years at University	.97	.23	4.25	< .001
Rice Counties	.29	.18	1.63	.10
Years at University*Rice	-.74	.26	-2.83	.005
N = 198				
Implicit Individualism				
	B	SE	*t*	*p*
Urbanization	.12	.04	2.90	.004
Years at University	-.35	.15	-2.38	.02
Rice Counties	-.24	.15	-1.66	.10
Years at University*Rice	.35	.17	2.01	.046
N = 139				
Loyalty/Nepotism				
	B	SE	*t*	*p*
Female	-.84	.73	-1.15	.25
Urbanization	-.52	.34	-1.53	.13
Rice Counties	-1.38	.66	-2.09	.04
N = 212				
Relational Mobility				
	B	SE	*t*	*p*
Female	-.96	1.25	-.77	.44
Urbanization	.25	.59	.42	.67
Rice Counties	-2.14	1.11	-1.94	.05
N = 217				

Note: Rice-wheat border is coded 0 = wheat county; 1 = rice county. As at the province level, "rice" is defined as > 50% of farmland devoted to paddy rice. Urbanization self-reported as 1 = rural, 2 = rural town, 3 = medium city, 4 = big city. Years at university and the interaction with rice counties were not significant for relational mobility or loyalty/nepotism, so they are omitted. For implicit individualism, the regression weight for gender was nearly zero (p = .95), so gender was omitted.

Table 6. Rice-wheat differences in the small ($N = 91$) Shanghai sample.

Holistic Thought				
	B	SE	*z*	*p*
Female	-.16	.34	-.46	.65
Urbanization	-.26	.21	-1.27	.21
GDP per Capita	-.48	.33	-1.44	.15
Rice	.65	.43	-1.50	.13
$N = 91$, 22 provinces				
Loyalty/Nepotism				
	B	SE	*t*	*p*
Female	1.75	1.71	1.02	.27
Urbanization	-.25	1.05	-.24	.81
GDP per Capita	-.59	1.17	-.50	.62
Rice	2.15	1.85	1.16	.26
$N = 91$, 22 provinces				
Relational Mobility				
	B	SE	*t*	*p*
Female	.31	2.75	.11	.91
Urbanization	1.66	1.71	.97	.34
GDP per Capita	5.48	1.92	2.86	.01
Rice	-5.80	3.10	-1.87	.08
$N = 88$, 22 provinces				

Note: Urbanization =1 for participants who grew up in provincial capitals or any of the top 50 largest cities.

Table 7. Relationship between holistic thought and logic performance.

Cognitive Reflection Test				
	B	SE	*z*	*p*
Holistic Thought	-.08	.59	-.13	.89
Belief-Conflict Syllogisms				
	B	SE	*z*	*p*
Holistic Thought	.28	.49	.58	.56
Abstract Syllogisms				
	B	SE	*z*	*p*
Holistic Thought	.91	.56	1.63	.10
Non-Belief-Conflict Syllogisms				
	B	SE	*z*	*p*
Holistic Thought	.41	.55	.74	.46
All Logic Syllogisms				
	B	SE	*z*	*p*
Holistic Thought	.50	.29	1.74	.08

Note: All logic tasks coded as number of correct responses.

Appendix

Appendix 1: Some measures of individualism are conflated with modernization

This paradox exists even though several of the survey items used in international surveys of individualism are probably actually measuring materialism, rather than individualism. For example, Hofstede's famous datasets (included in Figure 2) include several items that ask people to rate how important it is to have "an opportunity for high earnings" and "good fringe benefits." Not surprisingly, people in poorer countries rate money as more important. In fact, the third-highest-loading item asks whether it is important to "have good *physical working conditions* (good ventilation and lighting, adequate work space, etc.)."

These items are reverse scored, so the less people are concerned with good physical conditions, the more individualistic they supposedly are. As people become wealthier, they are much less likely to work in unsavory offices, dangerous sweatshops, or mines that kill hundreds of people each year. Thus, they care less about good ventilation and lighting as they grow wealthier—people take ventilation and lighting for granted when they work in comfortable offices. To call that individualism seems flawed. My point here is that *even with questions that are problematically linked to material wealth,* East Asia's wealth still has not made it as individualistic than it "should be."

Why are the surveys like this? I suspect it is because Hofstede (2001) let the correlations in the data decide the constructs. Being theory-blind at the beginning has advantages, but it can lead to problems. We must be wary of items that are third-variable correlations and not actually a part of a given construct. I suspect that items measuring materialism got baked into the Hofstede individualism construct because collectivistic cultures happened to be poorer at that time, and thus they put more importance on making money and having adequate physical surroundings.

Because some surveys seem to conflate collectivism with physical materialism, I analyzed how people in East Asia have responded to the World Values Survey over time (Figure 28). Many questions have changed over time, but the World Values Survey asked about the importance of family in China, Korea, and Japan several times from 1990 to 2007. During that time, China's per-capita GDP approximately tripled; Korea's more than doubled. Japan added about 15%.

If modernization reduces collectivism, family values should decline, particularly in China and Korea. Furthermore, because China is so much poorer, it should have stronger family values than both Korea and Japan. Figure 28 shows that none of these predictions are true. China seems to place slightly less importance on family, and family importance has remained stable (or even increased).

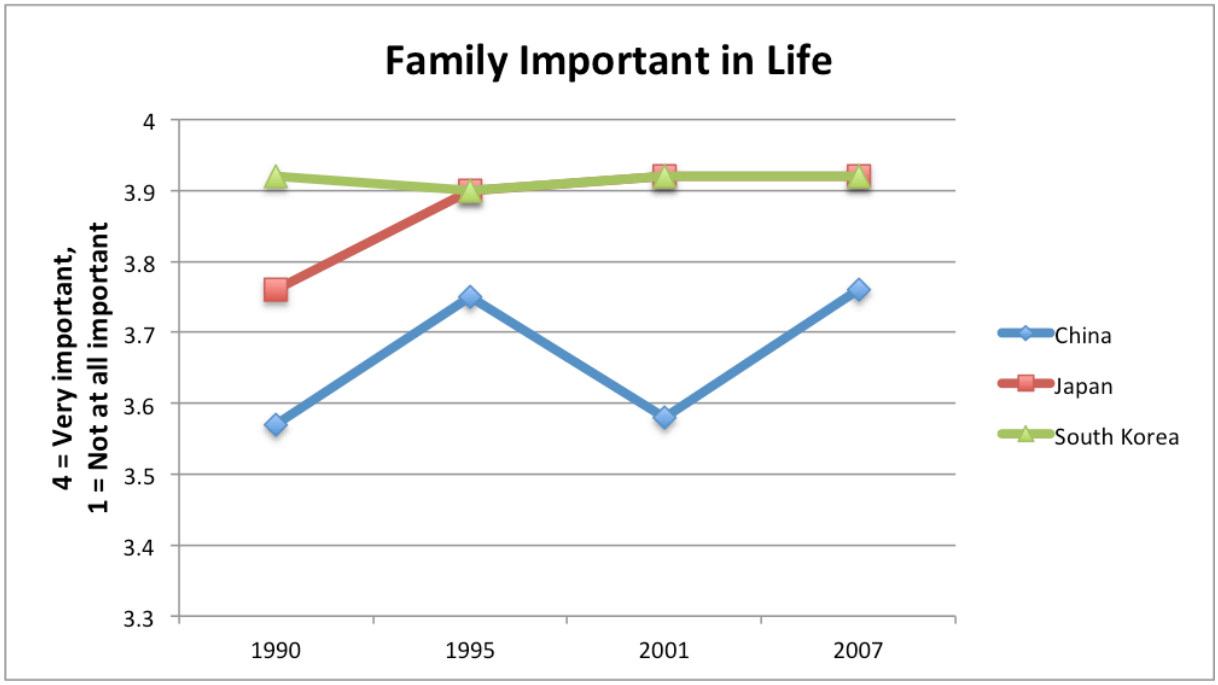

Figure 28. Responses to a World Values Survey item asking about the importance of family. If economic growth leads to individualism, we might suspect these values to decline in East Asia, particularly in Korea and China. Yet there is no clear downtrend. If anything, the numbers seem to go up slightly.

Appendix 2: Does labor exchange increase efficiency?

As I pointed out in Part 2, labor exchange can be difficult when many farmers have to transplant or harvest their crop at the same time. If everyone's field needs work, who is left to exchange labor with? One solution is to enlist people who do not normally farm—perhaps tradespeople or women who do not normally work in the field. Another solution is to enlist relatives or acquaintances in other villages (which Fei observed in the rice village he studied, 1945, p. 65).

However, Fei argues that labor exchange increases efficiency (Fei, 1945, p. 64). If so, that efficiency would also help solve the problem of not having enough labor at peak bottlenecks. Labor exchange might lead to efficiency in two ways. (1) First, exchange allows people to focus on a single task, leading to mini-specialization. For example, when farmers in the village that Fei studied harvested rice, four people would reap the rice, two would transport that rice to the threshing area, and four would thresh the rice. This could allow people to specialize on the tasks they do best, much like modern basketball teams allow big players to focus on rebounding and smaller players to focus on shooting three-pointers.

(2) Second, working together to plant one field in a single day means that the rice will ripen all at the same time. This would not be the case if a single person were to plant a single field over a week or two (Fei, 1945, p. 64). That way, farmers can focus their energy on a single field and harvest it all at once, rather than switching their focus from field to field every day.

Appendix 3: Han China as a Natural Test Case

Han China's value as a natural test case becomes apparent when it's contrasted with the world's other major cultural regions that have roughly the same number of people: Europe, India, and sub-Saharan Africa. Excluding Tibet, Xinjiang, and Inner Mongolia, China still has about 1.3 billion people (Tibet, Xinjiang, and Inner Mongolia hardly make a dent in the

overall population). Three other major cultural regions in the world have very roughly that number of people: Europe has about 700 million; sub-Saharan Africa has about 900 million; and India 1 billion.

For one, Han China has been more or less politically unified (with interruptions of course) for hundreds if not thousands of years. Similarly, the vast majority of Han China speaks some form of a single language family (Chinese) and is either non-religious or Buddhist. None of this can be said about Europe, sub-Saharan Africa, and India, which have been far more politically fragmented historically; have many more populous language families; and religious traditions.

Appendix 4: Are the Cultural Differences in China a Discovery?

It seems reasonable to ask, if there are such large cultural differences in China, why don't Chinese people know about it already? I think most Chinese people do know about these differences. I often hear Chinese friends describe northerners as more direct and outgoing and southerners as more careful and family-oriented.

In fact, at least one European visitor seems to have described these very differences hunderds of years ago. American merchant Amasa Delano visited China in the 1700s and described northerners as "much more free and candid…more sociable, and not so particular respecting their women being seen by the men" (Delano, 1817, p. 536). His preferences fit with the idea that northern China's greater individualism is closer to European culture's greater individualism. Delano says that his Dutch and English acquaintances "were much more favourable of the northern than of the southern Chinese" (Delano, 1817, p. 538).

However, I've never heard Chinese people describe northerners and southerners with the terms "collectivism" and "individualism." I think that's because our popular conceptions of collectivism and individualism do not correspond to the actual cultural traits of collectivistic and individualistic cultures (at least in China). In short, I think most Chinese

people do know about these differences. They just use terms that are more specific than catch-all terms like "collectivism." For example, I've heard Chinese friends describe northerners as direct (*zhishuang,* 直爽), rough (*cucao,* 粗糙), and southerners as more family oriented (*geng zhuzhong jiating,* 更注重家庭). (And I've never heard anyone in China explain these differences with a theory about agriculture.[27])

Appendix 5: Sociogram Site Effects

There was a main effect of sample $F(5, 766) = 5.96$, $p < .001$ (one-way ANOVA). There seemed to be two clusters: three samples where self-inflation values were positive (mean = 0.15, SD = 0.62), and three samples where self-inflation values were negative (mean = -0.05; SD = 0.47). This could be because the circles are measured by hand, and different researchers measured the circles at the different sites. It could also be because of differences in printing and paper size between sites.

With a significant site effect, it is important to be able to separate site effects from rice-wheat effects. To do that, each site needs to have a significant number of people from both rice and wheat regions. Otherwise, what may appear to be an effect of rice may actually be a site effect.

Unfortunately, the Guangzhou site had only 6 participants from the wheat region, and the Yunnan site had only 8 participants from the rice region (although Yunnan is physically in the south, it grows only about 30% rice). Therefore, the data from these two sites could not differentiate a north-south effect from a site effect, so I excluded these sites from the sociogram analysis. That left four samples: three from Beijing (which has universities with better geographical representation; north) and one from Fujian (south). Fortunately, this still allows us to test whether the rice-wheat differences hold in the north and south. In each

[27] From personal experience, the most popular theory I've heard is that it's the heat or the rainfall that makes southerners different. I've also heard Americans use the climate to explain southern US culture—for example, why southerners walk slower.

sample, people from the wheat region had higher self-inflation ($Beijing_{Summer2007}$ Wheat M = 0.30, SD = 0.81; Rice M = 0.05, SD = 0.66; $Beijing_{Winter2011}$ Wheat M = -0.06, SD = 0.37; Rice -0.11, SD = 0.37; $Beijing_{Minzu}$ Wheat M = 0.28, SD = 0.52; Rice M = 0.002, SD = 0.55; Fujian Wheat M = 0.31, SD = 0.85; Rice M = 0.09, SD = 0.51).

I entered dummy variables representing the different batches in an HLM (with Fujian as the reference sample). $Beijing_{Winter2011}$ was highly significant ($p < .001$). The other two site variables were not significant $Beijing_{Summer2007}$ $p = .83$, $Beijing_{Minzu}$ $p = .78$. Thus, all sociogram analyses in this study control for this batch effect.

Appendix 6: Effect Sizes in HLM

In some cases, the pseudo-R^2 can give estimates of $r = 1$. This was the case in the effect sizes on the sociogram and the loyalty/nepotism task. The HLM estimates may have been unstable because of the smaller sample size for these tasks. In these cases, I used province-level means to calculate the effect size. As a method of double-checking these effect sizes, I made slight modifications to the HLMs and found that this led to stable pseudo-R^2 estimates and effect sizes that were similar to estimates using province-level means. (See the Sociogram and Loyalty/Nepotism sections for more details.)

Because HLM estimates of pseudo-R^2 were unstable for the sociogram task, I used province-level means to calculate the province-level effect sizes. To correct for the effects of batch ($Beijing_{Winter2011}$) and gender, I used means that were residuals from a regression with these two variables. Because province-level means do not correct for reliabilities of each province estimate, I re-ran the analysis after limiting the sample to provinces with larger sample sizes. Limiting the sample size this way also removed an outlier of more than 2 SD from a province with two participants. Effect-size estimates were larger than the effect reported in the main text ($r = -.17$) when I limited the sample to provinces with at least 5 people ($r = -.24$) or with at least 10 people ($r = -.35$).

To test the reliability of the effect-size estimate in the main text (r = -.17), I also tried making slight adjustments to the HLM to get stable pseudo-R^2 estimates. Re-running the analysis with participants from the Beijing site only (n = 86 and thus removing the site effect from the model) produced a stable estimate of r = -.15, which is similar to r = -.17.

HLM estimates of pseudo-R^2 were also unstable for the loyalty/nepotism task, I used province-level means to calculate the province-level effect sizes. To correct for the Sichuan site effect, I used residuals from a regression with the site effect. Because province-level means do not correct for reliabilities of each province estimate, I scanned the means for outliers. There was one outlier of more than 2 SDs in a province (Chongqing) that had only one participant. This was removed for estimates of effect size (but it was retained in the HLMs used to estimate the regression coefficients and significance values because HLM takes into account the sample size of each province).

To test the reliability of this effect-size estimate (r = .49), I tried re-running the analysis by limiting the province estimates to provinces that had at least five participants, and the results were similar (r = .48). I also tried making slight adjustments to the HLM to get stable pseudo-R^2 estimates. Re-running the analysis with participants from the Beijing site only (n = 86) produced a stable estimate of r = .40, roughly similar to r = .49.