People in rice-farming cultures perceive emotions more accurately ☆

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ABSTRACT

Are people in interdependent cultures more accurate at perceiving people's emotional expressions? One problem with testing this question is that people tend to be more accurate at perceiving emotions of people of their own ethnic group. That makes it impossible to test East-West cultural differences using the same emotion pictures. We got around this problem by testing for cultural differences between southern and northern China. Southern China traditionally farmed rice, which requires more interdependence than the wheat farming of northern China. Paying more attention to people's emotions may have been useful in rice cultures because farmers had to manage shared irrigation networks and exchange labor more than wheat farmers. In Study 1, students who had grown up in rice-farming provinces guessed people's emotions in the Mind in the Eyes test more accurately than people who had grown up in wheat-farming provinces. In Study 2, we tested students from 13 prefectures (similar to US counties) in a single province along China's rice-wheat border. People from the rice side of the border perceived emotions more accurately than people from the wheat side. These results connect a long-term ecological cause (rice farming) to a modern psychological outcome (emotion perception). These results also offer an explanation for broader cultural differences in emotion perception.

People in rice-farming cultures perceive emotions more accurately

Perceiving other people's emotional expressions is an important skill in social life. Yet people are not universally accurate. Studies have found that people with autism are less accurate than people without autism (Baron-Cohen et al., 2001) and that women are more accurate than men on average (Greenberg et al., 2023; Vellante et al., 2013). We ask whether there are cultural differences in emotional accuracy.

Why interdependence might improve empathic accuracy

In this study, we test the theory that people in interdependent cultures are more accurate at perceiving other people's emotions than people in independent cultures. Why would interdependence make people more accurate? We draw inspiration from earlier studies on social class.

Several studies have found that people of lower socioeconomic status (SES) are more accurate at interpreting other people's emotions (Bjornsdottir et al., 2017; Kraus et al., 2010). Some researchers proposed the explanation that people from lower-class background are

more dependent on other people and therefore need to pay more attention to other people's emotions (Kraus et al., 2009). In contrast, people from upper-class backgrounds are less dependent on other people and do not need to pay as close attention to other people. If interdependence is the key, it makes sense to predict that interdependence across cultures (regardless of social class) would lead to more accuracy.

Another feature of interdependence is that people spend more time around other people. Simply spending more time with other people could give people more practice interpreting other people's emotions. There is evidence for this both for social class and culture. People from lower-class backgrounds spend more time with other people (Kraus and Keltner, 2009).

In the cultural domain, people in more individualistic states in the US are more likely to drive to work alone and live alone (Vandello and Cohen, 1999). College students in the US were more likely to be walking alone on campus than students in China (Talhelm et al., 2018a). Within China, people in more individualistic wheat-farming areas were more likely to be sitting alone in Starbucks than people in interdependent rice-farming areas (Talhelm et al., 2018b).
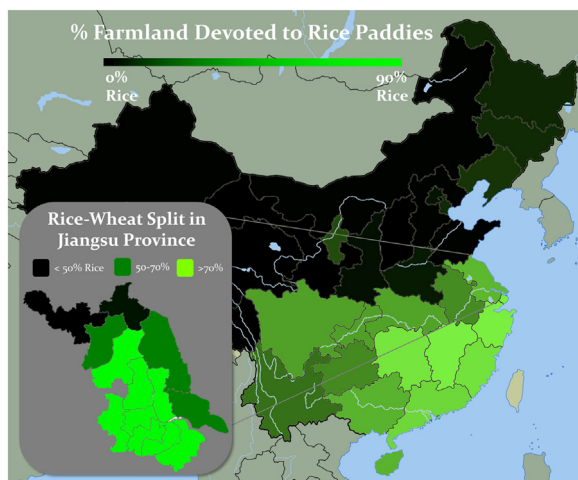
Fig. 1. The Distribution of Rice Farming in China and Rice-Wheat Split Within Jiangsu Province.

Note: The inset shows rice farming between prefectures in Jiangsu Province, along the rice-wheat border. The rice-wheat border is stark. Neighboring prefectures farm over 70% rice versus less than 50% rice. Province data comes from the 1996 *China Statistical Yearbook*. Jiangsu Prefecture data comes from the 2002 *Jiangsu Statistical Yearbook*. Both are the earliest available yearbooks we could source. Earlier data available from a subset of provinces from 1918 correlates highly with the 1996 data, $r(22) = 0.95$, $p < .001$. This suggests 1996 statistics adequately represent historical farming patterns.

One objection is that differences that *appear* to be cultural are just social class differences. However, there are reasons to think cultural differences are separable from class differences. For one, China's interdependent rice areas are wealthier than wheat areas on average (Talhelm et al., 2014). In addition, in Japan and in rice-farming areas of China, people of higher social status are actually *more* interdependent than people of lower status (Miyamoto et al., 2018; Zhang et al., 2021). Thus, culture is separable from class.

Measuring emotion perception

Researchers developed the Mind in the Eyes task to test people's accuracy at reading other people's emotions (Baron-Cohen et al., 2001). The test shows participants 36 pictures of actors expressing different emotions. The emotions go beyond basic happy, sad, and angry to include more complex emotions such as friendly, preoccupied, and defiant (Fig. 1). The task is difficult because the pictures only show a narrow region around the eyes. Participants guess the correct response from four options.

The Mind in the Eyes test is widely used. Over a dozen studies have used it (a review: Vellante et al., 2013). To make the test usable in more cultures, later researchers created a version with Asian actors (Adams et al., 2010). This is important because people tend to be more accurate with faces of their own race (Adams et al., 2010).

Testing differences in a single country has methodological advantages

To test this idea, we look for cultural differences within China. A logical starting place would be to test for differences between individualistic Western cultures and interdependent cultures around the world. A recent study of 56 cultures found that people in collectivistic cultures were more accurate at the Mind in the Eyes task (Greenberg et al., 2023). Thus, there is some data supporting this idea. However, testing within China has three methodological advantages over comparing East and West.

Fig. 2. Items from the Reading the Mind in the Eyes Task with White Actors and Asian Actors.

Note: The correct answers are insisting (top) and playful (bottom). The test is untimed, and participants receive no feedback.

1. Testing within China allows us to test for cultural differences while keeping the pictures the same. This is important because a previous study found that people in Japan were more accurate at the Mind in the Eyes task with pictures of Asian actors than with White actors (Adams et al., 2010). That study also found that white participants in the US were more accurate with White faces than with Asian faces. People showed an own-race advantage despite the fact that the actors were portraying the same emotions, and the response options were the same. Testing differences within China allows us to use the same faces for all participants.

2. Testing within China reduces potential confounds between nations, such as a religion and national political system.

3. For the Mind in the Eyes test itself, testing within the same culture allows us to rule out confounds in translation. Translation is always a challenge, but it is particularly challenging with the Mind in the Eyes task because it uses complex emotion words such as "flustered" and "contemplative." Because all participants took the task in the same language, we can be sure that the differences are not due to confounds in translation.

4. Testing within a single nation helps chip away at the overly essentialized view of "the East" versus "the West." It is true that there are broad differences between East Asia and Western cultures, but these broad differences can unwittingly encourage people to think of the East and West as unified cultures. Finding differences within East Asia (and within a single country) highlights diversity within these larger regions.

The rice theory

To test differences in China, we leverage differences in rice and wheat farming in China (Fig. 2). The rice theory is the idea that cultures with a history of rice farming are more interdependent than cultures with a history of farming wheat and other dryland crops (Talhelm et al., 2014). Paddy rice was built around shared irrigation networks, which required farmers to coordinate when they flooded and drained their fields (Bray, 1986; Talhelm and Oishi, 2018).

Rice farming also required twice the labor per hectare as dryland crops like wheat (Bray, 1986; Buck, 1935). The extra labor requirements pushed rice-farming cultures to develop tight, reciprocal labor exchanges (Bray, 1986; Suehara, 2006). In contrast, labor requirements were looser for wheat, which meant farmers had less of a need to rely on others. For example, wheat farmers in Europe often had long periods of slack time after planting, which some used to graze animals away from the home (Ang and Fredriksson, 2017).

Previous studies have found that people from Chinese rice-farming provinces are more interdependent than people from wheat-farming provinces (Dong et al., 2018; Talhelm et al., 2014; Talhelm and English, 2020; Zhang et al., 2021). Rice-farming cultures have tighter social norms and more fixed, stable social relationships both within China and around the world (Talhelm et al., 2014; Talhelm and English, 2020; Thomson et al., 2018).

The interdependence explanation that researchers proposed to explain social class differences in emotional accuracy could apply to rice versus wheat farming areas in China (Kraus et al., 2010). Rice farmers depended on other people more for their livelihood than wheat farmers. Decisions like work assignments and water allotments were social, not individual (Bray, 1986; Fei, 1983). For example, an anthropologist in one Chinese rice village observed farmers assigning work tasks to maintain the shared irrigation network and punishing villagers who failed to show up (Fei, 1983). If depending on other people makes people more sensitive to others' emotional expressions, then it would make sense that people in rice cultures are more attuned to others' emotions.

Study 1

Methods

Sample

We tested students at Beijing Normal University from 29 provinces across China. Beijing Normal is a large national university, with students from all over the country. A total of 279 college students completed the emotion perception test and demographics (74.0% female).

A sample of 279 participants has 99% statistical power to detect an effect of the individual-level rice-wheat differences in holistic thought from our earlier study, $d = 0.41$ (Talhelm et al., 2014). The sample has 80% power to detect effect sizes of $d = 0.24$ or larger. Participants provided informed consent, and the protocol received ethical approval by institutional review boards at the University of Virginia, the University of Chicago, and Beijing Normal University. Study 1 was not pre-registered.

Sampling at a large university naturally reduces demographic confounds

Although students are younger and more educated than China as a whole, they offer an advantage in testing for regional differences. By testing students at the same national university, the sample naturally controls for many potential confounds between regions. Students from rice and wheat regions are the same age, with similar test scores and education. Because college admissions in China are based largely on a national standardized test, sampling rice and wheat participants at the same university minimizes differences in test scores (and, by proxy, intelligence). One reason this matters is because a meta-analysis found that people who score higher on intelligence also score higher on social perception accuracy (Murphy and Hall, 2011).

Mind in the eyes task

Participants took the 36-item Mind in the Eyes task in Chinese (Baron-Cohen et al., 2001). We collected data in three waves: 2010, 2011, and 2016. In the first two waves, we used the original Mind in the Eyes pictures, which were all White actors (Fig. 1). Later, we learned that researchers had created a matched Asian version of the Mind in the Eyes task, so we used that version in our later data collection (Adams et al., 2010). Both versions use the same emotions and response options, although the gender and age of the actors are not matched between the Asian and White versions.

Participants were more accurate for the pictures of Asian actors ($M = 26.4$ $SE = 0.51$) than White actors ($M = 21.8$ $SE = 0.39$; Table 1). This difference fits with previous findings using these tasks in the US and Japan (Adams et al., 2010). In all models, we controlled for the version that participants took. As an extra check that the rice-wheat differences were not a confound of the different versions of the task, we re-ran the

analyses in Table 1 while limiting the sample to participants who took the White version (which had the larger sample size). Rice-wheat differences remained significant (Table S2).

Rice-Wheat heritage

To measure people's rice cultural heritage, we asked participants where they had mainly grown up, rather than where they were currently. We asked: "Where did you mainly grow up?" (你主要在什么地方长大的?)

Following prior research, we limited the sample to people who had a consistent rice or wheat heritage (Talhelm et al., 2014). We asked participants where their parents were from, and we used the province to code the rice versus wheat heritage of each parent. We coded consistent rice-wheat heritage as when the student's birth place, the place the student grew up, the mother's hometown, and the father's hometown were all in majority-rice provinces (> 50% cultivated land devoted to paddy rice) or all in majority-wheat provinces (< 50% cultivated land devoted to paddy rice). This categorization follows prior research (Talhelm et al., 2014).

Forty-four participants had mixed rice-wheat heritage and were excluded from analysis, leaving 235 participants. To be conservative, we ran a supplemental analysis that included all participants (including mixed-heritage participants), and rice remained significant ($p = .004$, Table S1). That result suggests that the findings are not dependent on the exclusion criteria.

However, including people with mixed rice-wheat heritage made rice-wheat differences slightly smaller ($B = 0.33$) than when analyzing people with a consistent rice-wheat heritage ($B = 0.41$). This result is consistent with the idea that culture is partly transmitted through parents' cultural backgrounds or by experiencing different environments while growing up.

Gender

We controlled for gender because several previous studies (but not all) found that women tend to perceive other people's emotions more accurately than men (Vellante et al., 2013). A recent study found that women scored higher than men in 56 out of 57 countries, although the difference was significant in 36 (Greenberg et al., 2023). In our basic model, women were more accurate than men ($p = .047$, Table 1).

Regional control variables

We controlled for several alternative theories between provinces. Table S5 lists all regional variables, sources, and rationales. Here we briefly describe the control variables and theoretical rationales.

GDP per capita

Modernization theory argues that economic development makes cultures more individualistic (Greenfield, 2009). An internet study of 56 cultures found that people in economically developed countries were less accurate on the Mind in the Eyes task (Greenberg et al., 2023). In the same model, they found significant differences for both economic development and collectivism (Table S7).

Ethnic diversity

A prior study found that cultures with more historical ethnic diversity have simpler, more direct interpretations of smiles than cultures with less diversity (Rychlowska et al., 2015). In the same way that two people speaking a foreign language will tend to use simpler words, the theory for emotions is that interacting with people from diverse backgrounds forces people into a simpler, more explicit form of communication because people cannot assume as much of a common understanding. We tested ethnic diversity in China by collecting Census data on the percent ethnic Han per province. Han are the majority ethnicity in China, so higher percentages reflect higher ethnic homogeneity.

Table 1
People from Rice-Growing Provinces Perceive Emotions More Accurately.

		B	SE	z	p
Basic Rice Model	Female	0.12	0.06	1.99	.047*
	Asian Eyes Version[a]	0.76	0.06	11.93	< 0.001***
	GDP per Capita	0.05	0.09	0.59	.559
	Percent Ethnic Han[b]	0.11	0.18	0.59	.556
	Percent Herding Cultures[c]	0.58	0.33	1.76	.079
	Percent Cultivated Land[d]	0.01	0.003	1.84	.066
	Percent Rice	0.41	0.13	3.20	.001**
Rice Non-Linear	Female	0.11	0.06	1.89	.059
	Asian Eyes Version	0.75	0.06	11.91	< 0.001***
	GDP per Capita	0.05	0.09	0.49	.622
	Percent Ethnic Han	0.02	0.18	0.12	.902
	Percent Herding Cultures	0.49	0.31	1.55	.121
	Percent Cultivated Land	0.01	0.003	1.85	.065
	Percent Rice^2	0.48	0.16	3.11	.002**
Non-Local Pop.	Female	0.12	0.06	2.00	.046*
	Asian Eyes Version	0.76	0.06	11.94	< 0.001***
	GDP per Capita	0.09	0.16	0.57	.572
	Percent Ethnic Han	0.10	0.18	0.56	.573
	Percent Herding Cultures	0.56	0.33	1.70	.090
	Percent Cultivated Land	0.01	0.004	1.43	.153
	Percent Non-local Residents[e]	−0.002	0.01	−0.27	.784
	Percent Rice	0.42	0.13	3.22	.001**
Pathogen Prevalence	Female	0.12	0.06	2.02	.044*
	Asian Eyes Version	0.76	0.06	11.90	< 0.001***
	GDP per Capita	0.05	0.09	0.53	.598
	Percent Ethnic Han	0.12	0.19	0.66	.510
	Percent Herding Cultures	0.59	0.33	1.76	.079
	Percent Cultivated Land	0.007	0.004	1.93	.054
	Pathogen Prevalence[f]	0.01	0.01	0.67	.504
	Percent Rice	0.41	0.13	3.17	.002**
Distance to Coast	Female	0.12	0.06	2.07	.039*
	Asian Eyes Version	0.76	0.06	12.07	< 0.001***
	GDP per Capita	−0.04	0.10	−0.43	.668
	Percent Ethnic Han	0.28	0.20	1.41	.159
	Percent Herding Cultures	0.63	0.32	2.00	.046
	Percent Cultivated Land	0.003	0.004	0.87	.385
	Distance to Coast (log 1k km)[g]	−0.02	0.01	−1.90	.057
	Percent Rice	0.34	0.13	2.65	.008**
	Provinces: 29; Participants: 235				

Note: Analyses are HLMs with participants nested in provinces. GDP is logged year 2010, when the largest wave of data was collected. [a]Participants in one wave took the Asian version of the Mind in the Eyes Task; others took the version with White actors. [b]Han are China's majority ethnicity, a measure of diversity. [c]Percent provincial population from traditionally herding cultures, such as Mongolians. [d]Cultivated land measures general farming, as opposed to rice in particular. [e]Non-local residents are one measure of regional mixing, which prior research suggests influences norms for emotional expression. [f]Some researchers argue that high rates of disease make cultures collectivistic. [g]Distance to the coast is a proxy for connection to other areas. *p < .05.
** p < .01.
*** p < .001.

Herding cultural heritage

China is mostly a farming culture, but there are regions that herded animals traditionally. For example, the Mongolians and the Manchus practiced herding. There is evidence that herding cultures are more individualistic than farming cultures, so people from regions with a history of herding could be less accurate (Uskul et al., 2008). We tested for the percent of provincial populations composed of traditionally herding groups, such as the Mongolians.

Cultivated land

The rice theory argues that rice farming in particular shaped interdependence, even compared to other types of farming. To make sure that our rice farming statistics are picking up rice farming rather than farming in general, we tested the percentage of cultivated land per province.

Residential mobility

Based on the theory that lacking a shared background encourages societies to communicate emotions more explicitly, we also tested for residential mobility (Rychlowska et al., 2015). Areas with more people

moving in and out may have less of a shared background and therefore a tendency toward explicit communication. We tested the percentage of non-local residents per province.

Pathogen prevalence

Pathogen prevalence theory argues that places with more communicable diseases historically are more collectivistic (Fincher et al., 2008). If so, areas with more diseases may be more accurate at perceiving other people's emotions. We tested this using provincial data on the average morbidity rates for human-transmitted diseases.

Distance from the coast

We tested provinces' log distance from the coast as a proxy for two factors. (1) Coastal provinces tend to be more economically developed, both now and back into history (Wang, 2019). (2) Coastal provinces may also have seen more movement of people, given the access to the sea, which could proxy for diversity and mixing (Rychlowska et al., 2015).

Emotion Perception Accuracy
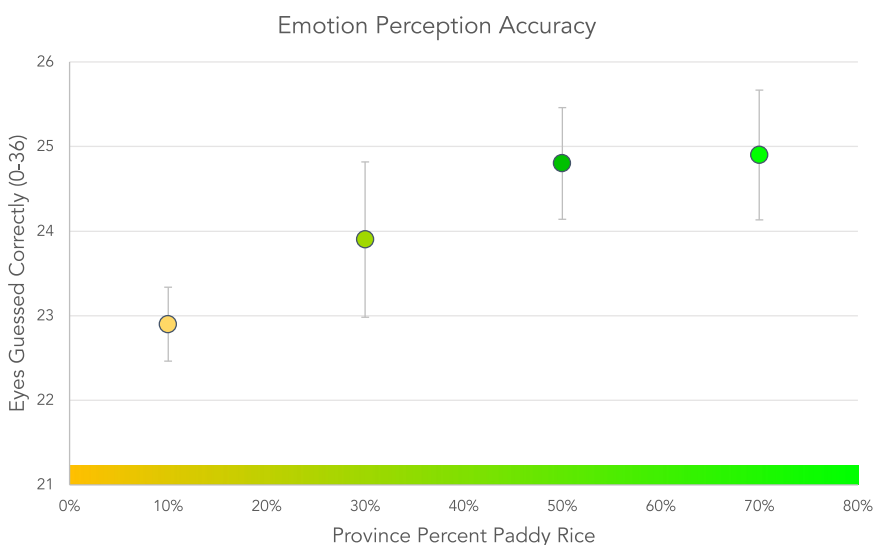
Fig. 3. People from Rice-Farming Provinces Across China Perceive Emotions More Accurately.
Note: Participants completed the 36-item Mind in the Eyes Task. Scores ranged from 11 to 32. Provinces are binned to achieve a sample size of at least 20 participants per category from 0 to 20% rice, 20–50%, 50–70%, and 70–90%. The values are estimated marginal means taking into account gender, whether the eye pictures were Western or Asian actors, and other variables in Table 1, Model 1. Error bars = 1 SEM.

Open data

Our materials, data, analysis scripts, and output are available in the OSF.

Statistical analysis

We analyzed the data using hierarchical linear models, with participants nested in provinces. These models take into account the fact that participants from the same province are not truly independent from each other. We used a binomial link to account for the fact that the test is essentially a series of binomials (correct or incorrect), rather than a true continuous variable. We ran models using the GLMER function in the program R, using formulas of this pattern:

Number Correct ~ Rice + Controls + (1|Province)

To calculate a standardized effect size for province-level variables, we calculated the residual province-level variance with and without the key predictor. To calculate standardized effect sizes for individual-level variables, we used z values (akin to t values but for GLMER) and degrees of freedom to calculate a correlation effect size. We used the "emmeans" function in R to estimate marginal means. These means take into account the factors in Table 1, Model 1, such as gender and the version of the task participants took.

Results

Rice areas more accurate

People from rice provinces were more accurate at the Mind in the Eyes task than people from wheat provinces ($p = .001$, $r_{province} = 0.88$, Table 1). The analyses use rice as a continuous variable, but to give a sense of the differences, we binned rice into four categories in Fig. 3. In provinces with less than 20% rice, people answered 22.9 of the eyes correct on average ($SE = 0.44$). In provinces with over 70% rice, people guessed 24.9 correctly ($SE = 0.77$).

To give a sense of the size of rice-wheat differences, a previous study found that women answered 1.4 more questions correctly than men on average (Vellante et al., 2013). The gender difference in our sample was smaller (0.8 questions) but significant ($p = .047$, $r_{individual} = 0.13$, Model 1). In comparison, rice-wheat differences were 2.0 questions. The difference between the general population and people with Asperger's or high-functioning autism was 4.3 questions (Baron-Cohen et al., 2001).

Rice: linear vs. non-linear

Next, we tested whether a non-linear rice variable was a stronger predictor than a linear rice variable because some research has found a stronger non-linear effect (Talhelm and English, 2020). One theoretical explanation for this is that, after a majority of farmland in an area is rice, the added effect of more farmland is smaller. However, in this sample, the non-linear rice variable was no better than the linear rice variable (Model 2).

Other regional differences

None of the other predictors of regional differences was significant across models. However, percent cultivated land was marginally significant in some models. Even after taking into account rice farming, people from provinces with more farming in general were marginally more accurate at interpreting other people's emotions.

A study in 57 countries found that economically developed countries did worse on average (Greenberg et al., 2023). However, in China, GDP was not significant. The regression coefficients for GDP were positive, which is in the opposite direction of prior findings. This could parallel findings that social class is correlated with independence in Western countries but interdependence in Japan and China (Miyamoto et al., 2018; Zhang et al., 2021).

Discussion

Study 1 found that participants from rice-growing provinces were more accurate at perceiving other people's emotions than people from wheat-growing provinces. These differences were robust to GDP, ethnic diversity, and farming in general. Rice-wheat differences were also identical whether the faces were White and Asian ($B = 0.41$) or just the White faces of the original task ($B = 0.41$, Table S2).

One contribution of Study 1 over previous studies is that it tests for cultural differences within the same nation, which holds constant language, ethnicity, and other factors that differ between nations (Adams et al., 2010). However, one weakness of Study 1 is that there may still be other confounds between rice and wheat regions that we did not control for. Study 2 makes up for this shortcoming by testing for rice-wheat differences in nearby prefectures in a single province along the rice-wheat border.
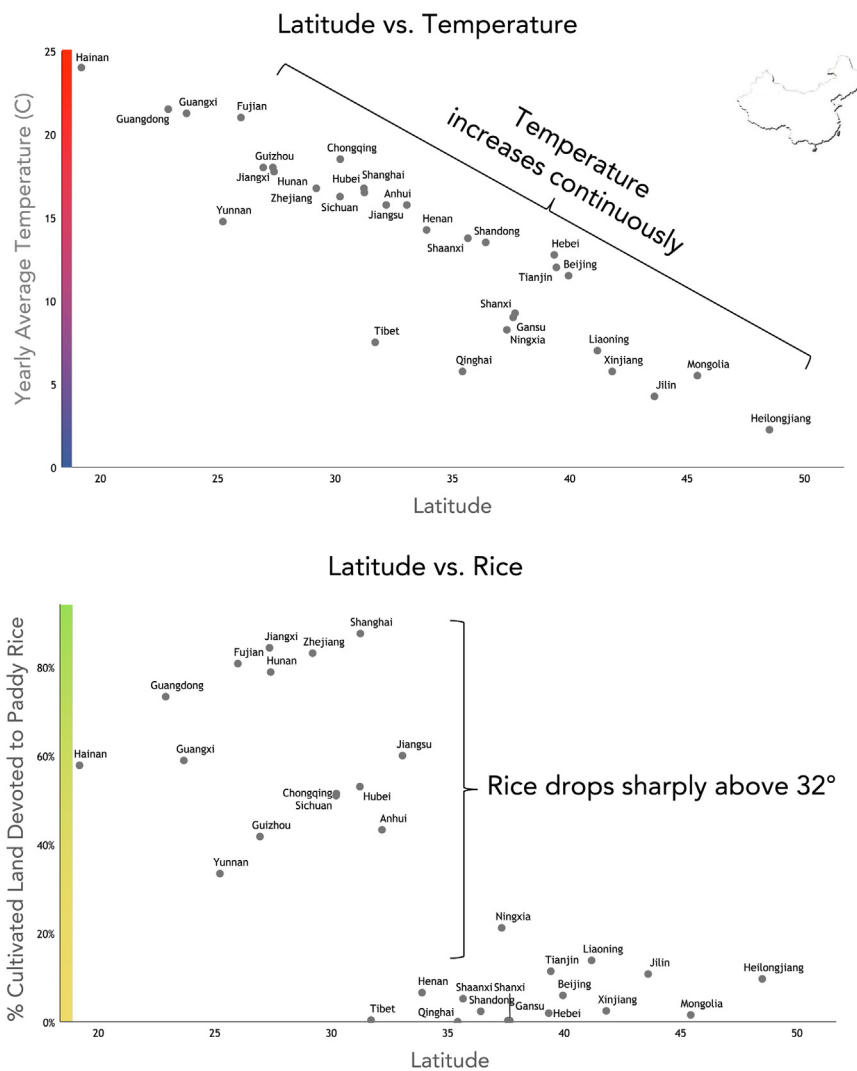
Fig. 4. Rice Drops Sharply Along the Rice-Wheat Border, But Temperature Does Not.

Study 2

In Study 2, we sampled college students in Jiangsu Province, which sits along China's rice-wheat border (Fig. 2 inset). One benefit of testing along the rice-wheat border is that rice farming changes very starkly along the rice-wheat border, whereas potential confounds like temperature change more smoothly (Fig. 4). Nearby prefectures (similar to US counties) are also more similar than northern and southern China as a whole in factors like historical contact with herding cultures, disease prevalence, and history of warfare.

A total of 165 participants (45.5% female) from all 13 prefectures in Jiangsu Province completed the Mind in the Eyes task in Chinese at Soochow University in summer 2012. Participants completed the Asian version of the task. We tested participants at the main campus and at the Dushuhu campus. We controlled for site in all models.

Rice

We estimated participants' farming heritage using their hometown prefecture percentage of cultivated land devoted to paddy rice. We used data from the 2002 provincial statistical yearbook, which was the earliest we could locate.

Rice-Wheat heritage

Similar to Study 1, we limited the main analysis to participants with a consistent rice-wheat heritage. We used the same criteria as Study 1.

Because Study 2 is focused on Jiangsu Province, we also limited the sample to students and parents who were born and grew up in Jiangsu. The heritage restrictions excluded 61 participants, leaving 104 participants from Jiangsu.

A sample of 104 participants has 84% statistical power to detect individual-level rice-wheat differences in holistic thought of our prior study, $d = 0.41$ (Talhelm et al., 2014). The sample had 80% power to detect effects of $d = 0.39$ and larger. Study 2 was not pre-registered.

To be conservative, we also re-ran the main analysis after relaxing the heritage criteria. Rice remained significant after including *all* participants who grew up in Jiangsu, including people who were born in other provinces and people whose parents were born in other provinces (Table S3). Similar to the rice heritage results in Study 1, the regression coefficient for rice was smaller when including people with mixed heritage ($B = 0.84$) than when analyzing people with consistent heritage ($B = 1.15$).

Regional control variables

Economic development

Supplemental Table S5 lists all regional control variables, data sources, and theoretical rationales. To measure economic development and modernization, we used city tier classification data from Yicai Global. The city tier data classifies prefectures into first tier (such as Beijing and Shanghai), second tier (such as Nanjing), and third tier (smaller, rural prefectures). City tier incorporates a broad index of indicators,

Table 2

Rice-Wheat Border in Jiangsu Province: Rice-Farming Prefectures More Accurate at Reading Emotions than Wheat-Farming Prefectures.

	B	SE	z	p
Female	0.31	0.08	3.89	< 0.001***
Site: Dushuhu Campus[a]	−0.07	0.09	−0.78	.434
Urbanization: City Tier[b]	0.06	0.14	0.43	.667
Prefecture Percent Cultivated Land[c]	0.14	0.77	0.18	.855
Prefecture Percent Rice	1.15	0.49	2.35	.019*
Prefectures: 13; Participants: 104				

Note: This analysis is an HLM with participants nested in prefectures using the GLMER function in R.

[a] Participants in Jiangsu came from two campuses at Soochow University. This dummy variable represents the Dushuhu campus, in contrast to the university's main campus.

[b] City tier data classifies prefectures into first tier (such as Beijing and Shanghai), second tier (such as Nanjing), and third tier (smaller, rural prefectures). Classifications come from Yicai Global, which used a broad index of indicators, such as the number of trains and flights from the city, the number of ranked universities, and GDP. We re-coded this so that higher numbers represent more developed/urban.

[c] Percent cultivated land distinguishes rice farming from farming in general. This demonstrates that differences are particular to rice farming, not all farming in general.

* $p < .05$, ** $p < .01$,

*** $p < .001$.

such as the number of trains and flights from the city, the number of ranked universities, and GDP. We re-coded this so that higher numbers represent more developed areas.

Cultivated land

We controlled for the percentage of cultivated land per prefecture, similar to Study 1.

Statistical analysis

We analyzed the data using hierarchical linear models with participants nested in prefectures, as in Study 1.

Results

Rice prefectures more accurate

People from prefectures with more rice farming answered more questions correctly, $B = 1.15$, $p = .019$, $r_{prefecture} = 0.65$ (Table 2). The analyses use rice as a continuous variable, but we binned rice in Fig. 5 to give a sense of effect size. In prefectures with less than 50% rice, people answered an average of 20.6 questions correctly ($SE = 2.12$). In prefectures with over 70% rice, people answered an average of 24.6 questions correctly ($SE = 1.15$).

Gender

Similar to Study 1, women were more accurate than men $p < .001$, $r_{individual} = 0.37$. On average, men answered 21.7 questions correctly ($SE = 1.05$), and women answered 24.2 questions correctly ($SE = 1.06$).

Other regional differences

No other regional difference variable was significant. However, it is worth noting that comparing nearby prefectures along the rice-wheat border is intentionally designed to maximize variation in rice and wheat while minimizing potential confounds of other regional differences. Thus, this methodological setup is not designed to maximize variance in other regional characteristics.

Discussion

Study 2 used a more controlled comparison of nearby rice and wheat prefectures within a single province. People in rice-farming prefectures were more accurate. These results help rule out the potential of unmeasured confounds between northern and southern China as a whole.

General discussion

People from rice-farming regions were more accurate at perceiving other people's emotion than people from wheat-farming regions. These findings fit with theory that people in interdependent cultures are more sensitive to other people's emotional expression. These results build on a recent internet study of 57 countries, which found that collectivistic cultures were more accurate on the Mind in the Eyes task (Greenberg et al., 2023). By comparing regions within the same country and ethnicity, these studies allow us to test interdependence while avoiding confounds that come with classic East-West comparisons (Adams et al., 2010]).

The findings fit with subsistence theory. Subsistence theory argues that how cultures made a living has a lasting influence on cultural differences (Nisbett and Cohen, 1996; Talhelm et al., 2014; Talhelm and Oishi, 2019; Uskul et al., 2008). It is noteworthy that these differences appeared among college students, who presumably have never farmed for a living. The fact that differences are apparent in young people who are not farmers suggests that these cultural legacies have a lasting influence. The cultural legacy of rice farming does not require the recipient to farm rice directly.

Limitations

One limitation of this study is that we collected limited demographic information on participants. We sampled at a large national university to limit potential demographic confounds, such as age and education. This will naturally limit demographic confounds. However, we did not measure social status, which is linked to accuracy on the Mind in the Eyes task (Kraus et al., 2010). Our regional measures of GDP and urbanization pick up on some differences in social status but not on individual differences within regions. One improvement futures studies can make is asking social status questions, such as parental education and subjective social status (wordings for measuring status in China: Zhang et al., 2021).

Another limitation is that college students are not representative samples. Sampling in universities helps limit demographic confounds between regions, but it limits how representative the sample is.

Finally, a limitation of the Mind in the Eyes task is that it is not a rich, real-world experience of emotion. The task is a multiple-choice quiz that asks people to reflect on unchanging pictures of emotional expressions. Real-life interactions are rich with situational cues, tone of voice, and expressions that change over time. It would be valuable to test people's ability to read emotions in real-life interactions.

Emotions in the eyes versus mouth?

Although this data makes contributions beyond prior studies, it leaves open questions for future research. One question is whether the cultural differences in perceiving other people's emotions are limited to the eye region. There is some evidence that people in East Asia pay more attention to other people's eyes than people in the West (Jack et al., 2009; Yuki et al., 2007). Thus, one possibility is that people from rice regions are more practiced at reading emotions in people's eyes and answered more questions correctly because the pictures were all of the eyes.

Future studies can test this possibility by using emotional expressions of the entire face. Future studies could also extend this by testing people's accuracy at interpreting body language and even emotional expression in writing. Testing in different domains would allow us to know
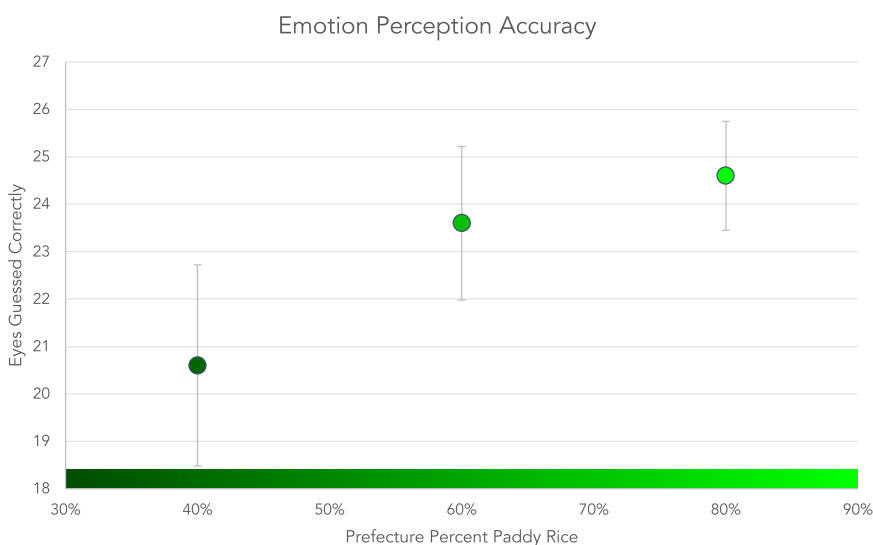
Fig. 5. Within a Single Province, People from Rice-Farming Prefectures Perceive Emotions More Accurately. Note: Participants completed the 36-item Asian version of the Mind in the Eyes Task. Scores ranged from 10 to 32. Prefectures are binned to achieve a sample size of at least 20 participants per category from 30 to 50% rice, 50–70%, and 70–92%. The means are estimated marginal means taking into account gender and other variables in Table 2. Error bars = 1 SEM.

whether these differences are specific to reading emotions in the eye region versus emotional expression in general.

Is holistic thought a mechanism?

Another open question is what specific mechanism or mechanisms cause people in interdependent cultures to be more accurate at perceiving other people's emotions. In addition to the factors we laid out in the introduction, there is also the possibility that cognitive style differences across cultures could explain the differences in emotion perception. Holistic thought in East Asia emphasizes intuition, context, and the relationships between objects (Nisbett et al., 2001). Holistic thought is more common in China's rice-farming regions than wheat-farming regions (Dong et al., 2018; Talhelm et al., 2014).

It is possible that holistic thought is better suited for interpreting people's emotions.

Future studies can test this potential mechanism by manipulating cultural thought style and testing empathic accuracy (one method for experimentally manipulating cultural thought style: Talhelm et al., 2015). However, it is worth keeping in mind that holistic thought is, in a sense, a part of interdependence. Interdependent cultures tend to think more holistically (Schulz et al., 2019; Varnum et al., 2010). And there is experimental evidence that temporarily putting people into an interdependent mindset makes them think more holistically (Oyserman and Lee, 2008). Thus, trying to pull apart interdependence and holistic thought may be an artifice.

Culture and communication style

Another potential mechanism we did not explore is cultural communication style. Researchers have classified Western cultures as "direct" communication cultures and many non-Western cultures as "indirect" or "high-context" communication cultures (Adair and Brett, 2005; Kashima and Kashima, 2003). The idea is that people in Western cultures tend to communicate directly, laying out their meaning explicitly. In non-Western cultures like Japan, people more often communicate indirectly, using the context to fill in details.

Pronoun drop is a classic example of high-context communication. In languages like Chinese and Japanese, it is common to drop the subject of the sentence. For example, "did you go to the store?" sounds quite natural as, "go to the store?" This habitual use of context could help explain why participants in Japan were slower than Americans to process audio clips in which people's emotional tone conflicted with the content (Ishii et al., 2003). For example, participants in Japan were slower to process the meaning of someone saying "happy" in a sad tone.

If emotional expressions around the eyes are a sort of optional context cue, perhaps they are more useful in high-context cultures like Japan. If people can rely on the explicit content of what people say, then they do not have to pay as much attention to people's facial expressions to round out the meaning. Thus, high-context cultural communication style could cause people to pay more attention to facial expressions.

As with holistic thought, it may be difficult to pull apart contextual communication and interdependence. It is difficult because contextual communication like pronoun drop is more common in interdependent cultures around the world (Kashima and Kashima, 2003). Future research can try to pull these factors apart by priming people with different communication styles. However, researchers should be careful to test whether getting people to use high-context communication also unintentionally primes interdependence or holistic thought.

Societal implications

The results here highlight China's cultural diversity (Talhelm et al., 2014). China has dozens of ethnic groups, but even the majority Han ethnic group, there are meaningful cultural differences. These rice-wheat cultural differences are linked to societal differences, such as patents for inventions (Talhelm et al., 2014; Zhu et al., 2019), differences in happiness as large as between nations (Lee et al., 2023), and the severity of Covid outbreaks (English et al., 2022; Talhelm et al., 2022).

Diversity can be a source of strength, but China's regional differences sometimes lead to prejudice and discrimination. A newspaper article in China argued that regional discrimination is a problem in China, causing "serious harm" (Zi, 2007). One path to lessening regional discrimination is understanding the different cultural systems and where they come from.

For example, a study of psychological adjustment tracked students from around China as they moved to college (English and Geeraert, 2020). They found that students who use an active coping style were happier and better adjusted in the wheat-farming region. But in the rice region, people who used a more passive and adjusting coping style were happier and better adjusted. Understanding regional cultural differences like coping styles and the importance of reading emotional expressions may help people adjust to cultural differences, anticipate difficulties in moving, or manage teams more effectively across China.

Conclusion

This study provides evidence that people in interdependent cultures are more accurate at perceiving other people's emotions. This adds an-

other documented factor related to people's emotion perception. Previous studies have documented differences based on gender, autism, and social class. The results here suggest that cultural differences can be at least as big as well-documented gender differences. And even though fewer and fewer people in China are farming for a living, cultural differences that trace back to rice farming are living on in modern China.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data and analysis syntax are available on the Open Science Framework: https://osf.io/mvjga/?view_only=6c5ea6e6066c49a4a16f55c4b14ca139

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.cresp.2023.100122.

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