How Do People Learn by Listening to Others? Experimental Evidence from Thailand

Andrew J. Healy*

Loyola Marymount University†

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Abstract

This paper presents experimental evidence about how individuals learn from information that comes from inside versus outside their ethnic group. In the experiment, Thai subjects observed information that came from Americans and other Thais that they could use to help them answer a series of questions. Two main findings emerge. First, subjects display overconfidence in their own opinions and place too low a value on the information that they observe. Second, conditional on this overconfidence, subjects weigh American information relative to Thai information in a nearly optimal way. The data also indicates that subjects appear to understand that outside information has extra value because people from different groups know different things and so have an opportunity to learn from each other.

*E-mail: ahealy@lmu.edu. All data and programs are available for replication purposes upon request.

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1 Introduction

For economic agents to make optimal decisions, they need to use information effectively. A large body of research shows that individuals who fail to do so suffer large welfare losses. Some of the most striking examples of this concept come from developing countries. Previous research has looked at how information sharing within social networks affects technology adoption in India and Kenya (Foster and Rosenzweig (1995), Duflo, Kremer, and Robinson (2004), Munshi (2004)). Information sharing, or lack thereof, also affects public health in Kenya, Bolivia, and Bangladesh (Dearden, Pritchett, and Brown (2004), Miguel and Kremer (2004), Munshi and Myaux (2002)). In the US, information sharing within social groups improves agents' savings decisions (Duflo and Saez (2002)). These papers show that individuals put high weight on information learned from others within their own group and that information sharing between groups often does not occur. This lack of sharing may come with costs, as listening to outside opinions may help individuals make better decisions. Information that comes from outside the group may have extra value in that people from different groups know different things and so have an opportunity to learn from each other.[1]

An agent who has access to a variety of information needs to decide how to weigh information that comes from inside her group relative to information from outside her group. The agent also needs to decide how much or how little she weighs any kind of observed information. For example, an overconfident agent may decide that she does not need to listen to her neighbors or to others from outside the community when deciding what technology to adopt. A large literature shows that individuals exhibit overconfidence in a variety of environments (Griffin and Tversky (1992), Keren (1987), Gigerenzer, Hoffrage, and Kleinbolting (1991), Camerer and Lovallo (1999)). Overconfident agents will suffer welfare losses by placing too little emphasis on others' opinions.

When making decisions, agents may deviate from the optimum either by not listening

[1] In the context of US corporations, Menon and Pfeffer (2003) discuss the value of information that comes from independent consultants due to their outside perspective.

enough to others' opinions or by putting excessive weight on one group over another, or both. This paper tests for these behaviors experimentally. In the experiment, subjects consider opinions that come from sources with different cultural backgrounds. Thai subjects first answer a series of general-knowledge questions that have correct numerical answers. The subjects then observe randomly selected answers given by Americans and by other Thais, who had answered the same questions at an earlier date, that they can use to help them revise their answers. By looking at how subjects change their answers, the experimental design provides estimates of the weights that subjects apply to observed American answers, to observed Thai answers, and to their own initial answers. I compare these weights to the optimal weights a subject should use to maximize her payments. The optimal weights that subjects should use take into account the quality of American answers relative to Thai answers and also incorporate the extra value in American answers to a Thai subject stemming from the fact that Americans and Thais know different things. The data shows that, even when any one Thai answer is equally good as any one American answer, an optimizing Thai should assign significantly higher weight to American answers than to other Thai answers. This extra value comes from the fact that, in the data, Americans and Thais tend to make different kinds of mistakes. When members of the same group tend to make the same kind of mistake, an agent from any group has more to learn from members of a different group than from other members of her own group.

Except for the questions that pertain to Bangkok or Thailand, subjects appear to understand this idea. Subjects underweigh American information relative to Thai information for questions pertaining to Bangkok or Thailand. When the questions do not refer directly to Bangkok or Thailand, though, subjects behave optimally in how they weigh Americans relative to Thais. In all cases, subjects do not listen to either group nearly enough in that they assign far too much weight to their own initial answers. Subjects have much more to gain by reducing this overconfidence in their initial answers than they do by changing how they weigh American answers relative to answers given by other Thais. On average, subjects could improve the mean squared error of their answers about fifteen times more by lowering the weight given to their initial answers than by changing how they relatively weigh observed American and observed Thai answers. The data also suggests that subjects appreciate not only how good each group is at answering the questions, but also the extra value of an American's independent perspective to a Thai decision-maker. In summary, subjects optimally weigh observed American answers relative to observed Thai answers, but they overvalue their own opinions.

Section 2 describes the experimental design. In Section 3, I model the process of using information to make decisions. Section 4 contains the summary statistics that describe the distributions of American and Thai answers to the questions. In Section 5, I estimate the weights subjects give to the information they observe and test a variety of hypotheses that explain that behavior. Section 6 tests the hypothesis that subjects both understand that Americans and Thais make different kinds of mistakes and apply this knowledge to their decisions. In Section 7, I look at how subjects could have improved their performance by changing their behavior in various ways. Section 8 concludes.

2 Experimental Design

In the experiment, American students from the Massachusetts Institute of Technology (MIT) and Thai students from Thammasat University's Rangsit campus answered a series of general knowledge questions. At a later date, separate groups of Thai students from Thammasat's Bangkok campus and from the National Institute of Development Administration (NIDA) answered the same questions. These students then observed randomly selected answers, given by the MIT and Rangsit students, which they could use to revise their answers.

2.1 The Questionnaire

The questionnaire consists of fifteen questions covering a range of topics. Most of the questions contain three distinct parts. For example, one question asks about the January temperature in Bangkok, the January temperature in Boston, and the sum of those temperatures. Another question asks for the number of Thai prime ministers since 1960, the number of American presidents since 1960, and the sum of those two numbers. A third question asks about the number of Thai and American 25-29 year-olds with some university education, as well as the sum of those two numbers. Figure 1 shows the format of the questions. Appendix A.1 contains the entire questionnaire and instructions, showing the format for all of the questions.

Figure 1: Format of the questions

From 1961-1990, average daily high temperature in January in Bangkok		From 1961-1990, average daily high temperature in January in Boston		Sum
______ °C	+	______ °C	=	______ °C

The difficulty of the questions used in this experiment could lead to substantial overconfidence. Previous research has shown that subjects show overconfidence when asked to answer general knowledge questions and that increased question difficulty amplifies this overconfidence (Griffin and Tversky (1992)). The experimental design makes it possible to separately estimate how overconfidence affects subject behavior and how behavior is affected by subjects' perceptions about American information compared to information provided by other Thais.

2.2 Stage 1: Creating a pool of American and Thai answers

In Stage 1 of the experiment, 116 introductory economics students at MIT and 130 introductory economics students at Thammasat University's Rangsit campus answered the series of questions, giving estimates of the population distribution of beliefs for each question. Students had 15 minutes to answer the survey. In both countries, students answered the questionnaire at the end of introductory economics classes. In Thailand, the questionnaire and instructions were given in Thai.[2] Each group answered the questions in the standard units prevailing in their respective countries. For example, Americans answered temperature questions in degrees Fahrenheit and Thais answered temperature questions in degrees Celsius.

Subjects received monetary rewards for answering accurately. For the American students, the top three performers on the entire set of questions received $50 each and the top fifteen performers on the individual questions received $10 each. Among the Thai students, the top five performers on the overall questionnaire received 1000 baht (approximately $25) and the top twenty on the individual questions received 200 baht. The additional rewards for the Thai students reflected the larger sample size.

Subjects also answered an optional personal survey before completing the questionnaire. The American students were asked to indicate their country of citizenship and the country where they attended high school, since some MIT undergraduates are citizens of other countries. Excluding this group of students from the sample has a negligible effect on the distribution of answers. Therefore, random selection of answers was based on the entire set of MIT students.

2.3 Stage 2: Subjects observe American and Thai information

In Stage 2, 300 economics undergraduates at Thammasat's Bangkok campus and master's economics students at the National Institute for Development Administration (NIDA) first received instructions in Thai (both read aloud and given in a packet) and then answered the questionnaire. Subjects were informed that they would receive 100 baht for participating and 20 baht for each question that they answered within a range of the correct answer. The incentives were intended to approximately provide subjects with the objective of minimizing the MSE of their answers, while keeping the instructions as simple as possible. The data

[2] Multiple translations and re-translations, as well as two pilots, verified the questionnaire's accuracy.

shows that a subject who maximized her payments would behave in basically the same way as a MSE minimizer. In other words, the experimental design succeeds in giving subjects the objective function of minimizing MSE.

In Stage 2, subjects first answered all of the questions using Microsoft Excel in computer labs at NIDA and Thammasat. They directly answered the Bangkok/Thailand and Boston/US questions, and the sum was calculated from those answers. After all subjects answered the questions, they received a second set of instructions. Subjects were told that they would observe randomly selected answers from MIT and Thammasat-Rangsit students who answered the same set of questions. These answers were provided in a separate packet. For each question, subjects saw the heading "Answers from Thai students" followed by the Thai information, and then "Answers from American students" followed by the American information. Payments were based on subjects' final answers. Figure 2 shows what one group of the Thai subjects saw for the questions about political leaders.

Figure 2: Sample of information that subjects observe

Since January 1, 1960, number of Thai prime ministers		Since January 1, 1960, number of American presidents		Sum
______	+	______	=	______

Answers given by Thai students

1. 15	+	1. 20	=	1. 35

Answers given by American students

1. 1	+	1. 9	=	1. 10
2. 5		2. 7		2. 12
3. 7		3. 10		3. 17

The subjects in this group observe that one randomly selected Thai student thought the number of Thai prime ministers was 15, the number of American presidents was 20, and the sum was 35. They also observe that a randomly selected American student thought

thought the answers were 1, 9, and 10, respectively. A second American student thought the answers were 5, 7, and 12; a third American students thought the answers were 7, 10, and 17.

In addition to the answers themselves, I randomly selected three features of the data that subjects observe: 1) the type of question (Bangkok/Thailand, Boston/US, or sum) for which subjects observe information, 2) how many Thai students' answers subjects observe, and 3) how many American students' answers subjects observe. For each question, a subject saw information about either the Bangkok/Thailand part, the Boston/US part, the sum part, or all three, each with probability $\frac{1}{4}$. Subjects observed up to three American answers and up to three Thai answers. The subjects who saw the information in Figure 2 observed one Thai opinion and three American opinions for all three parts of the question about political leaders. Subjects could observe any of twenty randomly selected sets of American and Thai answers.

2.4 Controlling for anchoring

Tversky and Kahneman (1974) show that individuals will tend to stick to a number that is given to them, even when that number is irrelevant to the question at hand, a phenomenon they called anchoring. In their example, an experimenter spins a wheel in front of a group of students. Then students answer a question about the number of African countries in the UN. When the wheel gives a higher number, students give much larger answers. In my experiment, subjects first answer the questions and then update their answers based on what they observe. Thus, anchoring presents a serious concern in this experiment; a subject provides her own answer that she can anchor to and that number contains meaning relevant to the task, unlike the random number which affects students' answers about countries in the UN.

Due to these concerns, an additional 42 students observed information and answered the questions without first providing their private beliefs. To test for anchoring, I compare these students to the students in the main treatment group. Subjects in the main group may anchor to their initial answers because they express them. In the experimental data, a subject who anchors would fail to sufficiently change the answer that she gives after observing new information. If anchoring is present in the main group, the 42 subjects who do not provide their private beliefs will choose final answers closer to the answers they observe.[3] The data will show that anchoring has a small and statistically insignificant effect on subject behavior in this experiment.

3 A Model of Information Aggregation

3.1 Summary statistics

Here, I describe a model of information aggregation that shows how the Thai subjects should weigh the information they see under the assumption that they are mean-squared error minimizers. I consider each question type (Bangkok/Thailand, Boston/US, or sum) separately. In later sections, I show that the primary results do not depend on any of the model's assumptions. Moreover, the data confirms the validity of the assumptions.

For a question q, take individual i in group j, where the groups are American and Thai, to have a private signal x_{ijq} about the correct answer for the question. The MSE, Δ^2_{jq}, for a group j for question q is then

$$\Delta^2_{jq} = \frac{1}{N_j}\sum_{i=1}^{N_j}(x_{ijq} - Truth_q)^2 \ ,$$

[3] In addition, 50 of the 300 students in the main group observed large samples for two questions. Subjects saw either 0, 5, 10, or 20 American and Thai answers. The model of information aggregation presented in the next section applies to any amounts of American and Thai information that subjects observe. Subjects may treat large amounts of information differently, though, due either to difficulties with processing all the information or to a lower bound to the weight a subject will give to herself. The presence of large samples makes it possible to see how subjects behave when they see large amounts of information. Results describing how subjects behave when they observe large samples are available upon request.

where N_j is the number of group j members in the sample and $Truth_q$ is the correct answer for question q. A group that is comparatively better at answering a question will have a lower MSE for that question. The population distributions of American and Thai answers give estimates for the MSE for Americans and the MSE for Thais for each question q.

The group MSE can be broken down into consistent estimators for the sample variance for the group (s_{jq}^2) and the squared group bias (α_{jq}^2), where $\overline{x}_{jq}$ is the mean answer given by group j for question q.

Proposition 1 *Where* $s_{jq}^2 = \frac{1}{N_j}\sum_{i=1}^{N_j}(x_{ijq} - \overline{x}_{jq})^2$ *and* $\alpha_{jq}^2 = \frac{1}{N_j}\sum_{i=1}^{N_j}(\overline{x}_{jq} - Truth_q)^2$*, the MSE for group* j *for question* q *can be expressed as*

$$\Delta_{jq}^2 = s_{jq}^2 + \alpha_{jq}^2$$

Proof. *See Appendix A.2.1* ■

This decomposition reflects the fact that the total error made by the group consists of individual and group components. The individual component comes from the variation in answers given by members of the same group and the group component comes from the distance between the group mean and the correct answer.

Define the fraction of a group's MSE that comes from this group bias by ρ_{jq}:

$$\rho_{jq} = \frac{\alpha_{jq}^2}{\Delta_{jq}^2}$$

For group j for question q, ρ_{jq} captures what share of total MSE comes from the common group bias. If individuals in group j tend to make different kinds of mistakes from other individuals in their group, ρ_{jq} will be low, as MSE will primarily be caused by individual-level variation. If people in a group make the same kind of mistake, ρ_{jq} will be high, as group bias will cause most of the group's MSE.

I focus on three parameters, averaged across questions: 1) the American-to-Thai MSE ratio, $\frac{\Delta_A^2}{\Delta_T^2}$, which captures how accurately the Americans answer the questions relative to

Thais, 2) the American group bias share, ρ_A, which captures the share of American MSE for which group bias is responsible, and 3) the Thai group bias share, ρ_T, which captures the share of Thai MSE for which group bias is responsible.

Proposition 2 *Where* Q *is the number of questions,* $\rho_{jq} = \frac{\alpha_{jq}^2}{\Delta_{jq}^2}$, *and* $\widehat{\alpha}_{jq} = \overline{x}_{jq} - Truth_q$, *the maximum-likelihood estimators (MLE) for these parameters are:*

$$\frac{\Delta_A^2}{\Delta_T^2} = \frac{1}{Q}\sum_{q=1}^{Q}\frac{\Delta_{Aq}^2}{\Delta_{Tq}^2},\ \rho_A = \frac{1}{Q}\sum_{q=1}^{Q}\rho_{Aq},\ \ \textit{and}\ \ \rho_T = \frac{1}{Q}\sum_{q=1}^{Q}\rho_{Tq}.$$

Proof. *See Appendix A.2.2* ■

These three parameters determine an optimal rule for how the Thai subjects should weigh the information they observe if they apply the same rule across questions. If the group bias share for Americans is low, for example, then multiple American guesses would provide significantly more information about the correct answer than a single American opinion. A high American group bias share, however, implies that Americans tend to make the same kind of mistake; therefore a large group of American answers contains only slightly more information than a single American opinion.

When the American (Thai) group bias share is greater than zero, optimal behavior implies that a subject puts a lower weight on any one piece of American (Thai) information when she observes more American (Thai) answers. Note that an optimizing Thai subject puts lower weight on an observed Thai answer even when she observes only one Thai answer. As a Thai individual, she shares the same group bias with the observed Thai.

3.2 A model of subject behavior

Described here is a model of how the Thai subjects treat the information they observe. Previous research suggests that a Thai subject may not treat an observed Thai answer in the same way as her own answer. When problems are difficult, individuals have shown overconfidence in a wide variety of environments (Griffin and Tversky (1992), Keren (1987), Camerer and Lovallo (1999)). To account for this idea, a subject's own perceived MSE is modeled as a fraction c of another Thai's. Where Δ_{sq}^2 is a subject's perceived MSE for question q,

$$\Delta_{sq}^2 = c\Delta_{Tq}^2 \ , \tag{1}$$

and overconfidence implies $c < 1$. A standard way to measure overconfidence involves comparing a subject's confidence interval for a given quantity to what it should be (Cesarini, Sandewall, and Johanneson (2003)). Consider as an example a weather forecaster who has to choose a 95% confidence interval for tomorrow's temperature. An overconfident forecaster will choose a confidence interval for tomorrow's temperature that is smaller than it should be. The actual temperature will be outside her confidence interval more than 5% of the time. The modeling of overconfidence in equation (1) corresponds to this idea. A subject perceives her confidence interval to be c times the width of another Thai's, for any given significance level. It is also assumed that a subject perceives her squared bias to be the same fraction c of another Thai's squared bias.

A subject who minimizes the expected MSE of her final answer will weigh information according to her perceptions of how good Americans are relative to Thais at answering the questions and how much of each group's MSE comes from group bias. Her perceptions of $\frac{\Delta_T^2}{\Delta_A^2}$, ρ_T, and ρ_A determine her behavior. The actual values of the parameters determine what she would optimally do.

Define y_{iq} to be the final answer that individual i gives after observing information about question q. For the case where subjects see n_A American answers ($x_{Aq,1}$ through x_{Aq,n_A}) and n_T Thai answers ($x_{Tq,1}$ through x_{Tq,n_T}), a subject's objective function is:

$$\begin{aligned} E(MSE) &= E(y_{iq} - Truth_q)^2 \\ & E\left(\lambda_T(x_{Tq,1} + ... + x_{Tq,n_T}) + \lambda_A(x_{Aq,1} + ... + x_{Aq,n_A}) + \lambda_s x_{iq} - Truth_q\right)^2 \end{aligned} \tag{2}$$

where

$$\lambda_s = \text{weight for own information}$$

$$\lambda_T = \text{weight for any one piece of Thai information}$$

$$\lambda_A = \text{weight for any one piece of American information}$$

Assuming independence between the American and Thai group biases and that the weights given to all information sum to one, the expressions in Proposition 2 below capture the weights that subjects would optimally use.[4] The expressions below define optimal behavior conditional on any level of overconfidence. To fully minimize MSE, subjects should also avoid overconfidence, choosing $c = 1$.

Proposition 3 *The following expressions define the MSE-minimizing weights that subjects should use to evaluate information:*

Weighing self relative to other Thais:
$$\frac{\lambda_s}{\lambda_T} = \frac{1}{c} + \frac{1-c}{c}\left(\frac{\rho_T}{1-\rho_T}\right) n_T \tag{3}$$

Weighing self relative to Americans:
$$\frac{\lambda_s}{\lambda_A} = \left(\frac{\Delta_A^2}{\Delta_T^2}\right)\left(\frac{1-\rho_A}{c} + \frac{\rho_A}{c} n_A\right) \tag{4}$$

Weighing Americans relative to other Thais:
$$\frac{\lambda_A}{\lambda_T} = \left(\frac{\Delta_T^2}{\Delta_A^2}\right)\left(\frac{1+(n_T-1)\rho_T - c\rho_T^2 n_T}{(1+(n_A-1)\rho_A)(1-\rho_T)}\right) \tag{5}$$

Proof. *See Appendix A.2.3.* ■

The same equations define the actual weights that subjects use under the model, with the actual parameter values substituted by subjects' perceptions of these parameters.

Equation (3) is the ratio of the self-weight to the weight for other Thais and thus the accuracy of Thais does not matter. But group bias does matter. When ρ_T is high and subjects

[4] This model implies that a subject behaves in a similar way as a Bayesian would. Other experimental evidence, such as Larrick and Soll (2003), indicates that cognitive failures may cause subjects to deviate from Bayesian rationality when they have to aggregate opinions. More general models of how Bayesians would behave when aggregating opinions can be found in Genest and Schervish (1985), West and Crosse (1992), and West (1992).

are overconfident, the weight that subjects put on other Thais becomes small. When the group effect accounts for more of total MSE, an overconfident subject puts more trust in her reading of the joint Thai information than in another Thai's. If $c = 1$, the subject is not overconfident and she puts equal weight on herself and any other Thai.

Equation (4) is the ratio of the self-weight to the weight subjects should put on observed Americans when $n_T = 0$. Subjects should put more weight on Americans when Americans are more accurate, a situation that corresponds to a low $\frac{\Delta_A^2}{\Delta_T^2}$ value. When c is low, subjects put less weight on American answers, since subjects perceive themselves to be better at answering the question. When ρ_A is high, subjects treat each additional American answer after the first as providing little added value. Dividing each side by n_A gives the optimal ratio of own-weight to the total weight given to all American information.

$$\frac{\lambda_s}{n_A \lambda_A} = \left(\frac{\Delta_A^2}{\Delta_T^2}\right)\left(\frac{1-\rho_A}{cn_A} + \frac{\rho_A}{c}\right)$$

This equation shows more clearly that when ρ_A is high, subjects should put less weight on each American answer when they observe more of them.

Equation (5) gives the weight ratio that subjects should assign to an American answer relative to an observed Thai answer. Not surprisingly, subjects should put higher weight on American information when Δ_A^2 is low relative to Δ_T^2. Also when ρ_A is low and ρ_T is high, subjects should put higher relative weight on American information.

The overconfidence parameter enters the expression in a second-order way through the $c\rho_T^2 n_T$ term. For reasonable values of ρ_T, overconfidence has a small, but noticeable, effect on the relative weight ratio that subjects should use for American versus Thai information. When overconfidence is high (c is lower), subjects put more relative weight on Americans because an overconfident subject trusts her perception of the common Thai information for a given question more than another Thai's perception. Another way to think of this idea is that overconfident subjects already put high weight on Thai information through the high weight they give to themselves. A Thai who is overconfident but otherwise rational will then put higher weight on observed Americans than on observed Thais.

Notice also that increases in ρ_A only cause subjects to put less weight on individual American answers when n_A is greater than one, but increases in ρ_T cause subjects to put less weight on observed Thais even when only one Thai is observed. When one Thai is observed, there are two Thai answers to consider: a subject's own answer and the one she observes. As a result, the Thai group bias term enters (5) when $n_T = 1$, but the American group bias term does not when $n_A = 1$.

The experimental data on how subjects update their answers provide estimates of the actual weights that subjects use. While the experiment does not directly observe subjects' perceptions of $\frac{\Delta_T^2}{\Delta_A^2}$, ρ_T, and ρ_A, the following sections show how the estimated weights that subjects use make it possible to test a variety of hypotheses relating to subjects' implicit perceptions.

3.3 A check on the optimal weights

To supplement the model in the previous section, I also estimate the optimal weights that subjects should use by regressing the correct answer to the questions on a subject's initial answer, the average of the American answers she observes, and the average of the Thai answers she observes. The regression by definition minimizes the MSE. Checking how closely these estimates of the optimal weights match the model's estimates provides a test of the model's applicability. The model's usefulness derives from making it possible to separately analyze the effects of overconfidence on subject behavior.

Included in the regression are question dummies for the three categories of questions: meteorology, economics/politics, and social/cultural questions. I run the regressions separately for the cases where subjects observe information for the Bangkok/Thailand questions, the Boston/US questions, and the sum questions. To run the regression that estimates optimal behavior, I first standardize the data to make it possible to compare answers across questions. The data appendix, Appendix A.3, describes how I standardize the data.

Where

$$
\begin{aligned}
Truth_q &= \text{(standardized) correct answer for question } q, \\
x_{iq} &= \text{(standardized) initial answer given by subject } i \text{ for question } q, \\
\overline{x}_{iAq} &= \text{(standardized) average observed American answer for question } q, \\
\overline{x}_{iTq} &= \text{(standardized) average observed Thai answer for question } q, \\
C_q &= \text{vector of dummy variables for question category for question } q,
\end{aligned}
$$

the regression equation is

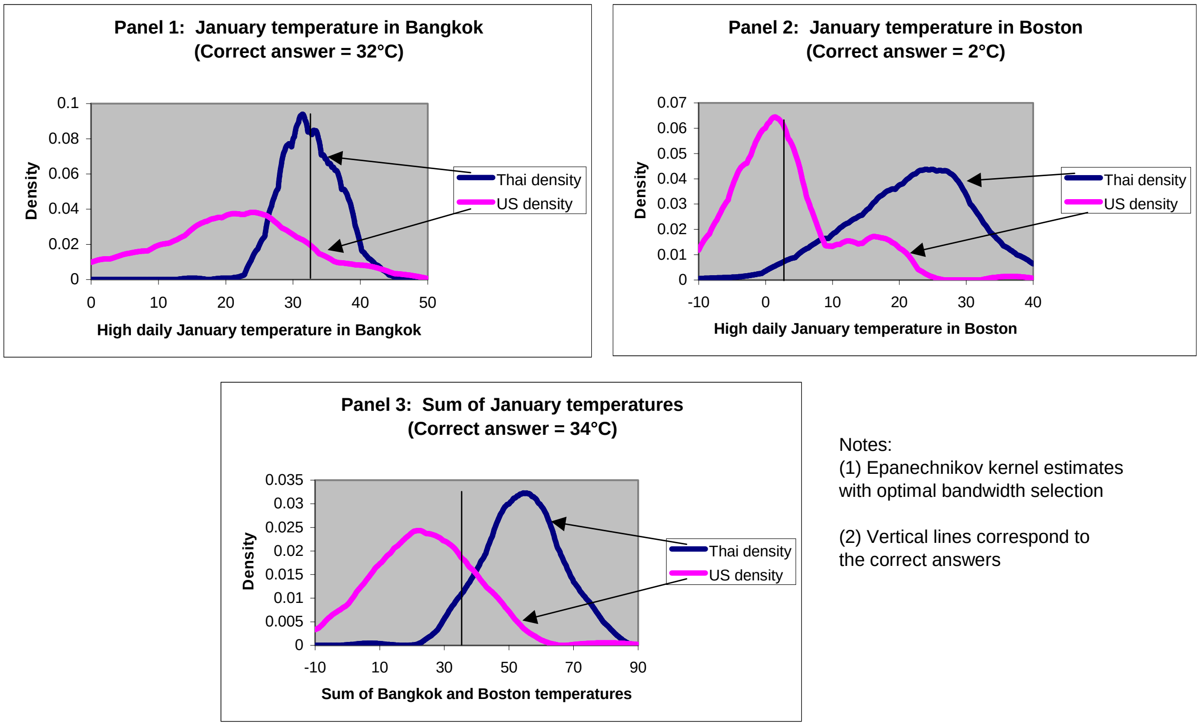
$$Truth_q = \alpha_s x_{iq} + \alpha_A \overline{x}_{iAq} + \alpha_T \overline{x}_{iTq} + C_q' \alpha_q + \varepsilon_{iq} \quad (6)$$

Relying only on a linearity assumption, this regression estimates the average weights that subjects should use to minimize their mean-squared error. I discuss the results from estimating (6) in Section 5. As described there, I also include terms that account for the number of American and Thai answers that a subject observes and different relative American-to-Thai accuracy for different questions. To estimate how subjects actually weigh information, I replace $Truth_q$ in (6) with the subjects' final answers to the questions.

4 Summary Statistics

The data shows that, across questions, Thais tend to make one kind of mistake and Americans make their own kind of mistake. This group bias means that American information contains extra value for a Thai subject. As an example of what the data looks like, Figure 3 shows kernel density estimates for the Thai and American answers for the questions about January temperature in Bangkok and Boston. Panel 1 shows that Americans have a mean of $20°C$ for the Bangkok temperature (truth=$32°C$) and Panel 2 shows that Thais have a mean answer of $20°C$ for the Boston January temperature (truth=$2°C$).

Figure 3: Kernel density estimates for American and Thai answers about January temperature



Across questions, the data provides estimates of the average Thai-to-American MSE ratio for each of the three types of questions. For the questions about Thailand, $\widehat{\frac{\Delta_T^2}{\Delta_A^2}}$ is 0.517, meaning that the expected squared distance between a randomly selected Thai answer and the truth is 0.517 times the expected squared distance between a randomly selected American answer and the truth. Table 1 summarizes the relative Thai-to-American accuracy for each of the three question types. The estimates in Table 1 come from the 116 Americans and the 430 Thais who either never observed anyone else's answers or who answered the questions before observing other subjects' opinions.[5]

[5] Thai subjects were informed that the answers they observed came from MIT students and Thammasat-Rangsit students. So if subjects had different perceptions about Thammasat-Rangsit than the universe of all Thai subjects in the experiment, it would be appropriate to use only the 130 Thai students from Stage 1 to calculate variances and correlations. Limiting the calculations to the Stage 1 students has little effect on the estimated variances and correlations.

Table 1: Relative accuracy of Americans and Thais

Question type	$\frac{\text{Thai MSE}}{\text{Thai MSE} + \text{US MSE}}$	$\frac{\text{Thai MSE}}{\text{US MSE}}$
	(1)	(2)
Type 1 (Questions about Thailand)	.341	.517
	(.008)	(.018)
Type 2 (Questions about US)	.755	3.086
	(.013)	(.216)
Type 3 (Questions about the sum)	.565	1.299
	(.01)	(.052)

Note: Bootstrapped standard errors in parentheses

Consider the second column in Table 1. Thais have about one-half the MSE of Americans for the Thai questions. Americans are three times more accurate for the questions about the US, and about 1.3 times more accurate for the sum questions. Note that these ratios exactly describe the weights that a subject should use if group bias did not matter. In that case, a subject should put 1.3 times more weight on any observed American answer than she puts on any Thai answer. The data will show that group bias means that a subject should actually put about 2.2 times more weight on American answers than on Thai answers.

The experimental design also enables me to estimate the share of group bias in total MSE for each question type, both for Americans and for Thais. Table 2 displays the estimated group bias shares for each question type.

Table 2: Group effects for Americans and for Thais

Question type	Estimated Thai group bias share	Estimated American group bias share
	(1)	(2)
Type 1 (Questions about Thailand)	.234	.307
	(.066)	(.056)
Type 2 (Questions about US)	.362	.227
	(.088)	(.063)
Type 3 (Questions about the sum)	.336	.277
	(.081)	(.062)

Note: Bootstrapped standard errors in parentheses

Table 2 shows that each group's bias share is higher for the question types that the group knows less well. For Thais, group bias is responsible for the smallest share, 23%, of total MSE for the Bangkok/Thailand questions and the largest share, 36%, for the Boston/US questions. In contrast, the group effect is responsible for the smallest share of total American MSE for the Boston/US questions and the largest share for the Bangkok/Thailand questions. For example, Thais make small errors about the average high daily January Bangkok temperature and the group effect causes a small share of that error. On the other hand, Thais make much larger errors for the January Boston temperature, and a larger share of their mistakes comes from the fact that the group mean for Thais is $20°C$. As I show in Section 6, the fact that ρ_T is biggest for the Boston/US questions and ρ_A is biggest for the Bangkok/Thailand questions has important implications for how a subject would optimally behave when she sees information for the sum question only.

In summary, the answer distributions show significant group biases for both Americans and Thais. American answers thus have extra value to a Thai due to the independence of observed American answers compared to observed Thai answers from her perspective. An optimizing Thai subject needs to account for group bias when deciding how to weigh the American opinions she observes compared to the Thai opinions she observes.

5 Estimating subject behavior

5.1 Regression estimates

A simple regression provides the weights that subjects give to the information they observe and to their own private beliefs. This involves regressing subjects' final answers after observing information on the initial answers they gave before observing information, the American answers they observe, and the Thai answers they observe. If subjects increase (decrease) their answers more in response to high (low) observed American answers than to high (low) observed Thai answers, the regression will estimate that subjects assign a higher weight to the American answers.

The following regression estimates the average weights that a subject puts on American answers (β_A), other Thai answers (β_T), and her own initial answer (β_s). Where

$$
\begin{aligned}
y_{iq} &= \text{(standardized) final answer given by subject } i \text{ for question } q, \\
x_{iq} &= \text{(standardized) initial answer given by subject } i \text{ for question } q, \\
\overline{x}_{iAq} &= \text{(standardized) average observed American answer for question } q, \\
\overline{x}_{iTq} &= \text{(standardized) average observed Thai answer for question } q, \\
C_q &= \text{vector of dummy variables for question category for question } q,
\end{aligned}
$$

I estimate the following regression equation:

$$y_{iq} = \beta_s x_{iq} + \beta_A \overline{x}_{iAq} + \beta_T \overline{x}_{iTq} + C_q' \beta_q + \varepsilon_{iq} \tag{7}$$

Optimal behavior implies that a subject chooses different weights for the American and Thai average when she observes different amounts, n_{iA} and n_{iT}, of observed American and Thai information. When a subject observes more American answers, a higher weight should be assigned to the American average since it contains more information. A high ρ_A, though, means that there is less new information in each additional American answer and that a subject should put less weight on each individual American answer when she sees more of them. To see how subjects actually do change the weights they give to information depending on how much they observe, I include terms to account for this in the regression.

In addition, if subjects have some knowledge of the group MSEs for individual questions, they will apply higher weight to American information for those questions where it is relatively better. To see if subjects behave this way, the regression can be expanded to include a term that captures relative group accuracy across questions:

$$Acc_q = \frac{\widehat{\Delta}^2_{Tq}}{\widehat{\Delta}^2_{Aq} + \widehat{\Delta}^2_{Tq}} \ . \tag{8}$$

When Acc_q is high, Americans are better relative to Thais for the question q.[6]

The full regression allows the weights that a subject uses to vary with how much American and Thai information she sees and also on the question that the subject is answering:

$$\beta_s = \beta_{s,1} + \beta_{s,2} n_{iA} + \beta_{s,3} n_{iT} + \beta_{s,4} Acc_q$$

$$\beta_A = \beta_{A,1} + \beta_{A,2} n_{iA} + \beta_{A,3} n_{iT} + \beta_{A,4} Acc_q$$

$$\beta_T = \beta_{T,1} + \beta_{T,2} n_{iA} + \beta_{T,3} n_{iT} + \beta_{T,4} Acc_q$$

For example, the regression that includes terms involving the number of observed American answers is:

$$y_{iq} = \beta_{s,1} x_{iq} + \beta_{s,2} n_{iA} x_{iq} + \beta_{A,1} \overline{x}_{iAq} + \beta_{A,2} n_{iA} \overline{x}_{iAq} + \beta_{T,1} \overline{x}_{iTq} + \beta_{T,2} n_{iA} \overline{x}_{iTq} + Q' \beta_q + \varepsilon_{iq} \tag{9}$$

Estimating these regressions gives the average weights that subjects put on Thai answers, American answers, and their own initial answers for each question type. Table 3 describes subject behavior for the Bangkok/Thailand questions.

[6] Subjects may also want to account for the spread in the answers they observe. For example, when a subject sees two answers that are near each other and one answer that is extreme, she may ignore the extreme answer, deeming it irrelevant. To look at this, I expand the regression to include a term that captures the spread in the observed answers. The spread is measured simply as the standard deviation in the observed information. Inclusion or exclusion of terms involving the standard deviation of observed information does not affect the results.

Table 3: Estimated weights for the Thailand questions

Dependent variable: Subjects' final answers for the Thailand questions

Regressor	(1)	(2)	(3)	(4)
Subject's initial answer ($\beta_{s,1}$)	.653	.654	.65	.662
	(.016)	(.016)	(.016)	(.018)
Initial answer • number of observed American answers ($\beta_{s,2}$)		.002	.008	.004
		(.019)	(.019)	(.019)
Initial answer • number of observed Thai answers ($\beta_{s,3}$)			-.038	-.04
			(.019)	(.019)
Initial answer • accuracy index ($\beta_{s,4}$)				-.142
				(.084)
Thai average ($\beta_{T,1}$)	.238	.242	.242	.24
	(.02)	(.021)	(.025)	(.026)
Thai average • number of observed American answers ($\beta_{T,2}$)		.004	.002	.012
		(.024)	(.024)	(.025)
Thai average • number of observed Thai answers ($\beta_{T,3}$)			.001	-.002
			(.025)	(.026)
Thai average • accuracy index ($\beta_{T,4}$)				.04
				(.098)
American average ($\beta_{A,1}$)	.056	.049	.039	.063
	(.012)	(.014)	(.015)	(.016)
American average • number of observed American answers ($\beta_{A,2}$)		-.016	0	-.003
		(.017)	(.019)	(.019)
American average • number of observed Thai answers ($\beta_{A,3}$)			-.036	-.027
			(.018)	(.018)
American average • accuracy index ($\beta_{A,4}$)				.232
				(.055)
Number of observations	1008	986	986	986

Notes:
(1) Regression standard errors are in parentheses.
(2) The regression in column (1) includes the data for questions 4 and 8 where subjects saw either 0, 5, 10, or 20 American and Thai answers.
(3) Regressions include dummies for the three question categories (meteorology, economic/political, and social/cultural).

Consider the first column of Table 3. For the Bangkok/Thailand questions, subjects put a weight of 0.653 on their private beliefs, 0.238 on the observed Thai average, and 0.056 on the observed American average. Thus, the model estimates that subjects assign 4.2 times more weight to the observed Thai answers than to American answers for the Bangkok/Thailand questions.

The complete regression results for the Boston/US and sum questions appear in Table A1 in Appendix A.4.[7] Table 4 captures the primary results for all three types of questions.

Table 4: Summary of estimated weights

Actual weight	Thailand questions	US questions	Sum questions
	(1)	(2)	(3)
Own initial answer	.653	.464	.731
	(.016)	(.02)	(.019)
Thai average	.238	.09	.068
	(.02)	(.03)	(.02)
US average	.056	.463	.165
	(.012)	(.019)	(.024)
N	1008	1053	557

Note:
(1) Regression standard errors are in parentheses.
(2) These estimates come from the regressions in column 1 in Tables 3, A1, and A2.

When subjects observe information about the Boston/US questions, they assign approximately 5.1 times more weight to American answers than to other Thai answers, choosing

[7] I include the cases where individuals see answers for all three types of questions in the regressions for the Thailand and US questions. One possibility is that there are spillovers across question types when subjects observe all answers for all three types of questions. For example, a subject who sees an American who answers well for the Thailand question may put more weight on that American for the US question. Testing for this possibility generally produces insignificant results. Details are available upon request.

0.464 as the weight for their initial answers, 0.090 for the weight given to observed Thai answers, and 0.463 for the weight given to observed American answers. When subjects observe answers for the sum question, the regression estimates that they assign 2.4 times more weight to American answers than to observed Thai answers, giving estimates of 0.731 for the own-weight, 0.068 for the Thai weight, and 0.165 for the American weight.

Table 3 and Table A1 indicate that subjects account for different group accuracies across questions. For all three types of questions, subjects put significantly more weight on American information for those questions on which Americans perform relatively better. For the Bangkok/Thailand questions, as seen in Table 3, an increase of 0.1 in the accuracy index (Thai MSE divided by the sum of American and Thai MSE) increases the weight given to American answers by 0.02. Given that subjects assign a weight of 0.058 to American answers, this represents a substantial increase.

It may seem surprising that subjects are able to appreciate the accuracy of Americans relative to Thais for individual questions. That they do is perhaps less surprising when the individual questions are considered. Relative to American answers, Thai answers are much more accurate for the question about temperature in Bangkok than for the question about female-labor force participation in Thailand. It seems reasonable to expect that the subjects would understand that it takes individual experience in Bangkok to know the weather there, but there may be more general knowledge involved with making an educated guess about labor-force demographics. Therefore, the Thai subjects may and apparently do put higher relative weight on Thai information for the question about Bangkok weather.

5.2 Anchoring

As discussed earlier, anchoring presents a major concern in this experiment. Subjects may adhere more closely to their initial answers because they express them. To test for this, a treatment group of 42 students observed randomly selected answers from Americans and Thais without first providing their private beliefs about the answers to the questions. These subjects observe one of the same twenty sets of information that the subjects in the main group observe. By comparing subjects in the anchoring group to subjects in the main group who see the same information, I can test for anchoring. If subjects anchor to their private signals when they reveal them, the subjects who do not reveal their private signals will choose final answers closer to the answers they observe.[8]

To test for anchoring, I consider the following regressions:

$$(y_{iq} - \overline{x}_{iTq})^2 = \theta_{1T} Anchor_i + Version'_{iv}\theta_{2T} + \varepsilon_{iq} \quad (10)$$

$$(y_{iq} - \overline{x}_{iAq})^2 = \theta_{1A} Anchor_i + Version'_{iv}\theta_{2A} + \varepsilon_{iq}, \quad (11)$$

where $Anchor_i$ is a dummy that is one if the subject belongs to the anchoring treatment group and zero otherwise. $Version_{iv}$ is a dummy that is one if subject i observed version v out of the 20 possible sets of randomly selected information. Including the version dummies creates a direct comparison between subjects in the anchoring group and subjects in the main group who observed the same information.

The first (second) regression looks at the distance between subjects' final answers and the Thai (American) answers they observe. If subjects in the main group anchor, then the following two conditions should hold: $\theta_{1T} < 0$ and $\theta_{1A} < 0$. Table 5 shows that the coefficients are always close to zero and insignificant except for the distance between subjects' answers and the American average they see for the Boston/US questions.

The first three entries in column (1) of Table 5 come from running regression (10) for each of the three types of questions and the last three entries in column (1) come from running (11) for each of the three types of questions. The results indicate, for the questions about Thailand, that the squared distance between subjects' final answers and the Thai average they observe is .013 units lower for subjects in the anchoring group than for subjects in the main group.

[8] Another way to test for anchoring involves looking at whether or not subjects in the anchoring group do better at answering the questions than the students in the main group because these 42 students do not suffer the losses associated with anchoring. On average, subjects in the anchoring treatment group appear to do slightly better, but the difference is not significant.

To put the regression coefficients into perspective, column (2) in Table 5 shows the average mean-squared distance from of subjects' final answers from the observed Thai or American average for the 300 subjects who were not in the anchoring group. Since the data has been standardized, the standard deviation for each question is one. The table indicates that, on average, subjects in the main group choose final answers that are 1.835 standard deviations from the observed Thai average for the US question. The regression estimates that the students in the anchoring group choose final answers that are .051 standard deviations closer to the observed Thai average than the main group. In other words, compared to subjects in the main group, subjects who do not have the chance to anchor choose final answers that are about $\frac{.051}{1.835} = 3\%$ closer in squared distance to the observed Thai average. In general, the results in Table 5 follow this pattern. Anchoring has a small and usually insignificant effect on subject behavior.

Table 5: Effect of anchoring on distance from observed information

Independent variable: Dummy for anchoring treatment group	Effect of not having a chance to anchor	Average squared distance for subjects not in the anchoring group
	(1)	(2)
A. Dependent variable: Squared distance from average of observed Thai answers		
Questions about Thailand	-.013	.827
	(.021)	(1.773)
Questions about the US	-.051	1.798
	(.065)	(3.23)
Questions about sum	-.026	1.75
	(.049)	(3.585)
B. Dependent variable: Squared distance from average of observed American answers		
Questions about Thailand	.042	1.716
	(.078)	(2.571)
Questions about the US	-.046	1.378
	(.022)	(2.945)
Questions about sum	-.049	1.781
	(.07)	(3.314)

Note:
For column (1), the robust regression standard errors are reported in parentheses.
For column (2), the standard deviation is in parentheses.

6 Tests for optimal behavior

6.1 Estimated optimal weights

Regressing subjects' final answers on their initial answers, the average American answer they observe, and the average Thai answer they observe gives estimates of the optimal weights subjects should use. Table A2 in Appendix A.4 shows in detail the optimal weights obtained in this way for all three types of questions. Table 6A summarizes the main results.

Table 6: Estimating the optimal weights

A. Estimates from regression with the correct answers as the dependent variable

Optimal weight	Questions about Thailand	Questions about US	Questions about sum
	(1)	(2)	(3)
Own initial answer	.292	.063	.179
	(.021)	(.017)	(.026)
Thai average	.458	.115	.250
	(.023)	(.02)	(.024)
American average	.250	.822	.571
	(.018)	(.016)	(.026)

Notes:
(1) Regression standard errors are in parentheses.
(2) These estimates come from the regressions in column 1, 5, and 9 in Table A2.

B. Estimates from the econometric model

Optimal weight	Questions about Thailand	Questions about US	Questions about sum
	(1)	(2)	(3)
Own initial answer	.258	.100	.154
	(.007)	(.008)	(.009)
Thai average	.458	.174	.332
	(.014)	(.015)	(.02)
American average	.284	.726	.514
	(.021)	(.024)	(.028)

Notes:
(1) Bootstrapped standard errors are in parentheses.
(2) These estimates come from the parameter estimates described in Tables 1 and 2.

For the Bangkok/Thailand questions, an optimally-behaving subject would put a weight of 0.292 on her private belief, a weight of 0.458 on the observed Thai average, and a weight of 0.250 on the observed American average. For the Boston/US questions, subjects would optimally choose a weight of 0.063 for their initial answers, 0.115 for the observed Thai average, and 0.822 for the observed American average. For the sum questions, the regression estimates that a subject should choose 0.179 for the self weight, 0.250 for the weight given to observed Thai answers, and 0.571 for the weight given to observed American answers. Notice that these regression estimates of optimal behavior do not account for overconfidence. These are the weights that a subject should use assuming overconfidence is not present.

The model described in Section 3 provides a different way to estimate the optimal weights that a subject should use. These estimates come from substituting the estimates of the American-to-Thai MSE ratio, the American group bias share, and the Thai group bias share into equations (3) and (5). I reported these estimates in Tables 1 and 2. Table 6B displays the econometric model's estimates of the optimal weights subjects should apply given that subjects do not show overconfidence.

For the Bangkok/Thailand questions, a subject should apply a weight of 0.258 to her initial answer, 0.459 to the Thai average she observes, and 0.284 to the American average she observes. For the Boston/US questions, the corresponding weights are 0.100, 0.174, and 0.726. For the sum questions, the model estimates that a subject would optimally choose 0.154 for the self-weight, 0.332 for the weight given to observed Thai answers, and 0.514 for the weight given to observed American answers. Bootstrapping gives the standard errors for these estimates.

For all three types of questions, the regression's estimates of the optimal weights in Table 6A and the econometric model's estimates in Table 6B match closely and equality cannot be rejected. The close correspondence between the estimates in Table 6A and those in Table 6B provides additional evidence supporting the importance of accounting for group bias in determining optimal behavior. If, in the model, the group bias shares ρ_A and ρ_T are assumed to be zero, the hypothesis of equality between the two sets of estimates of optimal behavior is rejected for all three types of questions.

6.2 Construction of confidence intervals

Simulations using the regression coefficients from (7) give the confidence interval for $\frac{\beta_A}{\beta_T}$, the weight ratio that subjects use to relatively weigh observed American and Thai information. The distributions of Thai and American answers generate confidence intervals for functions of Thai and American MSE and the Thai and American group biases. I focus on two such confidence intervals: 1) the naive weight ratio, which expresses the relative weight a subject would use if she understood each group's accuracy but ignored group bias, and 2) the optimal weight ratio discussed in Section 3, which expresses how a subject would behave if she correctly perceived each group's accuracy and accounted for group bias.

Weight ratios used for hypothesis tests:

$$\begin{aligned}
\text{Actual} &= \frac{\beta_A}{\beta_T} \\
\text{Naive} &= \left(\frac{\Delta_T^2}{\Delta_A^2}\right) \\
\text{Optimal} &= \left(\frac{\Delta_T^2}{\Delta_A^2}\right)\left(\frac{1+(n_T-1)\rho_T - c\rho_T^2 n_T}{(1+(n_A-1)\rho_A)(1-\rho_T)}\right)
\end{aligned}$$

Using the parameter estimates in Tables 1 and 2, I calculate the confidence intervals for the optimal weight ratios for a variety of different values of the overconfidence parameter c. Table 7 reports these results for each of the three question types. The p-values in the table correspond to tests that I describe in the next subsection.

Table 7: Comparing how subjects relatively weigh American and Thai information

	Thailand questions	US questions	Sum questions
	(1)	(2)	(3)
Actual weight ratio	.231	5.143	2.49
95% confidence interval	(.131,.352)	(3.144,15.17)	(1.45,5.366)
Naive weight ratio	.517	3.086	1.299
	(.477,.554)	(2.737,3.577)	(1.205,1.406)
	p=0.000	*p=0.065*	*p=0.017*
Optimal weight ratios for different overconfidence levels			
c = 1	.571	4.423	1.843
	(.475,.694)	(3.467,5.63)	(1.466,2.332)
	p=0.000	*p=0.622*	*p=0.346*
c = 0.75	.576	4.581	1.913
	(.464,.727)	(3.504,6.29)	(1.469,2.524)
	p=0.000	*p=0.732*	*p=0.423*
c = 0.5	.606	4.897	2.048
	(.476,.759)	(3.62,6.938)	(1.549,2.877)
	p=0.000	*p=0.879*	*p=0.572*
c = 0.25	.616	5.125	2.135
	(.468,.798)	(3.662,7.592)	(1.525,2.991)
	p=0.000	*p=0.986*	*p=0.676*
Estimated $c(n_A + n_T)$	.603	5.043	2.168
	(.476,.773)	(3.635,7.345)	(1.597,3.136)
	p=0.000	*p=0.979*	*p=0.75*

Notes: (1) Bootstrapped 95% confidence intervals are in parentheses.
(2) The bootstrap for the actual weights accounts for correlation in the coefficient estimates.
(3) *p*-values compare the given weight ratio to the actual weight ratio.

The optimal weight ratio increases as overconfidence increases. As discussed earlier, an overconfident subject already puts high weight on Thai information by assigning a high weight to her own beliefs. As a result, conditional on her overconfidence, an optimizing subject will put more weight on observed Americans relative to observed Thais. Even for very large overconfidence (small c), though, the direct effect of group bias on the optimal weight ratio is larger than the effect of overconfidence. Consider the Boston/US questions. With no overconfidence ($c = 1$), the presence of group bias causes the optimal weight ratio to increase from 3.09 to 4.42. Increasing overconfidence by lowering c to 0.25 causes the optimal weight ratio to further rise to 5.13.

The data can also be used to estimate the overconfidence parameter with some additional assumptions.[9] I use the estimated c values only for illustrative purposes in the calculation shown in Table 7. As the table reflects, estimated overconfidence puts the estimated c in the range between 0.25 and 0.5, on average.

To summarize, the data on how subjects use the information they observe to update their answers give confidence intervals for the ratio that subjects use to weigh observed American information relative to observed Thai information. The Thai and American answer distributions for the series of questions gives confidence intervals for the optimal weight ratio that subjects should apply. The data provides these optimal estimates for any value of the overconfidence parameter.

6.3 Testing behavioral hypotheses

By looking at how subjects revise their answers, I can test a variety of hypotheses relating to subjects' perceptions about the relative accuracy and group biases of Americans and Thais. The weights that subjects apply to the information they observe reflect their implicit perceptions of these parameters. To start, consider the hypothesis that subjects correctly perceive the MSE of Thais relative to Americans, but ignore group bias. Call this the naive hypothesis, N_0. Under this hypothesis, subject behavior will reflect the following perceptions:

$$N_0 : \left(\frac{\Delta_T^2}{\Delta_A^2}\right)_{perceived} = \left(\frac{\Delta_T^2}{\Delta_A^2}\right),\ (\rho_T)_{perceived} = 0,\ (\rho_A)_{perceived} = 0\ .$$

Under N_0, subjects will choose

$$\frac{\beta_A}{\beta_T} = \left(\frac{\Delta_T^2}{\Delta_A^2}\right)\ . \tag{12}$$

[9] This process involves estimating a non-linear model. Specifically, for each of the question types, if it is assumed that $\rho_A = \rho_T$ and c is allowed to be a function of $n_{iA} + n_{iT}$, then the overconfidence parameters $c(n_{iA} + n_{iT})$ can be estimated. The standard error bounds for the overconfidence estimates are large. Estimated overconfidence generally increases when more information is observed, but it appears for any amount. Details and regression results are available upon request.

Rejection of the prediction (12) implies rejection of N_0.

The second row of Table 7 displays the results of this test for all three types of questions. For the Bangkok/Thailand questions and the sum questions, we can reject this hypothesis at the 5% level ($p = 0$ and $p = 0.017$, respectively). For the Boston/US questions, we can reject it at the 10% level ($p = 0.065$). We reject the hypothesis for the Bangkok questions due to subjects choosing too low a weight for American answers relative to Thai answers. It is rejected for the Boston/US and sum questions due to subjects relatively overweighing American answers. For all three types of questions, subjects do not correctly perceive how accurate Americans are relative to Thais while at the same time failing to recognize the presence of group bias.

Now consider the hypothesis of optimal behavior, S_0:

$$S_0 : \left(\frac{\Delta_T^2}{\Delta_A^2}\right)_{perceived} = \left(\frac{\Delta_T^2}{\Delta_A^2}\right), \ (\rho_T)_{perceived} = \rho_T, \ (\rho_A)_{perceived} = \rho_A$$

This hypothesis states that subjects correctly perceive the MSE of Thais relative to Americans and also correctly account for group bias. Under S_0, subjects understand each group's accuracy and correctly value the independence in American information. Compared to a subject who behaves according to N_0, a subject who behaves according to S_0 will put more weight on American answers because she appreciates the value of an American's independent perspective.

Under S_0, subjects will choose the optimal weight ratio

$$\frac{\beta_A}{\beta_T} = \left(\frac{\Delta_T^2}{\Delta_A^2}\right)\left(\frac{1+(n_T-1)\rho_T - c\rho_T^2 n_T}{(1+(n_A-1)\rho_A)(1-\rho_T)}\right) \tag{13}$$

Table 7 displays the results of the above test for a variety of possible values of the overconfidence parameter. For the Bangkok/Thailand questions, S_0 is rejected. For all values of overconfidence, the test gives a p-value of nearly zero. Thais put too little weight on American answers in this case. On the other hand, for the Boston/US and sum questions, we cannot reject this hypothesis for any level of overconfidence. For $c = 1$, the optimal weight ratio estimates are 4.42 and 1.84, compared to the actual weight ratio estimates of 5.14 and 2.49. Tests of equality give p-values of 0.622 and 0.346, respectively.

Now consider the optimal weight ratios for the Boston/US and sum questions when overconfidence is taken into account. Given estimated overconfidence, the actual and optimal weight ratios match up remarkably closely in these two cases. For the Boston/US questions, the optimal weight ratio estimate is 5.04 and the actual weight ratio estimate is 5.14. The test for equality between the two, not surprisingly, gives a p-value of nearly one ($p = 0.979$). For the sum questions, the actual weight ratio estimate is 2.49, compared to the optimal estimate of 2.17. The test for equality gives a p-value of 0.750. In summary, individuals who display the same amount of overconfidence as the subjects in the experiment would optimally choose a weight ratio very close to the one that the experimental subjects actually use.

Biased behavior, however, could still explain subject behavior for the Boston/US and sum questions. Under this hypothesis, B_0, subjects perceive Americans to be better than they actually are compared to Thais and they ignore group bias:

$$B_0 : \left(\frac{\Delta_T^2}{\Delta_A^2}\right)_{perceived} > \left(\frac{\Delta_T^2}{\Delta_A^2}\right), \ (\rho_T)_{perceived} = 0, \ (\rho_A)_{perceived} = 0$$

Under S_0, subjects put extra weight on American information because they understand the extra value in American information that comes from the fact that Americans and Thais make different kinds of mistakes. Under B_0, subjects put extra weight on American information because subjects incorrectly perceive American answers to be better than they really are.

The experimental design can distinguish between S_0 and B_0. Subject behavior on the sum question gives a direct test of the hypothesis that subjects ignore group bias for any perception of $\left(\frac{\Delta_T^2}{\Delta_A^2}\right)$. By looking at how subjects who observe answers only for the sum question update their answers for both the Bangkok/Thailand and Boston/US questions, it is possible to test the hypothesis that subjects ignore group bias when choosing their final answers.

To explain this test, I expand the earlier notation that applied when each question type was considered separately. Define

$$\begin{aligned} \rho_{jk} &= \text{group bias share in total MSE for group } j \text{ for question type } k \\ \Delta^2_{jk} &= \text{mean-squared error for group } j \text{ for question type } k \ . \end{aligned}$$

For example, ρ_{Ta} is the group bias share in total MSE for Thais for the Boston/US questions.

Consider the case when a subject uses observed answers for the sum question to update her answer for the Bangkok/Thailand questions. A subject updates her answer for a Bangkok/Thailand question based on her initial answer for a Bangkok/Thailand question and the distance between the answers she observes for the sum question and her initial answer for the sum question. When a subject observes answers above her own for the sum question and uses them to update her answer, she is likely to revise upwards her answer for the Bangkok/Thailand question.

Define $\left(\frac{\phi_A}{\phi_T}\right)_{Thai}$ to be the weight ratio that subjects assign to American answers relative to Thai answers to the sum question when they update for the Bangkok/Thailand question. Also define $\left(\frac{\phi_A}{\phi_T}\right)_{US}$ to be the weight ratio that subjects assign to American answers relative to Thai answers to the sum question when they update for the Boston/US question. Consider the following proposition:

Proposition 4 *If* $(\rho_{Tt})_{perceived} = (\rho_{Ta})_{perceived} = 0$, *then optimal behavior* $\Rightarrow \left(\frac{\phi_A}{\phi_T}\right)_{Thai} = \left(\frac{\phi_A}{\phi_T}\right)_{US}$

Proof. See Appendix A.2.4 ■

Consider the hypothesis, I_0, that the perceived group bias shares are zero.

$$I_0 : (\rho_{Tt})_{perceived} = (\rho_{Ta})_{perceived} = 0$$

This hypothesis states that subjects ignore Thai group bias for Thais for both the Thai and US questions. Notice that I_0 encompasses N_0, the hypothesis that subjects perceive total MSE correctly and ignore group bias, and B_0, the hypothesis that subjects perceive Americans to have lower MSE relative to Thais than they actually do and ignore group bias. Rejection of I_0 means we must also reject B_0.

Under I_0, subjects will choose

$$\left(\frac{\phi_A}{\phi_T}\right)_{Thai} = \left(\frac{\phi_A}{\phi_T}\right)_{US} \tag{14}$$

Rejection of equality between the weight ratio subjects use to relatively weigh answers for the sum question when they update for the Thai question and the analogous ratio when they update for the US question would imply rejection of I_0.

The following two regressions give the parameter estimates needed to conduct the above test. The first equation expresses the change in a subject's answer for the Thai question (subscript t) as a function of the distance between the average observed American answer for the sum question and her own answer for the sum question (subscript s) and the distance between the average observed Thai answer for the sum question and her own answer for the sum question. The second equation expresses how subjects update their answers for the US question after observing information relating to the sum question.

Where

$$\begin{aligned} y_{iqt} &= \text{final answer given by subject } i \text{ to the Thai part of question } q, \\ x_{iqt} &= \text{initial answer given by subject } i \text{ to the Thai part of question } q, \\ y_{iqa} &= \text{final answer given by subject } i \text{ to the US part of question } q, \\ x_{iqa} &= \text{initial answer given by subject } i \text{ to the US part of question } q, \\ x_{iqs} &= \text{initial answer given by subject } i \text{ for the sum part of question } q, \end{aligned}$$

the regression equations are:

$$y_{iqt} - x_{iqt} = \phi_{A,Thai}(\overline{x}_{iAqs} - x_{iqs}) + \phi_{T,Thai}(\overline{x}_{iTqs} - x_{iqs}) + C_q'\phi_1 + \varepsilon_{iqt} \tag{15}$$

$$y_{iqa} - x_{iqa} = \phi_{A,US}(\overline{x}_{iAqs} - x_{iqs}) + \phi_{T,US}(\overline{x}_{iTqs} - x_{iqs}) + C_q'\phi_2 + \varepsilon_{iqu} \tag{16}$$

Table 8 reports the results from estimating equations (15) and (16). Notice that $\left(\frac{\hat{\phi}_A}{\hat{\phi}_T}\right)_{Thai} =$

$\frac{.075}{.056} = 1.34$ and $\left(\frac{\hat{\phi}_A}{\widehat{\phi}_T}\right)_{US} = \frac{.226}{.081} = 2.79$. The regression results provide the inputs needed to test (14). We can reject (14), at a 10% level ($p = 0.058$). At a 10% level, we reject I_0, the hypothesis that subjects fail to take group bias into account, regardless of how they perceive American and Thai accuracy.

Table 8: Subject updating for the Thai and US questions when they see answers for the sum

Dependent variables: (1) Final answer for Thai question
(2) Final answer for US question

Regression weights	Thailand questions (1)	US questions (2)
ϕ_T = Distance between observed Thai average and initial answer (*for sum question*)	.056	.081
	(.013)	(.019)
ϕ_A = Distance between observed American average and initial answer (*for sum question*)	.075	.226
	(.014)	(.022)
p-value for test of : $\left(\frac{\phi_A}{\phi_T}\right)_{Thai} = \left(\frac{\phi_A}{\phi_T}\right)_{US}$	0.058	
N	548	544

Notes:
(1) Regression standard errors are in parentheses.
(2) Regressions include dummies for question categories (meteorology, economic/political, and social/cultural).

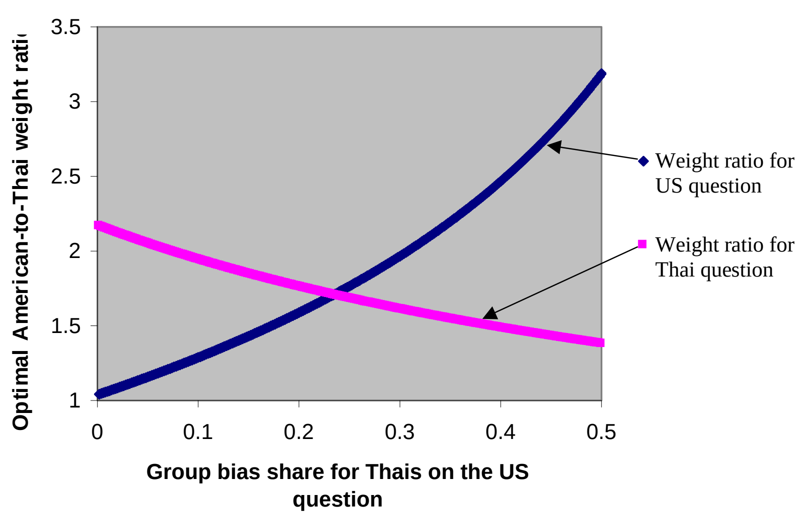
In contrast, correctly accounting for group bias would lead subjects to behave in a way that accords with how they actually behave. If the perceived group bias share for Thais for the Boston/US questions (ρ_{Ta}) is greater than the perceived group bias share for Thais for the Bangkok/Thailand questions (ρ_{Tt}), then subjects will put a higher relative weight on observed Americans for the US questions than for the Thailand questions. The proof of Proposition 4 demonstrates that:

$$\rho_{Ta} > \rho_{Tt} \Rightarrow \left(\frac{\hat{\phi}_A}{\widehat{\phi}_T}\right)_{Thai} < \left(\frac{\hat{\phi}_A}{\widehat{\phi}_T}\right)_{US}$$

To understand the intuition, consider a subject updating her answer for the Bangkok/Thailand question after observing answers for the sum question. If ρ_{Tt} is high, she should put less weight on Thais relative to Americans for the same reasons seen earlier; group bias means each additional Thai answer contains less new information. On the other hand, if ρ_{Ta} is high, she should put *higher* weight on observed Thai answers for the sum question. When ρ_{Ta} is high, Thai subjects have a better idea of what other Thai answers about the sum mean for what those observed students believe about the Thai question. For example, if ρ_{Ta} were equal to one, all Thais would give the same answer to the US questions. Then, a subject could deduce the observed individual's private belief about the Thai question from her answer to the sum question.

The data shows that the effects of group bias can explain how subjects actually weigh the information they observe. If subjects applied the estimated actual variance estimates and estimated actual group bias shares, they would choose $\left(\frac{\hat{\phi}_A}{\hat{\phi}_T}\right)_{Thai} = 1.51$ and $\left(\frac{\hat{\phi}_A}{\hat{\phi}_T}\right)_{US} = 2.53$. Figure 4 shows how the optimal weight ratios for the two types of questions vary as a function of ρ_{Ta}, holding the other parameters constant at their estimated values. The graph shows that, when updating their answers for the Bangkok/Thailand questions, subjects should put less weight on observed Americans answers to the sum question and more weight on observed Thai answers when ρ_{Ta} is high.

Figure 4: Optimal American-to-Thai weight ratio for the US questions



In summary, the earlier results showed that subjects used approximately the optimal weight ratio for the Boston/US and sum questions. We could explain this behavior in two ways. Either subjects appreciate the importance of group bias or subjects overestimate $\frac{\Delta_T^2}{\Delta_A^2}$, the ratio of Thai MSE to American MSE. By looking at how subjects update separately for the Bangkok/Thailand and Boston/US questions when they observe answers for the sum, we can reject the latter possibility. The hypothesis left standing, that subjects appreciate each group's accuracy and the extra value in an American's independent perspective to a Thai subject, describes the data quite closely.

7 Potential gains from changing behavior

Earlier results indicated that subjects choose a much larger weight for their initial answers than they optimally would. Here, I show directly how much subjects could reduce their MSE by: 1) changing how they weigh their initial answers, and 2) changing how they weigh observed American answers relative to observed Thai answers. The methods described below apply to the cases where subjects observe direct information; they observe information for either the Bangkok/Thailand question or the Boston/US question that they can use to update their answers for either the Bangkok/Thailand question or the Boston/US question. Similar logic applies for the case where subjects observe information for the sum question.[10] Details are in the data appendix, Appendix A.3.

[10] When subjects observe answers for the sum question only, subjects update their answers for both the Bangkok/Thailand and Boston/US questions. This means that a subject has more uncertainty about the answers she sees; she does not see direct information about the answers she changes. As a result, it is not correct to compare estimates of β_s from (7) to optimal estimates based on the assumption that subjects update specifically for the sum question. Optimizing behavior in terms of choosing $\frac{\beta_A}{\beta_T}$ (for the sum question), though, is the same whether updating occurs directly for the sum question or the observed answers to the sum question are used to update for the Bangkok/Thailand and Boston/US questions. In other words, when subjects observe answers for the sum question only, regression (7) gives a shortcut for estimating $\frac{\beta_A}{\beta_T}$ for the sum question.

The first column in Table 9 shows the MSE that subjects actually attain with their final answers y_{iq}, relative to the MSE they would attain by applying the optimal weights. The optimal MSE comes from regressing the correct answer on the initial answer, the observed American average and the observed Thai average.

$$Truth_q = \alpha_s x_{iq} + \alpha_A \overline{x}_{iAq} + \alpha_T \overline{x}_{iTq} + \varepsilon_{iq}$$

The estimated optimal MSE is the mean squared distance between $Truth_q$ and $\widehat{\alpha}_s x_{iq} + \widehat{\alpha}_A \overline{x}_{iAq} + \widehat{\alpha}_T \overline{x}_{iTq}$. The first column in Table 9 gives the ratio of the MSE associated with subjects' actual answers y_{iq} to the MSE associated with the optimal weights.

Table 9: Possible improvements in MSE

Efficiency measure = $\dfrac{\text{Restricted MSE subjects could attain}}{\text{Unrestricted MSE subjects could attain}}$

	MSE that subjects actually attain	MSE attainable under different restrictions	
	(1)	(2)	(3)
Subjects see direct information and update for:			
Questions about Thailand	1.641	1.393	1.043
Questions about US	2.656	1.816	1.012
Subjects see answers for sum question and update for:			
Questions about Thailand	1.492	1.400	1.048
Questions about US	1.701	1.539	1.001
Own weight (β_S) restricted to estimated value		Y	N
American-to-Thai weight ratio (β_A / β_T) restricted to its estimated value		Y	Y

Note:
The weights are constrained to sum to one in all cases, with each weight restricted to being greater than or equal to zero.

Now consider the MSE subjects would attain if they used the actual estimated weights without the variation in the error term. Equation (7) in Section 5.1 gives estimates of the predicted answer $\widehat{y}_{iq}$, where

$$\widehat{y}_{iq} = \widehat{\beta}_s x_{iq} + \widehat{\beta}_A \overline{x}_{iAq} + \widehat{\beta}_T \overline{x}_{iTq}.$$

The second column gives the MSE that subjects would attain by choosing $\widehat{y}_{iq}$, relative to the optimal MSE. Note that the MSE associated with $\widehat{y}_{iq}$ is smaller than that associated with subjects actual final answers, y_{iq}, because $\widehat{y}_{iq}$ does not contain the variation induced by the error term.

To estimate the loss that comes from subjects overweighing their initial answers, I use the regression

$$Truth_q = \varphi_s x_{iq} + \varphi_A \overline{x}_{iAq} + \varphi_T \overline{x}_{iTq} + u_{iq} \ ,$$

and restrict $\varphi_A = \frac{\widehat{\beta}_A}{\widehat{\beta}_T}\varphi_T$, where $\frac{\widehat{\beta}_A}{\widehat{\beta}_T}$ comes from the estimates reported in Table 7. So the restrictions are $\varphi_A = 0.231\varphi_T$ for the Bangkok/Thailand questions and $\varphi_A = 5.143\varphi_T$ for the Boston/US questions.[11] This gives the MSE that subjects could achieve if they optimally chose the weight given to their own initial answers, given the estimated actual relative weights applied to American and Thai information. I report this relative MSE in the third column of Table 9. This captures the gains subjects could make by changing the weight they assign to their own initial answers.

First, compare column 2 to column 1. For the Bangkok/Thailand questions, subjects would achieve 1.393 times the MSE achieved with the optimal weights if they followed the simple rule of always applying the actual average weights to all information. They actually achieve an MSE that is 1.641 times greater than the MSE achieved with the optimal weights. The error term captures the additional MSE. Subjects cannot eliminate this source of MSE simply by changing the average weight they give to any kind of information.

[11] Unlike the results for the case when subjects see direct information, these results when subjects see information for the sum question are sensitive to small variations in the regression restriction. Still, the finding that subjects could achieve most of the possible improvement by changing how they weigh their initial answers is robust.

Table 10: Comparing the possible improvements

Efficiency measure = % of the total possible MSE reduction a subject could achieve by changing her behavior	Eliminating overconfidence	Changing relative weight given to observed American and Thai answers
	(1)	(2)
Subjects see direct information and update for:		
Questions about Thailand	54.6%	6.7%
Questions about US	48.6%	0.7%
Subjects see answers for sum question and update for:		
Questions about Thailand	71.5%	9.8%
Questions about US	76.7%	0.1%

Table 10 expresses the gains shown in Table 9 in percentage terms. For example, I estimate that subjects could reduce their MSE by 54.8% by changing how they weigh their initial answers for the questions about Thailand. This estimate comes from the fact that changing the self-weight gives a possible improvement of $1.393 - 1.043 = 0.350$ over what subjects would achieve by using the estimated weights. The total possible improvement of $1.641 - 1.000 = 0.641$ also includes the share of mistakes attributed to the error term. So subjects could eliminate $\frac{0.350}{0.641} = 54.6\%$ of their MSE by changing how they weigh their initial answers. Except for the mistakes caused by the error term, subjects could achieve the remaining possible improvement by changing how they weigh American information relative to Thai information. For the Bangkok/Thailand questions, they could eliminate $\frac{0.043}{0.641} = 6.7\%$ of their MSE by changing how they relatively weigh observed Americans relative to observed Thais.

The table shows that, in all four cases, subjects' potential gains from eliminating overconfidence exceed by at least nine times those from changing how they relatively weigh Americans compared to Thais. When subjects observe answers for the Bangkok/Thailand questions, they can achieve 54.6% of the possible MSE reduction by eliminating overconfidence, compared to a possible improvement of only 6.7% by changing how they relatively weigh observed Americans and Thais. For the Boston/US questions, subjects can achieve a 48.6% improvement by changing how they weigh themselves and a 0.7% improvement by changing the American-to-Thai weight ratio.

When subjects see answers for the sum question, the results again show that most of the potential gains come from subjects changing how they weigh their original answers. For the Bangkok/Thailand questions, subjects can achieve 71.5% of the possible MSE reduction by eliminating overconfidence, compared to a possible improvement of 9.8% from changing how they relatively weigh observed information. For the Boston/US questions, subjects can achieve 76.7% of the possible MSE reduction by changing how they weigh themselves and a 0.1% improvement by changing the American-to-Thai weight ratio.

In all cases, subjects could improve their performances significantly more by decreasing their overconfidence than they could by changing how they relatively weigh observed American and Thai answers. Subjects only deviate significantly from optimally weighing observed American information relative to observed Thai information for the questions about Bangkok and Thailand. For those questions, subjects have relatively little to learn from Americans. Even in this case, subjects suffer a relatively small cost from underweighing Americans and a much larger cost from overweighing their initial answers.

8 Conclusion

This paper showed that economic agents can learn from information that comes from inside their country and from outside their country. For questions that do not specifically refer to Bangkok or Thailand, the experimental subjects apply the optimal relative weights to the American and Thai information they observe. In achieving this optimal behavior, the results show that the Thai students appreciate the extra value in American information due to its independence. The subjects achieve this success despite displaying considerable overconfidence.

The model presented in this paper may seem to require a level of statistical sophistication that demands too much of the experimental subjects. Almost certainly, subjects do not reason along the lines of Bayesian updating, mulling over their beliefs about the American group bias share in total American MSE. Their actions, however, reflect implicit perceptions. The experimental design made it possible to test a variety of hypotheses regarding these perceptions. Left standing is the hypothesis that subject actions reflect an understanding that American information has extra value to a Thai subject because members of different groups have different areas of expertise. A simple understanding of the idea that members of the same group tend to make the same kind of mistakes would lead subjects to behave as they do in the experiment.

The experimental results in this paper have important implications for our understanding of how agents conduct inference. Despite potential biases coming from salient ethnic labels, the subjects in the experiment treat the information they observe in an intelligent way. If, for example, people in developing countries appreciate the value of observing independent sources of information, ensuring access to a variety of information sources might help to change behaviors affecting agricultural output and public health. However, the results suggest that overconfidence will present a significant barrier to individuals appreciating the value of any information they observe.

It is interesting that the subjects fail to use the optimal relative weights only for the questions about Bangkok or Thailand. In this case, they overweigh observed Thais compared to observed Americans. They should put a high weight on observed Thais compared to observed Americans, but they choose an even higher relative weight than they optimally would. Future work could investigate whether it is generally the case that agents overweigh other members of their own group relative to outsiders specifically for tasks that refer to the group's presumed area of expertise.

In addition, future research could apply this experiment to American students, to see if and when they appreciate the value in the independence of Thai or other information. The experimental results reported here show that the ethnic labels attached to information generally do not interfere with Thai subjects making optimal decisions in terms of weighing observed American answers versus observed Thai answers. It would be interesting to see if we could come to the same conclusion about American students.

Finally, the results in this paper speak to an ongoing debate in behavioral economics. Does it make sense to model agents who are irrational in one dimension but rational in others, as behavioral models often do? This paper provides evidence that it may make sense to do so. The subjects in the experiment display overconfidence while otherwise acting in a strikingly sophisticated way.

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A Appendix

A.1 Experimental instructions and questionnaire

Below are the instructions given to the subjects in the main group.

A.1.1 Part A instructions

This questionnaire asks a series of questions about Thailand and the United States. Some of the questions pertain specifically to Bangkok (a city in Thailand) and Boston (a city in the northeast United States). Your participation on this questionnaire is voluntary. Please participate only if you desire to do so. You may also choose to stop participating at any time. For the integrity of the analysis, you are asked to not discuss the questions or your answers with others at any time.

You will be asked to answer fifteen questions about various topics. You will have 15 minutes to complete the questionnaire. You should round each answer to the nearest whole number or percent, unless otherwise indicated.

Here is a sample question and a possible answer:

Land area of Thailand		Land area of United States		Sum
510,000 sq. km.	+	3,720,000 sq. km.	=	4,230,000 sq. km.

You will fill in your answers in the blank red spaces in the Excel file. When you have finished answering the questions, save the file as “A#” and “B#”, where # refers to the questionnaire number on your instruction packet. For example, if you have questionnaire number A37, save the files as A37 and B37 in the folder “Answers.” After saving, close the folder Excel and wait until everyone finishes. When everyone has finished, we will continue to section 2 of the questionnaire.

You will receive 100 baht for your participation and 20 baht for each of your answers that are within a range of the correct answer. The size of the range depends on the question's difficulty level. So, if you get 10 answers that are close enough to the right ones, you will get $100 + (10 * 20) = 300$ baht.

If you decide to participate, please turn to the next page where there is a brief personal survey. Your answers to these questions will be kept confidential and will have no impact on your rewards.

A.1.2 Part B instructions

In an earlier phase of this research, approximately 100 introductory economics students at Thammasat University's Rangsit campus and approximately 100 introductory economics students at the Massachusetts Institute of Technology (a university near Boston) answered the same questionnaire that you just answered. We have randomly selected answers from those Thai and American students, and attached those answers to this packet. For each question, you can see answers given by Thai and American students. Please bear in mind that the American students were asked to answer the questions in units familiar to them (such as miles), and those answers have been converted into units familiar to you.

Here is a sample question and set of answers:

Land area of Thailand sq. km.	+	Land area of United States sq. km.	=	Sum sq. km.

Answers given by Thai students:

1. 20,000 sq. km.	1. 2,000,000 sq. km.	1. 2,020,000 sq. km.

Answers given by American students:

1. 1,000,000 sq. km.	1. 40,000,000 sq. km.	1. 41,000,000 sq. km.
2. 500,000 sq. km.	2. 35,000,000 sq. km.	2. 35,500,000 sq. km.

Please carefully consider the information you observe when choosing your final answers.

Open the file B# that you previously saved. You will have 15 minutes to choose your final answers. How you use the information that you observe is entirely up to you. When you finish, please save the file as B# again and close Excel. Your final answers will determine the payments that you receive.

A.1.3 Questionnaire

Questions: Group 1

1) At the equator, the sun sets 12 hours after it rises on any day. In other places, the day is longer than 12 hours in the summer and shorter than 12 hours in the winter.

Length of longest day in Bangkok hours minutes	+	Length of longest day in Boston hours minutes	=	Sum hours minutes

2)

In 2002, highest recorded temperature in Bangkok °C	+	In 2002, highest recorded temperature in Boston °C	=	Sum °C

3)

From 1961-1990, average number of days per year with recordable precipitation (of any type) in Bangkok days	+	From 1961-1990, average number of days per year with recordable precipitation (of any type) in Boston days	=	Sum days

4)

From 1961-1990, average daily high temperature in January in Bangkok °C	+	From 1961-1990, average daily high temperature in January in Boston °C	=	Sum °C

5)

Distance between Bangkok and Boston =
km

Questions: Group 2

1) The per capita gross national product (GNP) is a measure of the annual mean income that is earned per person in a country. So per capita GNP is the total income of a country divided by the total number of people in that country (including adults and children).

In 2002, per capita GNP of Thailand (in Thai baht) ____ baht	+	In 2002, per capita GNP of US (in Thai baht) ____ baht	=	Sum ____ baht

2)

2002 population of Thailand ____ million	+	2002 population of US ____ million	=	Sum ____ million

3)

Since January 1, 1960, number of Thai prime ministers ____	+	Since January 1, 1960, number of US prime ministers ____	=	Sum ____

4) Please answer in Thai baht.

On October 1, 2003, average price of a gallon of premium gasoline (95 octane) in Bangkok ____ baht	+	On October 1, 2003, average price of a gallon of premium gasoline (95 octane) in Boston ____ baht	=	Sum ____ baht

5)

On October 1, 2003, the average Thai baht-to-US dollar exchange rate = ____ baht / $

Questions: Group 3

1)

In 2002, percentage of Thai women aged 15-24 infected with HIV %	+	In 2002, percentage of US women aged 15-24 infected with HIV %	=	Sum %

2)

In 2002, percentage of Thai workers who were women (average for year) %	+	In 2002, percentage of US workers who were women (average for year) %	=	Sum %

3)

In 2002, percentage of Thais aged 25-29 at least least some university education %	+	In 2002, percentage of Americans aged 25-29 with at least some university education %	=	Sum %

4)

In 2002, percentage of Thais whose primary occupation was in agriculture %	+	In 2002, percentage of Americans whose primary occupation was in agriculture %	=	Sum %

5)

In 2000, percentage of Thais who reported they were of Chinese ethnicity %	+	In 2000, percentage of Americans who reported they were of African ethnicity %	=	Sum %

A.2 Proofs

A.2.1 Proof of Proposition 1

From the definition of the MSE for group j for question q:

$$\Delta_{jq}^2 = \frac{1}{N_j}\sum_{i=1}^{N_j}(x_{ijq} - \overline{x}_{jq} + \overline{x}_{jq} - Truth_q)^2$$

Expanding the expression gives:

$$\Delta_{jq}^2 = \frac{1}{N_j}\sum_{i=1}^{N_j}\left[(x_{ijq} - \overline{x}_{jq})^2 + 2(x_{ijq} - \overline{x}_{jq})(\overline{x}_{jq} - Truth_q) + (\overline{x}_{jq} - Truth_q)^2\right]$$

Since $\overline{x}_{jq} = \frac{1}{N_j}\sum_{i=1}^{N_j} x_{ijq}$, the middle term drops out, giving the result:

$$\begin{aligned}\Delta_{jq}^2 &= \frac{1}{N_j}\sum_{i=1}^{N_j}(x_{ijq} - \overline{x}_{jq})^2 \;+\; (\overline{x}_{jq} - Truth_q)^2 \\ &= s_{jq}^2 + \alpha_{jq}^2\end{aligned}$$

QED.

A.2.2 Proof of Proposition 2

Consider group j (either A or T). For a given question q, the MLE for the true mean-squared distance of group j answers from the truth, σ_{Tq}^2, is:

$$\widehat{\sigma_{jq}^2} = \frac{1}{N_j}\sum_{i=1}^{N_j}(x_{ijq} - Truth_q)^2 \tag{17}$$

The total MSE between a group's answers and the correct answer consists of the sample variance and the squared group bias. Where $\overline{x}_{jq}$ is the average answers for group j members for question q, the MLE for the sample variance, s^2_{jq}, is

$$s^2_{jq} = \frac{1}{N_j} \sum_{i=1}^{N_j} (x_{ijq} - \overline{x}_{jq})^2 \tag{18}$$

Since the sample variance is the part of total MSE that does not come from group bias and the MLE of a function is the function of the MLEs, the sample variance can be expressed as:

$$s^2_{jq} = (1 - \widehat{\rho}_{jq})\widehat{\sigma^2_{jq}}$$

Substitution of (17) into (18) then gives

$$1 - \widehat{\rho}_{jq} = \frac{\sum_{i=1}^{N_j} (x_{ijq} - \overline{x}_{jq})^2}{\sum_{i=1}^{N_j} (x_{ijq} - Truth_q)^2},$$

which leads to

$$\widehat{\rho}_{jq} = \frac{\sum_{i=1}^{N_j} (\overline{x}_{jq} - Truth_q)^2}{\sum_{i=1}^{N_j} (x_{ijq} - Truth_q)^2} = \frac{\widehat{\alpha^2_{jq}}}{\widehat{\sigma^2_{jq}}}$$

Since the questions are assumed to be independent, the MLE for ρ_j is just the average of the estimates provided by all the Q questions:

$$\widehat{\rho}_j = \frac{1}{Q} \sum_{q=1}^{Q} \widehat{\rho}_{jq} = \frac{1}{Q} \sum_{q=1}^{Q} \frac{\widehat{\alpha^2_{jq}}}{\widehat{\sigma^2_{jq}}}$$

Similarly, question independence implies that averaging across questions gives the MLE for the ratio of American and Thai MSEs:

$$\widehat{\frac{\Delta^2_A}{\Delta^2_T}} = \frac{1}{Q} \sum_{q=1}^{Q} \frac{\widehat{\Delta^2_{Aq}}}{\widehat{\Delta^2_{Tq}}}$$

QED.

A.2.3 Proof of Proposition 3

Assuming that $n_T\lambda_T + n_A\lambda_A + \lambda_s = 1$ so that the sum of the weights put on all pieces of information is one, equation (2) becomes

$$E(MSE) = E\left(\lambda_T \sum_{k=1}^{n_T}(x_{Tk} - Truth) + \lambda_A \sum_{k=1}^{n_A}(x_{Ak} - Truth) + \lambda_s(x_s - Truth)\right)^2$$

Also assume the group biases are uncorrelated,

$$E((x_{Tk_T} - Truth)(x_{Ak_A} - Truth)) = 0,$$

as holds true in the experimental data. Then expanding the expression for MSE gives

$$\begin{aligned} E(MSE) &= n_T\lambda_T^2\Delta_T^2 + n_T(n_T-1)\lambda_T^2\rho_T\Delta_T^2 + n_A\lambda_A^2\Delta_A^2 + n_A(n_A-1)\lambda_A^2\rho_A\Delta_A^2 \\ &\quad +2cn_T\lambda_T\lambda_s\rho_T\Delta_T^2 + c\lambda_T^2\Delta_T^2 \end{aligned}$$

The first two terms in the above expression describe the expected MSE of all the observed Thai answers and the error that comes from the shared group bias among the n_T Thais (a total of $n_T(n_T-1)$ interactions). The next two terms capture the analogous errors for the observed American answers. The next-to-last term describes the shared group bias between the subject herself and the other Thais she observes. The final term describes the subject's own perceived MSE.

Taking the derivatives with respect to the weights gives the expressions in Proposition 2. QED.

A.2.4 Proof of Proposition 4

Consider the case when a subject uses observed answers for the sum question to update her answer for the Bangkok/Thailand question. A subject updates her answer for the Bangkok/Thailand question based on her initial answer for the Bangkok/Thailand question and the distance between the answers she observes for the sum question and her initial answer for the sum question.

When she observes n_A American answers and n_T Thai answers, her expected mean-squared prediction error is

$$\begin{aligned}
E(MSE) &= E\left(\phi_T\left((x_{Ts1}-x_{is})+...+(x_{Tsn_T}-x_{is})\right)+\phi_A\left((x_{As1}-x_{is})+...+(x_{Asn_A}-x_{is})\right)+x_{it}\ -\mu_t\right. \\
&= E\left(\phi_T\sum_{k=1}^{n_T}(\varepsilon_{Ttk}+\varepsilon_{Tak})+\phi_A\sum_{k=1}^{n_A}(\varepsilon_{Atk}+\varepsilon_{Aak})-(n_T\phi_T+n_A\phi_A)(\varepsilon_{it}+\varepsilon_{ia})+\varepsilon_{it}\right)^2 \\
&= n_T\phi_T^2\left[(\Delta_{Tt}^2+\Delta_{Ta}^2)+(n_T-1)(\rho_{Tt}\Delta_{Tt}^2+\rho_{Ta}\Delta_{Ta}^2)\right]+n_A\phi_A^2[\Delta_{At}^2+\Delta_{Aa}^2+(n_A-1)(\rho_{At}\Delta_{At}^2+ \\
&\quad (1-n_T\phi_T-n_A\phi_A)^2\alpha\Delta_{Tt}^2+(n_T\phi_T+n_A\phi_A)^2\alpha\Delta_{Ta}^2+2(1-n_T\phi_T-n_A\phi_A)n_T\phi_T\alpha\rho_{Tt}\Delta_{Tt}^2 \\
&\quad -2(n_T\phi_T+n_A\phi_A)n_T\phi_T\alpha\rho_{Ta}\Delta_{Ta}^2\ ,
\end{aligned}$$

where ϕ_A is the weight given to American answers for the sum question and ϕ_T is the weight given to other Thai answers for the sum question.

Taking the derivatives with respect to ϕ_A and ϕ_T gives the optimal weights. The optimal weight ratio $\frac{\phi_A}{\phi_T}$ can be expressed as a function of the optimal weight ratios derived in Proposition 2 for how subjects should weigh American information relative to Thai information for the Bangkok/Thailand questions and the Boston/US questions: $\left(\frac{\lambda_A}{\lambda_T}\right)_{Thai}$ and $\left(\frac{\lambda_A}{\lambda_T}\right)_{US}$. The optimal weight ratio is

$$\left(\frac{\phi_A}{\phi_T}\right)_{Thai}=\frac{\left(\frac{\lambda_A}{\lambda_T}\right)_{Thai}+\left(\frac{\lambda_A}{\lambda_T}\right)_{US}\frac{y_A}{y_T}+\frac{cn_T\Delta_{Ta}^2(\rho_{Tt}-\rho_{Ta})(1-\rho_{Ta})}{y_T}}{1+\frac{y_A}{y_T}\frac{1-\rho_{Tt}}{1-\rho_{Ta}}+\frac{cn_T\Delta_{Ta}^2(\rho_{Ta}-\rho_{Tt})}{y_T}}\ ,$$

where

$$\begin{aligned}
y_A &= (1+(n_A-1)\rho_{Aa})(1-\rho_{Ta}) \\
y_T &= (1+(n_A-1)\rho_{At})(1-\rho_{Tt})
\end{aligned}$$

If the perceived group bias shares for Thais for the Thailand and US questions, ρ_{Tt} and ρ_{Ta}, are zero, this reduces to the following simple expression:

$$\left(\frac{\phi_A}{\phi_T}\right)_{Thai}=\frac{\Delta_{Tt}^2+\Delta_{Ta}^2}{\Delta_{At}^2+\Delta_{Aa}^2}$$

The same line of reasoning implies that, if ρ_{Tt} and ρ_{Ta} are zero,

$$\left(\frac{\phi_A}{\phi_T}\right)_{US} = \frac{\Delta_{Tt}^2 + \Delta_{Ta}^2}{\Delta_{At}^2 + \Delta_{Aa}^2}$$

This gives the desired result:

$$(\rho_{Tt})_{perceived} = (\rho_{Ta})_{perceived} = 0 \Rightarrow \left(\frac{\phi_A}{\phi_T}\right)_{Thai} = \left(\frac{\phi_A}{\phi_T}\right)_{US}$$

QED.

A.3 Data Appendix

A.3.1 Standardization

Where the subscript i denotes the individual, j denotes the group (either A or T), and q denotes the question, any variable y_{ijq} is standardized in the following way:

$$z_{ijq} = \frac{y_{ijq} - \overline{y}_{Tq}}{\frac{1}{2}(s_{Tq} + s_{Aq})} \ .$$

In the above equation, s_{Tq} is the standard deviation of the Thai answers, s_{Aq} is the standard deviation of the American answers, and $\overline{y}_{Tq}$ is the mean of the Thai answers, for question q.

Another possibility is to just use the standard deviation of the Thai answers to standardize the data. For questions where Thais have a small standard deviation, this standardization would cause the standardized American mean to be far from zero if the American and Thai means are different. These points can then have excessive influence on the regression reported in the text. Still, the results remains similar if the data are standardized in this way.

A.3.2 Estimates in Table 9

In Section 7, I described the procedure for estimating potential gains for the case when subjects observe direct information. Here, I describe the analogous procedure for estimating potential improvements when they observe information about the sum question that they can use to update their answers. Consider the case when subjects use the information that they observe about the sum question to update their answers for the Bangkok/Thailand questions.

The optimal MSE that subjects could attain can be estimated by regressing the correct answer to the Thailand question, $Truth_{qt}$, on the initial answer the subject gave to the Thailand question, the difference between the observed American average for the sum question and the subject's answer to the sum question, and the difference between the observed Thai average for the sum question and the subject's answer to the sum question.

$$Truth_{qt} = \theta_s x_{iqt} + \theta_{A,Thai}(\overline{x}_{iAqs} - x_{iqs}) + \theta_{T,Thai}(\overline{x}_{iTqs} - x_{iqs}) + \varepsilon_{iqt}$$

Analogous to equation (15), θ_s is restricted to equal one. The estimated optimal MSE is the mean squared distance between $Truth_{qt}$ and $x_{iqt} + \widehat{\theta}_{A,Thai}(\overline{x}_{iAqs} - x_{iqs}) + \widehat{\theta}_{T,Thai}(\overline{x}_{iTqs} - x_{iqs})$.

Now consider the MSE subjects would attain if they used the actual estimated weights without the variation in the error term. Equation (15) gives estimates of the predicted answer $\widehat{y}_{iqt}$, where

$$\widehat{y}_{iqt} = x_{iqt} + \widehat{\phi}_{A,Thai}(\overline{x}_{iAqs} - x_{iqs}) + \widehat{\phi}_{T,Thai}(\overline{x}_{iTqs} - x_{iqs}) + \varepsilon_{iqt}$$

The second column in Table 9 gives the MSE that subjects would attain by choosing $\widehat{y}_{iqt}$, relative to the optimal MSE.

To estimate the loss that comes from subjects overweighing their initial answers, I use the regression

$$Truth_{qt} = x_{iqt} + \theta_{A,Thai}(\overline{x}_{iAqs} - x_{iqs}) + \theta_{T,Thai}(\overline{x}_{iTqs} - x_{iqs}) + \varepsilon_{iqt} \qquad (19)$$

and restrict $\theta_{A,Thai} = \frac{\widehat{\phi}_{A,Thai}}{\widehat{\phi}_{T,Thai}}\theta_{T,Thai}$, where $\frac{\widehat{\phi}_{A,Thai}}{\widehat{\phi}_{T,Thai}} = 1.34$, as reported in Table 8. Everything proceeds in the same way for the case where subjects use information about the sum question to update for the Boston/US questions. For that case, regression (19) is estimated under the constraint $\theta_{A,US} = 2.79\theta_{T,US}$.

A.4 Additional Tables

Table A1: Estimated weights for the US and sum questions

Dependent variable: Subjects' final answers

Regressor	Questions about US				Questions about sum			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Subject's initial answer ($\beta_{s,1}$)	.464 (.02)	.474 (.02)	.48 (.021)	.492 (.021)	.731 (.019)	.731 (.02)	.731 (.02)	.728 (.02)
Initial answer • number of observed American answers ($\beta_{s,2}$)		.003 (.024)	.001 (.024)	.013 (.024)		.001 (.024)	-.001 (.024)	-.001 (.024)
Initial answer • number of observed Thai answers ($\beta_{s,3}$)			.041 (.024)	.045 (.024)			-.002 (.026)	.002 (.026)
Initial answer • accuracy index ($\beta_{s,4}$)				-.273 (.127)				.266 (.13)
Thai average ($\beta_{T,1}$)	.09 (.03)	.086 (.03)	.054 (.036)	.064 (.036)	.068 (.02)	.07 (.025)	.064 (.028)	.076 (.032)
Thai average • number of observed American answers ($\beta_{T,2}$)		-.015 (.034)	-.004 (.035)	.003 (.038)		.006 (.03)	.011 (.031)	.008 (.03)
Thai average • number of observed Thai answers ($\beta_{T,3}$)			-.053 (.038)	-.038 (.041)			-.024 (.037)	-.017 (.037)
Thai average • accuracy index ($\beta_{T,4}$)				-.123 (.221)				-.151 (.204)
American average ($\beta_{A,1}$)	.463 (.019)	.481 (.02)	.476 (.021)	.455 (.021)	.165 (.024)	.092 (.037)	.088 (.037)	.081 (.038)
American average • number of observed American answers ($\beta_{A,2}$)		.075 (.022)	.09 (.023)	.07 (.024)		-.07 (.032)	-.069 (.032)	-.061 (.032)
American average • number of observed Thai answers ($\beta_{A,3}$)			-.046 (.024)	-.053 (.024)			-.023 (.025)	-.012 (.025)
American average • accuracy index ($\beta_{A,4}$)				.398 (.124)				.351 (.139)
Number of observations	1052	1032	1032	1032	557	548	548	548

Notes:
(1) Regression standard errors are in parentheses.
(2) The regression in column (1) includes the data for questions 4 and 8 where subjects saw either 0, 5, 10, or 20 American and Thai answers.
(3) Regressions include dummies for the three question categories (meteorology, economic/political, and social/cultural).

Table A2: MSE minimizing behavior for the all three types of questions

Dependent variable: Correct answers to the questions

Regressor	Questions about Thailand				Questions about US				Questions about sum			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Subject's initial answer ($\beta_{s,1}$)	.292	.289	.266	.285	.063	.057	.042	.086	.179	.148	.152	.142
	(.021)	(.021)	(.021)	(.019)	(.017)	(.017)	(.017)	(.014)	(.026)	(.028)	(.029)	(.022)
Initial answer • number of observed American answers ($\beta_{s,2}$)		.034	.052	.032		-.055	-.048	-.029		-.117	-.118	-.121
		(.024)	(.024)	(.021)		(.019)	(.019)	(.015)		(.034)	(.034)	(.025)
Initial answer • number of observed Thai answers ($\beta_{s,3}$)			-.114	-.115			-.079	-.095			.018	-.044
			(.023)	(.02)			(.02)	(.016)			(.036)	(.027)
Initial answer • accuracy index ($\beta_{s,4}$)				-.897				-.747				-.517
				(.086)				(.083)				(.132)
Thai average ($\beta_{T,1}$)	.458	.437	.497	.403	.115	.079	.092	.157	.25	.249	.247	.405
	(.022)	(.023)	(.025)	(.023)	(.02)	(.02)	(.021)	(.016)	(.024)	(.032)	(.034)	(.027)
Thai average • number of observed American answers ($\beta_{T,2}$)		-.145	-.187	-.151		-.137	-.135	-.056		.038	.038	.022
		(.029)	(.029)	(.026)		(.023)	(.023)	(.019)		(.035)	(.035)	(.026)
Thai average • number of observed Thai answers ($\beta_{T,3}$)			.182	.144			.036	.118			-.006	-.001
			(.028)	(.025)			(.022)	(.018)			(.036)	(.027)
Thai average • accuracy index ($\beta_{T,4}$)				-.231				-1.406				-2.316
				(.091)				(.1)				(.154)
American average ($\beta_{A,1}$)	.25	.274	.237	.312	.822	.865	.866	.757	.571	.603	.601	.453
	(.018)	(.019)	(.02)	(.018)	(.016)	(.016)	(.017)	(.014)	(.026)	(.036)	(.038)	(.029)
American average • number of observed American answers ($\beta_{A,2}$)		.112	.135	.119		.192	.183	.084		.08	.08	.099
		(.024)	(.026)	(.022)		(.019)	(.019)	(.015)		(.033)	(.033)	(.025)
American average • number of observed Thai answers ($\beta_{A,3}$)			-.068	-.028			.043	-.023			-.011	.045
			(.025)	(.022)			(.019)	(.015)			(.031)	(.023)
American average • accuracy index ($\beta_{A,4}$)				1.128				2.153				2.833
				(.064)				(.082)				(.14)
Number of observations	1008	986	986	986	1052	1032	1032	1032	557	548	548	548

Notes:
(1) Regression standard errors are in parentheses.
(2) The regression in column (1) includes the data for questions 4 and 8 where subjects saw either 0, 5, 10, or 20 American and Thai answers.
(3) Regressions include dummies for the three question categories (meteorology, economic/political, and social/cultural).
(4) The regressions are estimated under the constraints:
$\beta_{s,1} + \beta_{A,1} + \beta_{T,1} = 1$ and $\beta_{s,j} + \beta_{A,j} + \beta_{T,j} = 0$ for j = 2, 3, or 4.