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REVIEW ARTICLE

Cultural Adaptations to Environmental Variability: An Evolutionary Account of East–West Differences

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Abstract Much research has been conducted to document and sometimes to provide proximate explanations (e.g., Confucianism vs. Western philosophy) for East–West cultural differences. The ultimate evolutionary mechanisms underlying these cross-cultural differences have not been addressed. We propose in this review that East–West cultural differences (e.g., independent versus interdependent self construal; autonomy versus harmony in values; hierarchical versus egalitarian relationships) result from social learning and individual learning as primary means to adapt to the local environment. Historical and contemporary evidence from multiple sources is reviewed that indicates smaller extents of environmental variability in East Asia including China than in Europe and North America, favoring social learning in the East and individual learning in the West. Corresponding to these different adaptive strategies, East–West differences stem from learning styles that differ between copying and rote memorization, on the one hand, and critical thinking and innovative problem solving, on the other hand. These primary cultural differences are correlated with such personality attributes as conformity, compliance, and independence that serve to facilitate social or individual learning. This and other cross-cultural and educational psychological research is reviewed as evidence to support our evolutionary explanation of why Eastern and Western cultures differ in the ways in which they do.

Keywords Evolution · Cultural evolution · Cultural adaptation · Social learning · Individual learning · East–West differences · Learning styles · Conformity · Compliance · Self-concept · Cross-cultural differences · Chinese

Cross-cultural research in the past 50 years has mainly focused on comparisons between Eastern and Western cultures, yielding a myriad of observations and findings of East–West differences. In educational psychology, these findings are relevant to issues ranging from achievement motivation (e.g., Hess *et al.* 1987), academic performance (e.g., Stevenson *et al.* 1985), and

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learning styles (e.g., Geary *et al.* 1996) to such social-personality concepts as conformity (e.g., Kim and Markus 1999) and compliance (e.g., Chen *et al.* 2003). Different theories focusing on different facets of the multidimensional concept of culture have been proposed to provide primarily proximate explanations of the observed East–West differences. For example, explanations are made according to the different value emphases (Schwartz 1999) or different social relationships (Hofstede 1980) that define a culture. In these explanations, differences in social conformity and compliance, for example, are said to exist because Eastern countries value hierarchy and conservatism or because they are collectivistic or group-conscious. Similarly, most Western countries are said to value autonomy and egalitarianism (Schwartz 1999) and individualism (Hofstede 1980). In another explanation based on the self-construal focus of culture, East–West differences exist because Asians see themselves as interdependent in relation to others but Westerners see themselves as independent individuals (Markus and Kitayama 1991). According to cultural cognitive theory (e.g., Nisbett *et al.* 2001), East–West differences in tolerance for ambiguity or dependence on context are due to one culture being holistic and dialectic and the other culture being analytic and deterministic (Nisbett *et al.* 2001). These are all proximate explanations. However, the ultimate questions remain why, for example, Eastern cultures are more collectivistic, interdependent, hierarchical, and dialectic, why Western cultures are more individualistic, independent, egalitarian and less context dependent, and why the two cultures are not the other way around.

The purpose of this article is to answer these questions by providing an ultimate account of the widely observed East–West differences. This account is based on the integration of theories of evolutionary psychology (e.g., Cosmides and Tooby 1989) and cultural evolution (Boyd and Richerson 2005). The common link joining these two theories is environmental variability, to which both genetic adaptation and cultural adaptation respond. We argue that, consistent with human genetic evolution that was driven by the environmental change vs. stability mainly of the East African rift valley during the Pleistocene and earlier, human cultures later evolved in response to environmental change vs. stability of a much larger habitat range covering the four continents. We employ the concepts of social learning and individual learning (Boyd and Richerson 2005) as two broad and overarching adaptive responses to different extent of environmental change vs. stability over time. Early humans also employed these same two broad learning or adaptation strategies. However, the narrow habitat range of the Eastern African rift valley prevented diverse cultural development. We demonstrate that the narrow habitat and long time span resulted in the evolution of human genetic blue print, including domain-specific and domain-general cognitive architectures that enabled learning and cultural building in the subsequent cultural evolution. There were individual differences but few noticeable group or regional or cultural differences. Human cultures and cultural differences started after *Homo sapiens* left Africa to encounter much larger and variable environment.

We define culture in this review as specific methods and as general styles by which groups of individuals use to adapt to the local environment that varies in terms of the specific environmental characteristics and in terms of the stability vs. change of these characteristics over time. We focus on the second dimension of environmental stability vs. change over time which evokes differential use of social vs. individual learning. The differential use of these two learning strategies in response to the relative change vs. stability of different local environmental characteristics resulted in cultures as we know today, including specific habits and customs and broader value and belief systems. For convenience, these cultural characteristics are often dichotomized into broad dichotomies of Eastern and Western cultures. Consistent with this cultural categorization, we argue that

East–West cultural differences result from differential use of social and individual learning representing two general directions in adapting to the relative changing vs. unchanging environmental characteristics. To the extent that human beings have employed mixtures of social- and individual-learning strategies, we argue that the human groups known today as Asians used more social than individual learning whereas human groups of European decent employed more individual than social-learning strategies. These adaptive differences arose because Europeans in the past faced relatively more variable environments than Asians, whose recent evolutionary history indicates relative environmental stability. East–West differences are the result of and, in turn, facilitate differences in the use of social versus individual learning from which the two cultures have evolved by adapting to different types and degrees of environmental variability. We support our hypothesis by reviewing evidence on environmental variability as the cause and, as outcomes, learning and instructional characteristics and personality attributes of the two regions that are traceable either to social or individual learning.

The remainder of this review is divided into five sections. We first present an evolutionary psychological account of how human mind works. This discussion delineates the evolved human cognitive architecture by which humans, from the Pleistocene to the present day, engage in learning and problem solving to adapt to different extent of environmental variability. The next section discusses methods by which humans learn and solve problems. These are social learning or copying and individual learning or innovation. The use of different mixtures of these two learning styles responds to the same environmental variability discussed in the first section and results in human cultures including East–West differences as we know today. These develop our hypothesis that East–West cultural differences stem from different uses of social and individual learning in response to different extent of environmental variability. The next three sections provide empirical evidence to support this hypothesis. We first demonstrate that East Asia has had a smaller extent of environmental variability compared with Europe and North America which saw more changes historically. The evidence is drawn from six areas of the environment—climate, governance, migration, war, agriculture, and pathogen. The last two sections present evidence on the outcomes. We show that the Eastern culture has historically adopted social-learning based educational practices that emphasize knowledge, memorization, and rote learning whereas the Western conception and practice concerning learning and instruction focus on innovation and problem solving that are traceable to individual learning (fourth section). Eastern cultures also value efforts over abilities and encourage conformity and compliance and social hierarchy all of which facilitate social learning or copying and Western cultures encourage independence, self-assertion, and personal pursuit of interest which enable individual learning or innovation (last section).

An Evolved Human Cognitive Architecture for Learning

Evolution is a continuing and continuous process. For convenience, however, researchers study and present evolution as if it is discretely demarcated by historical milestones. Human evolution, for example, is presented according to several qualitatively different stages. These include the arboreal *Ardipethecus* (approximately 4 mya) and *Australopithecus* stage (approximately 3 mya) which marks the ape-to-man transition, the stage of *Homo erectus* (approximately 1.8 mya), who seem to have completed much of the physiological transformation into modern humans, and the stage of *H. sapiens* (approximately 0.2 mya), who finally acquired the modern human brain. Similarly, human cognitive evolution is

represented by two seemingly separate processes—the gene-driven evolution that took place mainly during the Pleistocene era between 10,000 years ago and 2.5 million years ago and the cultural evolution of the past 10,000 years. The discrete approach to studying human evolution is also evident in the emergence of two separate fields of study, namely, evolutionary psychology (e.g., Cosmides and Tooby 1989) and cultural evolutionary studies (e.g., Boyd and Richerson 1985) that treat human cognitive evolution very much independently. The result is a discontinuous picture of human cognition as if the human species completed its genetic transformation and emerged from the Pleistocene ready and fully equipped to build cultures and civilizations. Once culture arose, human evolution took a different course that seems to bear little resemblance to or connection with the genetic evolution of the Pleistocene (Boyd and Richerson 1996). We argue in this section that genetic and cultural evolution follow the same principle, which is matching behavior to the environment. This evolutionary principle can be described by cultural evolution's distinction between social and individual learning, the outcome of which resembles or approximates what evolutionary psychologists describe as domain-specific versus domain-general cognitive adaptation. The relationship between these two evolutionary approaches is such that, whereas cultural evolutionists suggest ways and processes by which humans have learned to adapt to environmental changes, evolutionary psychologists focus on the cognitive outcomes of these learning processes. Below, we first present, in the remainder of this section, the evolutionary psychological account of how the mind works in terms of the outcomes of cognitive evolution during the Pleistocene. We then present, in the next section, the cultural evolutionary views on the ways in which humans, from our ancestral past to the present day, have learned to adapt to the environment.

Two cognitive systems

Different cognitive theories converge on the view that the working of the human mind encompasses two underlying systems. These have been referred to by different names, such as systems 1 and 2 (Kahneman 2003; Stanovich 1999), associative and rule-based systems (Sloman 1996), and experiential and rational systems (Epstein 1994). Despite differences in reasoning among these theories, the consensus view is that system 1 is heuristic based, its operation is effortless, and its outcome is approximate whereas system 2 is rule based, effortful, and nearly exact (Stanovich 1999). This view is consistent with the evolutionary account of how the mind works. According to evolutionary theory, system 1 consists of domain-specific computational modules and heuristics that evolved early and are species general rather than human specific. Likened to a Swiss army knife, they provide fast and frugal means of solving specific problems (Cosmides and Tooby 1992). System 2 represents domain-general cognitive abilities that rely on executive functioning and working memory (Evans 2003) in part to inhibit modularized system 1 responses when solving novel problems across domains (Geary 2005). In determining a "Jack of all trades" kind of solution to different problems, domain-general processing involves more brain activation and demands more brain energy. The processing demand in energy and effort also suggests that system 2 cognition must have evolved late, probably during the late Pleistocene era, as human-specific adaptations (Geary 2005). General intelligence is an example of the domain-general system 2 cognition, whereas Cosmides and Tooby (2001) coined "dedicated intelligence" to represent domain-specific system 1 modular computations.

Applying the biological concept of modularity and generality to human cognition suggests that, like other integrated parts of an organism, cognitive adaptations are subject to

the same natural selection processes whereby the extent of environmental variability either constrains or plasticizes the adaptive outcome. Evolutionary constraining processes are those "that limit the ability of the phenotype to evolve or bias it along certain paths" (Schwenk and Wagner 2003, p. 52). Plasticity refers to "the ability of an organism to react to an environmental input with a change in form, state, movement, or rate of activity" (West-Eberhard 2003, p. 34), and "phenotypic plasticity has evolved as an adaptive response to environmental heterogeneity" (Brakefield and Wijngaarden 2003, p. 288). In the context of cognitive evolution, environmental homogeneity–heterogeneity presents variant–invariant information patterns, the processing of which shapes cognition (Geary 2002; Tooby and Cosmides 1992, 1995). The system 1 modules are constrained, inflexible in solving problems outside the information patterns from which they evolved. These constrained cognitive modules or behavioral heuristics result from solving recurrent survival and reproductive challenges forming invariant information patterns or a lesser extent of environmental variability. Plasticity underlies system 2 executive functioning or general intelligence because it has evolved as an adaptive response to variant information patterns or a larger extent of environmental variability.

Effects of physical and social environment on cognitive adaptations

There are two major sources from which variant–invariant information patterns or different extents of environmental variability arrive. One is ecology, or the physical world in which humans reside. The three-dimensional structure of the world and gravity are unchanging features of life on earth that present invariant information for all animals including humans. These and other invariant information patterns about the physical world constrain the perceptual and cognitive systems, resulting in modular processing and knowledge clusters known as folk physics (see Geary 2002, for detailed treatment of folk knowledge and abilities). Visual perceptual properties (e.g., color and size constancy), spatial orientation abilities (e.g., sense of direction), and causal inference abilities (e.g., using a time sequence of events to determine cause and effect) are examples of modularized responses to these unchanging information patterns. Ecologically invariant information forms also arise from human interactions with other living things. The results of these interactions are folk biological modules used to process and represent the behavior and growth patterns of flora and fauna in the local ecology, especially in relation to foods and medicine (Geary 2002; Geary and Huffman 2002). The abilities to distinguish between animate and inanimate and between organic and inorganic things are examples of modularized responses to invariant biological forms of information. Biological and physical ecology also present variant information forms to plasticize cognitive adaptations. Climatic change in terms of glacial–interglacial variations, seasonal fluctuations, and changes due to natural disasters would create pressure for phenotypic plasticity of cognitive systems (Geary 2002). The increasing climatic fluctuations of the Pleistocene put special pressure on the development of plastic cognitive responses, as evidenced by the enlargement of brain cortex for most mammals (Jerison 1973). Throughout human evolution, migration has contributed to an increasingly large and variable habitat range, including an increasing variety of flora and fauna, and increasingly more complex interactions with them. In short, physical and biological ecology present both variant and invariant information patterns representing different extents of environmental variability, which lead to constrained versus plastic cognitive responses (see Geary and Huffman 2002, for a detailed treatment of how variant–invariant information patterns constrain and plasticize neural, perceptual, and cognitive systems both within and across knowledge and problem-solving domains).

The other source of invariant–variant information by which to constrain or plasticize the brain is social interaction with conspecifics. As frequently cited from Alexander (1989), once our ancestors achieved ecological dominance, the primary pressure that drove evolution was the pressure to reciprocate, cooperate, and compete with one another. Social dynamics represents a source of environmental variability by generating unpredictable social situations which would favor the evolution of plasticity of the brain (Geary 2005). The dynamics of competitive social interactions lie in the fact that the objects of an interacting actor are other actors who constantly adjust their responses to out-compete the first actor, resulting in an "arms race" that constantly change the game strategies. There is much pressure to evolve cognitive plasticity to handle the variable information patterns created by social interactions. Known as human coalitional psychology (Tooby and Cosmides 1988) and social and political intelligence (Alexander 1971, 1979), this socially derived domain-general ability far exceeds that derived from dealing with the physical world. Much of the human brain size was added in the last 200,000 years due to social interaction and competition (Humphrey 1976). Cooperation, competition, and coalition among human conspecifics exert the strongest pressure on brain development and human intelligence (Alexander 1989; Dunbar 1998). Cognitive development, including the solving of mathematical and physical problems, has central significance in social competition (Alexander 1989).

Within this large realm of social dynamics, certain themes exert constant pressure to evolve domain-specific heuristics. The social contract module (Cosmides 1989) is an example of a constrained cognitive response system that evolved through the recurrent need to detect cheaters in human interactions. Cosmides showed that people have difficulties in understanding and correctly using conditional logic reasoning in the form—"if P, then Q and, therefore, if not Q, then, not P." People have difficulties even when this conditional statement is put into a familiar context rather than in abstract forms (e.g., when Harvard students were presented with "if a person goes to Boston, she takes the subway," most of them did not see the issuing logic that "if a person takes a taxi (not the subway), then she is going to Arlington (not Boston)." However, when such a problem is presented in a "social contract" form (e.g., to verify the rule that "if drinking beer, one must be 18"), people correctly understand the issuing logic, which is to check for cases in which the age is "not 18." This result has subsequently been replicated (e.g., Cosmides and Tooby 1992; Brown and Moore 2000). A social contract in the form of "if receiving a benefit, one must pay a cost" has been selected that provides a heuristic shortcut to solve conditional reasoning problems because honoring social contracts and detecting cheaters have been recurrent issues in our social interaction and reciprocal cooperation (Cosmides and Tooby 1992).

Another example is kith–kin rationality (Wang 1996). One invariant information pattern has arisen from our encounters with in-group/out-group relationships as a recurrent problem. For over a million years, we lived as small bands of hunters and gatherers. The band size has been estimated to be between 100 and 150 (Dunbar 1993). The estimate has been supported by evidence ranging from contemporary work unit size and contemporary and historical military unit size to tribal size among contemporary hunter–gatherers (Dunbar 1993). For hundreds of thousands of years, we have adopted pair bonds or the monogamous mating system, which results in nuclear families with sizes similar to those of modern-day extended families. The invariant information pattern resulting from these constant group sizes shaped the human mind to distinguish between in- and out-groups. Wang used "kith–kin rationality" to denote this special mental algorithm that is modularized to process in-group/out-group information (Wang 1996, 2006, 2008; Wang and Xin 2002). Human kin rationality is likely to be activated when encountering a small

group of fewer than ten individuals, whereas groups of approximately 100 people are likely to activate kith rationality. Both kinds of groups are in-groups comprised of either kin or friends. In a series of experiments, Wang demonstrated how priming these two group sizes might change our decision making. Wang tested kith–kin rationality using the Asian disease problem (Tversky and Kahneman 1981). When group size was set to six, representing kin, or 60, representing kith, the framing effect (i.e., a risk-taking decision depends on whether the positive or the negative outcome of the decision is emphasized in presenting the decision-making problem) disappeared. These results showed that group size serves as a cue in activating kith–kin rationality, which has been modularized to process the invariant information about in-groups and out-groups. Recent work also suggests an episodic memory bias in temporally distancing unpleasant past experiences involving kin relative to those involving non-kin (Lu and Chang 2009).

Two Ways to Learn and to Solve Problems

The above describes the outcome of human cognitive adaptations in response to variant–invariant information patterns of the Pleistocene—the constrained domain-specific system 1 and plastic domain-general system 2. The contingent condition by which these two cognitive systems have been fashioned is environmental variability. This section focuses on the processes and methods by which humans respond and adapt to variant vs. invariant information patterns resulting from different types of environmental change over time and space. This is a process about learning which is mapping behavior to the environment and takes the form of social and individual learning (Boyd and Richerson 2005). The results are cultures and cultural differences as we observe today. Learning takes place from the beginning of life and drives genetic as well as cultural evolution. However, human cultures and cultural differences only became relevant when humans left Africa to encounter vast environmental variability which exerts similar selection pressures on groups of individuals sharing similar local environmental characteristics and similar extents of environmental variability over time. In terms of social and individual learning strategies, when the mapping of group-varying behaviors to group-varying environments is differentially practiced by populations of individuals at certain points in time and, when this differential learning practice is associated with the geographic distance between Asia and Europe, the results are Eastern and Western cultures and East–West cultural differences.

Genetic and cultural adaptations

When the environment hosts generation after generation of individuals with the same adaptive problems, natural selection favors system 1, special-purpose, domain-specific cognitive and behavioral adaptations fashioned within a narrow range of ecology. A narrow ecological range is true for most animals (other than humans), who, in turn, become experts within their limited habitat range. For example, pandas live in a narrow range of less than 4,000 square miles in Wolong Mountain. Their limited ecology also includes one kind of food—umbrella and arrow bamboo leaves—and a simple foraging technique, i.e., grasping the leaves with specially designed paws. Koala bears live on eucalyptus trees and have developed eucalyptus-expert digestive system that takes up to 2 weeks to extract the minute nutrients from the harsh plantation. Large predators like lions and wolves have larger ranges compared with pandas and koalas. However, as far as subsistence is concerned, their ecology shows little variability. They hunt on smaller prey using limited but expert preying

techniques consisting mainly of ambushes, attacks, and chases. Consequently, their problem-solving adaptations are limited but specialized. Chimpanzees have wider ranges of subsistence means but their food procurement consists mainly of collected foods (e.g., distinguishing ripe from unripe bananas) rather than on extracting or hunting for foods, which take more processing (Kaplan *et al.* 2000). All these animals including chimpanzees have quite limited system 2 cognitive adaptations compared to humans. Human beings have evolved the most sophisticated system 2, which encompasses a wide-ranging ability to learn and to solve new problems. This unique cognitive development is the result of human beings occupying the widest and most variable ecological reach across species. Humans could not have survived the variable and fast changing environment on domain-specific system 1 skills alone. Humans have relied on system 2, i.e., learning to adapt to the variable environment, more than have any other animals.

However, learning is not unique to humans but represents the basic adaptation principle governing all animals and organisms. The principle is mapping behavior to the environment (Boyd and Richerson 2005). "Learning mechanisms generate contingent behavior based on "observations" of the environment" (Boyd and Richerson 2007, p.32). This process of mapping behavior to environment includes specific methods by which humans and other animals learn to adapt to specific environmental characteristics. It also includes general styles by which humans and other animals learn to adapt to different extents of change of these environmental characteristics over time (and space in terms of migration). When talking about human cultures, we focus on the latter styles of adapting to different environmental changes, the result of which are cultures and cultural differences (Boyd and Richerson 2005). Learning and culture building help to shape the selection process in that organisms, especially human beings, take cues from the information patterns of the environment to actively learn and copy what is adaptive in the local environment. Although cultures and learning styles cannot be genetically transmitted, the phenotypes that benefit from such cultures can. As a consequence, genetically similar individuals behave differently in different cultures (Boyd and Richerson 2005). The same learning takes place, feeding the gene-driven selection of the systems 1 and 2 cognitive adaptations. Cultural adaptations and the gene-driven cognitive adaptations act together rather than separately (Richerson and Boyd 2001). Human cognitive adaptations provide the species with the necessary tools to learn and to adapt faster and better to the changing environment (Richerson and Boyd 2001). These are mainly domain-general cognitive abilities but also include domain-specific heuristics which are often employed as shortcuts of learning. It can be argued that cultural adaptations run parallel to genetic adaptations and many of the genetic adaptations are selected not because they bring about direct fitness gains but because they aid cultural adaptations which in turn bring about direct fitness gains.

However, cultures and cultural differences emerged mainly after but not before humans left Africa. The narrow habitat range of the East African Valley and the long span of time of Pleistocene and earlier led to the evolution of a genetic blueprint, including the domain-general and domain-specific cognitive architectures, which differ across individuals but not across groups or regions. Thus, the differences between today's Asians and Westerners as two groups are due mainly to cultural adaptations to different environments after humans left Africa, whereas these peoples share the same genetic blueprint established in Pleistocene Africa. Another factor contributing to fast growing cultures and cultural differences is human acquisition of language, which also seems to have occurred after, rather than before, humans left Africa. One of the strongest pieces of evidence for the emergence of human speech comes from DNA dating of a mutated region of the FOXP2 gene that is responsible for speech production (Enard *et al.* 2002). The estimate is that this

mutation was fixed in the human population between 100,000 and 150,000 years ago, corresponding to out of Africa migration by *H. sapiens*. Anthropological and anatomic data put the beginning of human spoken language at a similar time, i.e., between 100,000 and 200,000 years ago (Bickerton 1990). Aided by language, culture allows invention and transmission of solutions for adapting to fast changing environments far more efficiently than genetically inherited adaptations. Two specific ways to achieve cultural adaptation are social and individual learning.

Individual and social learning and cultural differences

Logically, there can only be two ways to solve a problem when it occurs. One is to figure out a solution by oneself, and the other is to copy or imitate what others do in similar situations. The contingent condition is the extent to which situations are similar enough to befit the solution. These two ways of problem solving are individual learning and social learning, the activation of which depends on environmental variability (Boyd and Richerson 2005). According to Boyd and Richerson (1988), social learning is defined by faithfully copying the behavior of other individuals in the population, whereas individual learning is defined by acquiring the behavior through trial and error. Individual learning is the result of the interaction between the genetically inherited learning mechanism of an individual and the local environment. As such, individual learning takes place individually, independent of other individuals in the population. Social learning takes place in the form of social interaction among individuals in the population. Individual learning does not lead to cultural transmission whereas social learning does.

Individual learning has the potential costs of making errors or failing to solve the problem. However, one assumption in deriving their mathematical model of cultural adaptation is that all individuals bear some cost associated with individual learning, regardless of whether they ultimately acquire the behavior by social or individual learning (Boyd and Richerson 1988).

Clearly, individual learning is less efficient than social learning. Trial and error take up time and energy that could otherwise be used for other fitness-enhancing activities. Failing after inaccurate learning incurs more severe fitness costs, which social learning can avoid. Mathematical models and computer simulations have tested and confirmed the intuition that social learning is adaptive because it avoids trial and error, whereas individual learning is error prone (Boyd and Richerson 1985, 1995; Rogers 1988). However, the adaptiveness of social learning depends on the probability that people live in the same environment from which their socially learned solutions are derived. If the environment changes rapidly, either vertically, from one generation or cohort to another, or horizontally, due to migration among habitats, faithful copying of an existing adaptive behavior might not be adaptive to the changing environment. Individual learning is needed to match adaptive behaviors to the changing environment. In a changing environment, the cost associated with trial and error of individual learning thus outweighs the efficiency of social learning, which might result in futile imitation. When the environment is relatively stable either vertically or horizontally, copying is more effective and efficient than trial and error (Boyd and Richerson 1983, 1985, 1988).

Humans and other animals switch between individual and social learning depending on environmental change (Kameda and Nakanishi 2003; Mesoudi 2008). Individual learning is employed more often when the environment changes rapidly (McElreath *et al.* 2005) and social learning is employed when individual trial and error becomes relatively costly in an unchanging environment (Mesoudi 2009). Because environmental variability normally

affects a group of individuals living in the same environment in a similar fashion, this facultative switching in response to environmental change may take place at the group level (Henrich and Boyd 1998), resulting in population differences in their general approach to problem solving. At any given time, some groups or populations can be defined as more individual than social learning oriented, whereas others are more socially than individually oriented learners. We argue that, when individual and social learning is differentially practiced by populations or groups of individuals, the results are cultures and cultural differences. This cultural development is different from diffusion of a specific cultural variant such as a particular skill or technology which is a form of social rather than individual learning. We refer to how a particular environmental change vs. stability should evoke similar social or individual learning from the individuals sharing the same environment. This group phenomenon itself is neither social nor individual learning. Corresponding to the East–West cultural differences as we observe today, we argue that Asians, as compared to Westerners, must have experienced a relatively smaller amount of environmental change over time and have responded with more social and less individual learning. Europeans, in contrast, must have responded with less social and more individual learning in response to greater environmental change patterns within Europe. The results are East–West cultural differences as we know them today.

Within this theoretical framework, we present below three sets of evidence to support our evolutionary account of East–West differences. We first present evidence showing that Europe, as the geographical origin of Western cultures, has had greater environmental variability than has Asia, which has experienced slower environmental change. The evidence is drawn from six areas including climate, governance, migration, war, agriculture, and pathogens. We then present evidence to show that more Asians than Westerners adopt social rather than individual learning strategies as shown in learning and instructional activities. Finally, we demonstrate that Asians and Westerners also differ in certain personality attributes according to the distinction between individual and social learning to facilitate the two learning strategies.

Historical and Contemporary Evidence of Environmental Variability of East and West

Latitude and climate

Higher latitude has been shown to indicate climate and other environmental variability (e.g., Ash and Gallup 2007). The climate in Europe (36°N to 63°N in latitude) is thus more variable than that in China (18°N to 45°N). Firstly, rainfall and temperature become more variable over the course of a year and extreme cold and drought are more severe as the geographic location moves away from the equator toward the poles (Cashdan 2001; Stevens 1989). Annual variations in temperature and weather patterns in Europe also mean more severe natural disasters in Europe than in China. For example, 19 of the worst famines and droughts in recorded history happened in Europe, whereas China has only experienced 9; more ice storms and snowstorms are recorded in Europe than in China; and there have been more earthquakes in Europe than in China (Davis 2002). During the period between the sixth and sixteenth centuries, there were more severe winters in Europe than China. Excluding the fourteenth century, Europe had, on average, 19 severe winters per century, whereas China had an average of 16 severe winters per century (Chu 1931). Luterbacher *et al.* (2004) plotted the average temperature of Europe for each of the last five centuries. Wang *et al.* (2007) used the same method to plot China's century

temperature over the past ten centuries. A comparison of the two plots shows more variation in the European than the Chinese data.

Because Earth is tilted at 23°, the duration of daylight at higher latitudes is also more variable throughout the year than it is at lower latitudes. In many European countries, the sun remains above the horizon at 10:00 p.m. or later during the summer and sets as early as 4:00 p.m. in the winter. At 50°N, representing many European countries, the longest duration of daylight in the summer is 18 h and the shortest in the winter is 6 h, yielding a difference of 12 h across the year. At 30°N, covering many Chinese territories, the longest and shortest durations of daylight are 14 and 10 h, respectively, yielding a difference of 4 h. Related to duration of daylight, insolation, or the solar radiation energy received on a given surface area, varies throughout the year. Insolation variations increase with latitude. Deviations from the present-day annual mean insolation over the last 200,000 years are larger at high latitudes than at low latitudes (Loutre *et al.* 2004). For example, at 80°N, the maximum deviation over the last 200,000 years is 14 W per square meter, whereas at the equator the maximum deviation is only 3 W per square meter (Loutre *et al.* 2004). This means that on a long time scale, China, occupying lower latitudes, has a more stable insolation level than Europe, located at higher latitudes. Finally, because most hominid and human evolution took place in Africa close to 0° of latitude, high latitude by itself represents environmental novelty and variability deviating from the human evolutionary environment. In sum, the higher latitude of Europe brings about more changing environment than the lower latitude of China.

Political unity–plurality

Forms of governance and political systems contribute to social environmental variability. Since the establishment of the Qin Dynasty in 221 BC, the land comprising China has been ruled by a single centralized government (Garraty and Gay 1972; Qi 1985; Yang 1998). In its 2,000 years of unity, China's territories have remained very much the same at its present 9,600,000 km^2, with the exception of the Yuan Dynasty (1,271 to 1,368 AD), which covered much larger territorial holdings (Shi *et al.* 1961). Pluralities and separations have been infrequent and short-lived in contrast to the long Chinese history of unity. The separation periods include 200 years of the Warring Period (403 to 221 BC) before the unification of the Qin Dynasty, 60 years of the Three Kingdoms Age (220 to 280), 150 years of the Southern and Northern Dynasties (420 to 589), and 70 years of Five Dynasties and Ten Kingdoms (907 to 979 AD). These periods total only 480 years in China's 2,000 years of unity. Other than these temporary separations, "there was always more continuity than change in China's bureaucratic institutions, from the establishment of the Qin (the author originally wrote Ch'in in Wade-Giles) Empire in 221 BC until its fall in AD 1912." (Garraty and Gay 1972, p. 125). Political unity has been accompanied by language unity. For most of its history and in most of its territories, China has maintained a single written language.

In Europe, however, centralized governance has been much shorter-lived and has ruled smaller areas than in China. The Roman Empire lasted 500 years, from 30 BC to 476 AD Its geographical area in Roman times was estimated to be between 2,750,000 and 5,000,000 km^2 (Taagepera 1979). After the division of the Roman Empire into two halves in 395 AD and the eventual collapse of the western half of the Roman Empire in 476 AD, in the succeeding 1,600 years until the present, Europe has been divided into many different political entities (Koenigsberger 1987). The number of these has ranged from 200 duchies, principalities, and city-states during the Middle Ages to 50 countries in the present day (Tilly 1990). On a land area similar to China's in size at 10,180,000 km^2, there are over 50

different written languages. Thus, by governance plurality and language diversity, Europe has had much more changing and variable environment than China in the past 2,000 years till the present day.

Migration

Migration, which has been an impetus for the ever changing and increasing range of human habitats (Richerson and Boyd 2008; Boyd and Richerson 2009), provides another important source of environmental change and variability. From about the eighth century BC to the sixteenth century AD, the frontier zones separating the middle kingdom of China from its northern nomads remained virtually unchanged (Bell-Fialkoff 2000). During the same period in Europe, the frontier zones separating its high civilizations from underdeveloped civilizations have periodically expanded, suggesting successive migration and population movement (Bell-Fialkoff 2000). Throughout Chinese history, different dynasties, including earlier periods of the current government, practiced strict resident registration systems restricting population movement (Jiang 2001). For instance, during the Ming Dynasty (1368–1644 AD), residents had to apply for official leave certificates to travel more than 30 miles away from home (Jiang 2001).

In Europe, citizens, merchants, and craftsmen traveled much more freely, without restrictions by a powerful centralized authority. Europe's political fragmentation also facilitated outward exploration by seafarers, merchants, and members of the clergy, leading to the discovery and settlement of other continents, including the New World. This outbound exploration started in the fifteenth century and continued until the end of World War II, lasting 500 years (McNeil 1984). In contrast, Chinese navigation, at its historical peak during the Ming Dynasty, lasted less than 30 years (1405–1433 AD). There was also no follow-up migration or population settlement. Overseas settlement and colonization by the Europeans later brought about influxes of immigrants from the colonies, increasing population diversities in Europe. China and Asian countries therefore also lack this kind of inflow of immigrants. According to 2005 statistics, 0.4% of the population of East Asia lived outside their country of birth, but 9.3% of Northern Europeans, 7.2% of Southern Europeans, 11.9% of Western Europeans, and 12.9% of Americans lived abroad (United Nations 2006). North America also enjoys the highest net migration rate, at 4.2 migrants per 1,000 inhabitants annually between 2000 and 2005. The net migration rate for the same period was negative in Eastern Asia at −0.2. It was 2.4 in Northern Europe, 4.1 in Southern Europe, 1.9 in Western Europe (United Nations 2006). Population migration provides lateral environmental variability which has been more changing in Europe than Asia.

Warfare

War adds to environmental change through increased population movement, which includes mobilization of young men to fight, emergence of refugees, and postwar population redistribution. For example, World War II saw the mobilization of 22% and 17% of the populations of the former Soviet Union and the USA, respectively (Neiberg 2001). Within 15 years after the war, more than 12 million Germans were redistributed to West Germany from other countries (Peach 1997). Environmental change has also been realized through the utilization of new military weapons and technologies and diffusion of the ideas and cultures of the victorious nations. Nuclear technology, rocket launching and the later development of space travel, as well as many medical breakthroughs, including the discovery of penicillin, are all direct results of World War II. Throughout history,

more wars have been fought in Europe than in Asia. From 1816 to 1965, Europe saw 144 interstate and extra-systematic wars whereas 28 of these two types of wars have taken place in Asia (excluding the Middle East) (Singer and Small 1972). The number of war-engaging months for this period was 2514 for Europe and 737 for Asia (Singer and Small 1972). Another data source shows that, among a total of 177 major military conflicts that happened in the world between 1648 and 1989 (Holsti 1991), Europe had 97 wars whereas Asia had only 26, most of which broke out after 1945, and many of which involved Western nations. Other statistics lead to similar conclusions. According to Gochman and Maoz (1984), as many as 261 armed confrontations occurred between 1816 and 1976 in Europe. During the same period, Asia had 140 military disputes, and 99 of them occurred after 1945. According to Neiberg (2001), Chinese and Asians preferred defense to offense, as shown by the centuries of effort expended in building the Great Wall whereas Western civilizations advance through exploratory and expansionary means. These different military philosophies and actions drive more environmental changes in Europe than in Asia.

Agriculture

As a land-based, home-bound, family production mode, agriculture constrains population movement. By following the seasonal and climatic changes, this production mode also limits self-generated environmental changes, such as those from industrial production cycles that are independent of weather changes. China has been an agricultural or horticultural state throughout its history whereas Europe has practiced nomadic pastoralism and dairy farming alongside agriculture (Hu 2000). The Industrial Revolution brought about further subsistence diversity in Europe, whereas China continued its agricultural existence. For example, the urban population ratio in China (for cities of at least 10,000 inhabitants) was 5% during 1368–1644, 6% during 1644–1736, and 4% in the early nineteenth century. In Europe, the urban population ratios stood at 8%, 9%, and 10%, respectively, for these three time periods (Broadberry and Gupta 2006). By the seventeenth century, the rural population in Europe was reduced to 54% of the total population, with an upper limit of 64% in Spain and a lower limit of 36% in England (Broadberry and Gupta 2006). Up until 1949, peasants represented at least 90% of China's total population (Zhang 1991). Agricultural production in China has also been family based throughout its history. Such popularity of the family business propels a culture that depends on land and family traditions rather than mobility, trade, and innovations (Zhang 1991). Ancient European agriculture production practiced a manor system that promoted divisions of labor, trade, and the eventual development of a commodity economy (Allen 2000). Overall, China's reliance on agriculture and a family-based production mode facilitated the continuation of centralized despotism for over 2,000 years. In contrast, Europe has seen more diverse subsistence modes that covary with its population movement, trade, and political pluralities.

Pathogens

Pathogens affect environmental variability and human behavioral response in two ways. First, pathogen level is expected to be negatively correlated with environmental variability. A habitable environment must have a pathogen level that does not exceed the human physical immune threshold. Within the threshold of human habitability, a high pathogen load means that the pathogenic level is chronically closer to the

threshold and thus the pathogenic distribution, which is assumed normal like most naturally occurring events, thus has a narrower range limited by the human immune threshold. A low pathogen load, on the other hand, means the pathogenic spread is chronically farther away from the threshold and is potentially more variable. Within this logic, high pathogen load is associated with low environmental variability, which should elicit social learning as a behavioral response. Secondly, pathogen itself presents an independent drive for social learning because the cost of trial and error may be injury or death. Existing studies seem to support these two hypotheses. Many studies have found that pathogen prevalence is negatively correlated with absolute latitude (Cashdan 2001; Guernier *et al.* 2004). Specifically, China (18°N to 45°N) has been found to have higher pathogen prevalence than Europe (36°N to 63°N) by both historical and contemporary measures of pathogen prevalence (Fincher *et al.* 2008). In this study, the historical pathogen prevalence index for China was 1.00 (a standardized score representing a value one standard deviation above the mean). The 31 European countries and regions scored between −1.17 and 0.56. The contemporary pathogen prevalence index for China was 37 whereas the European aggregate score was 26.5 (World M=31.32; SD=6.49). These data suggest that pathogen load may be another factor contributing to the various observed differences between China and Europe that are potentially linked to advantages of social or individual learning.

The above presents some of the historical environmental characteristics of today's Asia and Europe. Asia, and particularly China, is characterized by relatively stable climates, centralized government and unified language, predictable agricultural subsistence that is confined to the land and cycles with the seasons, and stable populations relatively undisturbed by war, disease, or migration. These environmental characteristics contribute to relatively invariant information patterns that are best dealt with through social learning by matching similar solutions to recurrent challenges. Europe and Western cultures have faced more variable environments that include relatively variable climates, decentralized governance and languages, combinations of agricultural and pastoral subsistence, and more social changes through war, migrations, and such revolutions as the Renaissance and the Industrial Revolution. In such a changing environment, there is a greater chance for new and unique challenges to arise, the solving of which relies on trial and error or individual learning rather than copying existing solutions.

In this review, we did not distinguish the primary physical and natural environment from the man-made subsistence, social and political environment some of which are cultures in response to the primary environmental characteristics. Culture, which is an adaptive response to environmental change vs. stability, has an additional perpetuating effect in contributing to the initial environmental change vs. stability in the same direction in which the adaptive strategy is evoked in the first instance, creating cascade social and historical effects. For example, agriculture as an adaptation to a temperate and predictable climate adds to the environmental stability by reducing population movement which helps to sustain the local social structure and status quo, contributing to a long lasting and unchanging governance and stable ways of life over generations. The resulting social and political stability in turn reinforces social learning to adapt to a further stabilized environment. In the following, we review the relevant educational psychology literature to examine the hypothesis that East–West cultural differences stem from the use of social versus individual learning. Asians are primarily social more than individual learners who adapt well to a relatively unchanging environment. Westerners adopt individual more than social-learning strategies to cope with more rapid environmental changes.

Eastern Social and Western Individual Learners

Attitudes toward learning and teaching

How a cultural group currently thinks about learning may help to understand the learning strategies that gave rise to the culture. Li (2003) examined differences in cultural beliefs about learning between American and Chinese students. Participants were asked to generate a list of learning-related terms in their native language. A large majority of the learning terms generated by American students were about thinking, mental process, and inquiry, whereas few (9%) of the Chinese terms touched on such concepts. Instead, Chinese students defined learning and learning methods in terms of memorization, copying, and following instructions. Chinese students especially considered as desirable extraordinary memory abilities, such as "can even recite something backwards; prose flows from the mouth; (be) a living dictionary." American students, however, defined learning in terms of such concepts as "free thinking," "challenging assumptions," "critical thinking," and "learning by doing and hands on." Clearly, the two cultural groups have different understanding about learning in a direction consistent with the distinction between individual learning and social learning. Chinese students also ascribed effort, hard work, and persistence to learning, making such comments as "always have a book in one's hand," "put one's heart into one's study," "if you work at it hard enough, you can grind an iron rod into a needle," and "keep on learning as long as you live." American students tended to regard learning as fulfilling curiosity and interest, making reference to "interest," "travel," and "adventure" (Li 2003). American students also showed willingness to "challenge assumptions," whereas Chinese students were more deferent towards authorities, making such statements as "respect one's teachers and value the principles" (Li 2003).

These cross-cultural differences in learning-related understandings and expectations are consistent with the cultural evolutionary prediction about Asian and Western cultures differing between social and individual learning. The cultural evolutionary explanation about East–West learning differences also coincides with existing cross-cultural predictions about learning. According to Hofstede (2001), the distinction between individualistic and collectivistic cultures can be defined by the extent to which students show respect to the teacher in classrooms, the extent to which the teacher has control over the class, and the extent to which students speak up in class. Other researchers have reached similar conclusions. According to Chan (1999), Asian students treat teachers as guiding authorities, mentors, and as sources of wisdom. Students therefore rarely question or challenge teachers or their teaching. Newell (1999) observed the tendency among Chinese students to seek definitive answers from experts and teachers. Asian students are overall more positive about their teachers than their Western counterparts. Using a questionnaire to measure teacher-student interactions, Rickards *et al.* (1996) found that students from an Asian cultural background rated their teachers more positively by giving high scores on leadership, helping, understanding, and being responsible. In a similar survey (Woodrow and Sham 2001), British-European students were found to describe their teachers as moody, annoying, and boring, although they also thought their teachers were intelligent. In the same survey, British-Chinese students were again more positive about their teachers, describing them as helpful, caring, and sensitive. This kind of deference and respect Asian students show toward their teachers should facilitate compliance-based social learning.

Memorization and rote learning

Many studies report Asian students' reliance on memorization in learning. Zhang and Dai (2004) observed that the learning and teaching of mathematics in China emphasize

memorization. "Pupils must memorize and recite the 9×9 multiplication table when they are 8–9 years old" (Zhang and Dai 2004; p. 125). Students are required to "recite angle-sum formulae, double-angle formulae and half-angle formulae and the formulae for changing a trigonometric sum to a product and vice versa" (Zhang and Dai 2004; p. 126). In response to the question, "Do you prefer subjects where you have to memorize facts or subjects where you have to solve problems or make up your own mind?" 71.8% of British-Chinese pupils 13 to 17 years old preferred the subjects requiring memorization, whereas only 6% chose the subjects where they need to make up their own mind (Woodrow and Sham 2001). British-European pupils exhibited almost equal preferences for "solving problems" and "making up their own mind," whereas they favored memorization the least. In response to the question, "I learn best when I memorize things by heart," 82.6% of British-Chinese versus 26.5% of British-European pupils agreed that this statement best described their learning situation. Similarly, 83.3% of British-Chinese and 30.5% of British-European students preferred "learning facts and details about things rather than trying to understand them." Most of the British-Chinese respondents (90%) preferred teachers who prepared notes for them. Conversely, only 10% of the British-Europeans preferred this kind of teachers, whereas 80% of them liked teachers who encouraged them to have discussions in class (Woodrow and Sham 2001).

Marton *et al.* (1996) reported similar observations of Chinese students who perceived learning primarily as acquiring knowledge rather than making discoveries. In another survey of Asian students studying in Australia (Wong 2004), students from Malaysia and Vietnam reported that they had to rely on memorization to do well on exams. These and other Asian students also described learning in their home countries as being passive and teaching as spoon-feeding. They equated Australian learning methods to critical thinking, problem solving, and relying on one's own opinions (Wong 2004). Dahlin and Watkins (2000) compared Hong Kong and German secondary school students in their use of recitation as a learning method. Hong Kong students (90%) were asked to recite texts by heart in school more often than German students were (50%). The majority (60%) of Hong Kong students believed that "repetition plus attentive effort can lead to new meaning," whereas just 33% of German students thought the same. German students saw repetition as an exercise of the brain and as preparation for real studies rather than as part of learning itself (Dahlin and Watkins 2000). In another study, Watkins (1996) found that memorization played a role in three out of four steps of Hong Kong students' learning strategies. These East–West differences in learning strategies parallel those predicted by the distinction between individual and social learning.

Similar cross-cultural differences in learning and solving basic arithmetic problems are observed among young children. According to Geary (1994), young children across cultures use a combination of strategies to solve simple addition problems. These include the use of manipulatives, finger counting, verbal counting without manipulatives, derived facts, and fact retrieval. The last strategy is memorization by directly retrieving answers from long-term memory. Children who use this strategy generate answers quickly without counting. These children report that they just remember the answer or know it by heart (Geary 1994). Geary and colleagues compared the use of these strategies by American and Chinese kindergarten and primary school children who were tested twice 6 months apart on single-digit addition problems (Geary *et al.* 1996). During Time 1 testing in kindergarten, American children relied more heavily on finger counting and retrieval strategies than Chinese children, whereas Chinese children used verbal counting and finger strategies (e.g., looked at their fingers but did not count them) more frequently than their American counterparts. In the second testing 6 months later, more Chinese children

used fact retrieval than American children, who continued to use a combination of finger counting and retrieval. Comparing Times 1 and 2, response time decreased for the retrieval strategy among Chinese but not American children. Similarly, Chinese first graders in both testing sessions used retrieval much more than their American peers, who relied mainly on finger counting and verbal counting. Chinese second and third graders almost exclusively used the retrieval strategy, whereas the American children continued to rely on a combination of retrieval and counting. American children's error rate of retrieval was higher than Chinese children's in all age groups at both times of testing. Clearly, Chinese children use more learning strategies predicted by social rather than individual learning.

Teaching environment and teachers

The observations that Chinese children shifted their strategy from counting to retrieval after half a year of kindergarten and that Chinese students relied on retrieval increasingly more from first grade to third grade also shed light on the impact of the teaching method, which in itself is conducive to social rather than individual learning. Mathematics teaching in China, for example, seems to emphasize rote learning (Zhang and Dai 2004), and schools strive to adopt the same rather than different teaching methods (An *et al.* 2004). In a study comparing mathematics teaching and learning between American and Chinese middle school classrooms, Cai (2005) found that whereas American teachers expected students to solve problems using whatever method they could, Chinese teachers only encouraged algebraic approaches to solving mathematical problems. American teachers adopted varying methods and activities to encourage students to think on their own whereas Chinese teachers used the same kinds of activities and consistently emphasized learning procedures and concepts (Cai 2005). Other researchers have also found the American teaching method to foster creativity and critical thinking whereas the Chinese teaching method is believed to create consistency and uniformity (An *et al.* 2004). Cai (2005) asked Chinese and American primary school teachers to write an introductory lesson on the same topic. The Chinese lesson plans were "detailed and incredibly similar." Eight of the nine lesson plans even used the same example to illustrate the concept to be taught (Cai 2005). The American plans looked like outlines with "extremely varied content."

In fact, the policy of most Chinese primary and middle schools is to ensure standardization and uniformity not only in the curriculum but also in teaching and preparing to teach (Chang 2003). A "teaching preparation group" is used in most Chinese schools in which teachers of the same subject matter follow the same teaching plans and prepare their lessons together. Under this system, veteran teachers also take on inexperienced teachers as apprentices to help them to conform to common instructional plans (Paine 1997). This system is consistent with the social-learning principle by which young teachers learn or copy from older teachers and students eventually learn or copy the same information from their teachers. Also consistent with the social-learning origin, learning in Asian cultures consists mostly of students obtaining information from teachers. In practice, Asian teachers tend to give students far more instruction than Western teachers do (Stevenson and Stigler 1992). Through classroom observations in Taiwan and the USA, Stevenson and Stigler (1992) found that 90% of classroom time in Taiwan was spent with the teacher giving instructions or leading student activities, with only 9% of the time having no teacher-led activities. In American classrooms, however, children are led by teachers only 46% of the time, with 51% of the classroom time consisting of "no instruction" time.

In Chinese and Japanese primary schools, students were paying attention to the teacher's instruction during about 85% of the class time, whereas in American classrooms, instruction represented 60% of the class time (Stevenson and Lee 1995). Perry (2000) drew the same conclusion from his repeated observations of American, Taiwanese and Japanese primary schools. During each of four observations, the average number of explanations the teacher provided to the students was 3.35 in Japan, 2.90 in Taiwan, and 1.50 in the US. Lan *et al.* (2009) reported similar results by comparing teaching activities in Chinese and American classrooms. Teacher-directed large-group activities took up 93% of the Chinese students' class time. Similar teaching activities accounted for 58% of American students' class time (Lan *et al.* 2009).

In addition to teaching methods, teachers' attitudes also reflect individual or social learning as a cultural origin. Consistent with social-learning traditions, Asian teachers and schools do not seem to be supportive of creative behaviors or creative personalities among their students (Chan and Chan 1999). Teachers of primary and secondary school in Hong Kong were found to use both positive (e.g., artistic, curious, and imaginative) and negative words (e.g., opinionated, rebellious, and self-centered) to describe students who were otherwise identified as creative and independent thinkers. Chan and Chan (1999) explained that these and other attitudes are common among teachers in the Chinese culture, which encourages conformity and compliance but discourages independent thinking. Other researchers have made the same observation that Asian schools reward repeating and memorizing the knowledge taught by teachers rather than learning initiatives taken by the students (Martinsons and Martinsons 1996). These attitudes discourage individual learning among students. According to Cai and Cifarelli (2004), Chinese students are much less willing to try different answers than American students when they cannot figure out the correct answer. Nearly half of Chinese students but only 10% of American students left a mathematic question blank without solving it (Cai 2000). Chinese students' unwillingness to take risks when answering questions is shown in another study in which 15% of the students did not even guess the answer to a question when there was no penalty for guessing (Cai 1995). In summary, the East–West comparative studies reviewed in this section suggest differences in learning and instruction between these two cultural groups that are traceable to social learning for Asians and individual learning for Westerners rather than the other way around. We next review East–West differences in personality attributes as social and individual learning enablers.

Enabling Attributes of Social and Individual Learning

The process of cultural evolution through social and individual learning is expected to activate and, in turn, be aided by personality attributes according to the same frequency-dependent selection. When individual innovation is deemed adaptive in an unpredictable environment, natural selection should also favor high rather than low confidence in one's own abilities as well as high rather than low interest in finding new solutions that are potentially costly. If social learning or copying existing solutions to an unchanging environment is adaptive, such personality attributes as conformity, compliance, and gullibility should also remain active in the population. The existing cross-cultural literature seems to support these expectations. We review this literature in this section to show that Asians are more conforming and compliant than their counterparts in Western cultures, where higher levels of confidence and independence spread.

Conformity and compliance to follow the crowd or the leader

According to Boyd and Richerson (2005), social learning operates under two related premises. One premise is called the conformist model, where people preferentially copy the most widely accepted models or solutions. Related to this premise is a model-based bias in favor of tangential characteristics of the individuals who have adopted the models. People tend to copy solutions adopted by those who have such characteristics as success, status, and prestige rather than copying models merely on the basis of the models' popularity (Boyd and Richerson 2005). Examples of personality or psychological attributes that are both facilitative of and responsive to these kinds of social learning are conformity and compliance (Caldini and Goldstein 2004). Our theory would find Asians to be more conforming and compliant than Westerners because their cultural origin derives from social learning, which is facilitated by and in turn activates such psychological attributes. Whereas conformity and compliance are part of the personality repertoire of all humans, such attributes are expected to be more active in some cultures at certain times because of a reliance on social over individual learning.

The best cross-cultural comparison of conformity comes from a meta-analysis that summarizes 133 experiments using the Asch line judgment task with 4,627 participants from 17 countries (Bond and Smith 1996). Individuals from countries defined as collectivistic either by Hofstede (1980), Schwartz (1994), or Trompenaars (1993) have clearly higher levels of conformity than those from individualistic countries (Bond and Smith 1996). Other primary research confirms these findings. Kim and Markus (1999) compared Asians and Americans on different measures of conformity in a series of four studies. Study 1 had European American and Chinese American high school students choose from two sets of abstract figures. One set consisted of eight subfigures of similar kinds and one outlier that was different from the rest. The other set consisted of several subfigures that were different from the majority. The results showed that European American students were more likely to pick the set with several unique subfigures than Chinese participants were. The same finding was replicated in a second study that compared Korean students from South Korea to Caucasian students from the USA.

The third study compared American and Asian passengers recruited at an international airport on their choice from a set of five pens, one or two of which were unique in color from the majority. More American than Asian participants chose the unique pen from the group of five pens, whereas more Asian than American participants avoided the unique pen. In their fourth study, Kim and Markus (1999) compared 136 magazine advertisements from the USA and 157 from South Korea. The themes of these advertisements were rated by two Korean and two American judges in terms of the presence of uniqueness and conformity. American ads had higher ratings of uniqueness (89% of American ads vs. 49% of Korean ads used the uniqueness theme) than Korean ads, which had higher ratings of conformity than American ads (95% of Korean ads vs. 65% of American ads used the conformity theme). Other studies have reported similar findings showing that East Asians are more likely to conform to social norms than Westerners are (Chang 2004; Iyengar and Lepper 1999; Suh *et al.* 1998).

Tan *et al.* (1998) compared levels of compliance between Singaporeans and Americans in a mock jury experiment. Each group consisted of four persons, three of whom were confederates and one was the target participant. The four-person group had to reach consensus on how much to be awarded to a mock plaintiff. During the deliberation, the three confederates would consistently propose higher amounts than did the participant. The variable of interest was the number of round of deliberations it took the target participant to comply with the position of the confederates. (The study also investigated three conditions of communication

among the four "jury members") The results showed that the Singaporean participants took fewer rounds to accept the majority position (Ms=3.83, 3.45, and 3.67 for the three communication conditions) than the American counterparts (Ms=4.50, 5.63, and 6.38) (Tan *et al.* 1998).

Compliance also means attending to hierarchy, authority, and inequality. Hofstede's power distance measures acceptance of the uneven distribution of power in a given society by its members. East Asian countries and regions have higher power distance than their counterparts in Western Europe and North America (Buttery and Leung 1998; Hofstede 1991). For instance, the power distance index for Singapore was 74, Hong Kong, 68, and Taiwan, 58, compared with the UK at 35, Denmark at 18, Austria at 11, and USA at 40. Asians were also found to prefer brand names more than Americans did (Kim and Drolet 2009). In a sample of 50 Asian-born Asian Americans, 54 US-born European Americans, and 133 US-born Asian Americans, participants were asked to choose a corn flake cereal, lemon–lime soda, and aspirin from sets containing one lower-cost generic option and one more expensive brand-name option. The results showed that the preference for brand-name over generic products was strongest among immigrant Asian Americans, followed by American-born Asians, and European Americans showed the weakest preference for brand-name products among these three groups (Kim and Drolet 2009).

An East–West difference in observance of authority and status was reported in another study. Bond *et al.* (1985) conducted an experiment in which undergraduate students received insults from out-group members of either high or low social status. They found that social status affected tolerance for insults among Hong Kong undergraduates but not among American undergraduates. The mean insult acceptance score (ranging from 1 to 7, with higher numbers indicating greater acceptability) was similar between low-status (M=1.80) and high-status insulters (M=2.07) for American participants. Among Hong Kong participants, acceptance was much higher when the insult was given by a high-status (M=2.93) than a low-status insulter (M=2.29). In a similar study (Brockner *et al.* 2001), 118 business students from China and 136 MBA students from the USA were asked to imagine that a new manager was coming to change things in their workplace and that they either would be consulted or would not be consulted by the manager about the change. Commitment to the workplace under these two involvement conditions was measured. Americans' commitment declined from being consulted (M=3.57, SD=0.56) to not being consulted (M=2.63, SD=0.72, $p<.01$). However, the commitment scores were nearly the same for Chinese participants when they were consulted (M=3.60, SD=0.43) and when they were not consulted (M=3.27, SD=0.68). These findings suggest that Chinese and Asians are more observant of and deferent to status and hierarchy than Europeans are. Such personality attributes facilitate social learning by more expeditiously copying from successful individuals who are accorded more status and prestige by the group (Henrich and Gil-White 2001).

Self-concept and confidence

When it is difficult to determine which cultural variant is best, natural selection favors heavy reliance on imitating others and low confidence in one's own experience (Boyd and Richerson 1988). Individual learning that takes many trials and errors may require high confidence in one's experience and abilities independent of one's actual abilities or competence. In line with our cross-cultural predictions, it has been widely reported that Asians tend to have lower self-concept despite higher cognitive performance than Westerners. A large-sample cross-cultural study of university students from the USA

(n=475), New Zealand (n=260), Australia (n=262), Japan (n=359), Hong Kong (n=281), and Taiwan (n=414) found lower decision self-esteem means for the Asian countries (combined M across the three countries=7.00; SD=2.36) than the Western countries (combined M=8.44, SD=2.37), whereas there were no East–West differences in other measures (Mann *et al.* 1998). Another study comparing Chinese and British high school students found the Chinese students to score low on almost every dimension of self-esteem (general self-esteem: Chinese M=3.72, UK M=4.72; general self-esteem in school: Chinese M=3.55, UK M=4.12; self-esteem in verbal skills: Chinese M=3.84, UK M=4.48; self-concept about parental relationships: Chinese M=4.03, UK M=4.64; self-concept about emotional stability: Chinese M=3.55, UK M=3.78) (Rogers 1998). American middle school students had higher general self-efficacy (M=2.97) than Hong Kong students (M=2.58, p<.05) (Chen *et al.* 2006).

According to the TIMSS report, children from East Asian countries have among the highest mathematics scores (Ms=661 for Chinese Taipei, 627 for Hong Kong SAR, 634 for Japan, and 650 for Korea) and much higher scores than Americans (M=534). At the same time, these children were much lower in their self-confidence about learning mathematics (the percentage of students who had high self-confidence in learning mathematics was 26% for Taipei, 30% for Hong Kong SAR, 17% for Japan, and 30% for Korea) than Americans (51%) (Mullis *et al.* 2004). Another study comparing 427 South Korean with 375 American college students found Koreans to be less self-differentiated (Korean M=3.21, SD=0.43; American M=3.86, SD=0.51) and less assertive of their positions (Korean M=3.62, SD=0.57; American M=4.10, SD=0.68) than their European American counterparts (Chung and Gale 2006).

Other studies have measured individualism and collectivism as person-level variables and found them to correlate differently with self-perceived cognitive abilities. In one study, individualism was correlated with self-rated cognitive ability, r=0.38, self-rated cognitive performance, r=0.23, self-enhancement propensity, r=0.42, and general self-efficacy, r= 0.35. Collectivism was correlated with self-rated cognitive ability at 0.25, self-rated cognitive performance at 0.10, self-enhancement propensity at 0.12, and general self-efficacy at 0.27 (Xie *et al.* 2006). In another study, self-esteem was correlated with independence at 0.42 and with interdependence at −0.14 (Singelis *et al.* 1999). Individualistic and independent self construal emphasizes personal autonomy and emotional independence whereas collectivistic and interdependent self construal encourages emotional dependence and reliance on the group. These culturally derived self-systems are adaptive in their respective cultures by facilitating the culture's learning strategies. High self-efficacy and confidence are more relevant and important for individual pursuit of solutions than for copying them from others. A sense of efficacy is therefore part of individualistic more than collectivistic self-systems. As shown by data from 1,777 American and Hong Kong middle school students (Chen *et al.* 2006), the negative correlation between self-efficacy and depressed mood among American students (r=−0.47) is twice as strong as it is among Chinese students (r=−0.23).

These two self-systems derived from social and individual learning may directly affect the cognitive performance underlying these two learning forms. Iyengar and Lepper (1999) compared Asian American and European American grade school (second to fourth grade) students on their motivation and performance in solving anagrams. The children were randomly assigned into three conditions, which were playing anagrams chosen by the children themselves, by the experimenters, and by the children's mothers. The results showed that the performance of American children was much higher in the personal choice condition, with a higher mean number of correctly solved anagrams (M=7.39, SD=1.88)

than in the experimenter choice (M=3.06, SD= 1.89) and mother choice conditions (M=2.94, SD=1.84). On the contrary, Asian American students performed best in the mother choice condition (M=8.78, SD=2.24), followed by the personal choice condition (M=6.47, SD= 2.10) and the experimenter choice condition (M=4.28, SD=2.65). The motivation measure yielded similar results, with American children spending more time playing anagrams of their own choice (M=324 s, SD= 70) than those chosen by their mothers (M=98, SD=94) or by the experimenter (M= 103, SD=99; $p<.001$). Asian American children spent more time playing the anagrams chosen by their mothers (M=340, SD=35) than those they themselves chose (M= 229, SD= 99) or the ones chosen by the experimenter (M=116, SD=98).

In another experiment involving a different sample of Asian and European American grade students, the researchers manipulated three choices of a computer game and related mathematics problems. Three conditions were the children's own choice of a game, an in-group choice that was made by the children's classmates, or an out-group choice that was made by students in another class. American students liked the game most under the personal choice condition (M=4.79) compared with the in- (M=2.55) and out-group choice conditions (M=2.19). Asian students liked the in-group choice condition (M=4.72) more than the personal choice (M=3.81) and the out-group choice conditions (M=2.42). In terms of task engagement, American students played more games under the personal choice condition (M=4.71) than the other two conditions (M=2.91 for in-group and M=2.94 for out-group choice). Asian American students played more games with in-group choice (M=4.89) than with personal choice (M=3.69) or out-group choice (M=2.58). European Americans preferred challenges in a game under the personal choice condition (M=1.73) more than the other two conditions (M=1.10 for in-group and M=1.25 for out-group). Among Asian students, preference for challenge was highest in the in-group choice condition (M=2.24), followed by the personal choice (M=1.52) and out-group choice conditions (M=1.31). European American children liked the mathematics problems the most under the personal choice condition (M=3.93; M=2.36 for in-group and M=2.63 for out-group conditions). Asian American students liked the mathematics problems the best under the in-group choice condition (M=4.00; M=3.25 for the personal choice and M=2.25 for the out-group choice conditions). Finally, American students reported having learned more under the personal choice condition (M=18%) than the other conditions (M=0% for in-group and M=−2% for out-group conditions). Asians learned the most under the in-group choice condition (M=18%; M=11% for personal choice and M=−2% for out-group choice conditions).

In summary, social learning and individual learning are facilitated and in turn activate different personality attributes. Social learning takes two forms by copying the majority and copying the successful (Boyd and Richerson 2005). These forms of copying in turn activate conformity, compliance, and hierarchical social relations. Social learning is in general facilitated by low rather than high confidence in one's own abilities or experience and by low rather than high level of interest or curiosity in pursuing one's own solutions (Boyd and Richerson 1985, 1988). Individual learning or self-pursuit of trial and error, on the other hand, requires and, in turn, facilitates high confidence, interest, and independence. Empirical evidence reviewed in this section support the East–West differences in these and other personality attributes as facilitators of social versus individual learning.

Conclusions

Hofstede's theorizing of East–West differences contrasts individualism, reflecting emotional independence or detachment from groups and organizations, with collectivism, which

centers on relationship hierarchies. An individualism index was found to be negatively correlated with a Power Distance index at $r=-.67$. Therefore, East–West cultural differences center on the extent to which social hierarchy versus equality is emphasized (Gouveia and Ros 2000). Schwartz (1999) draws similar East–West comparisons between hierarchy and egalitarianism, between conservatism and autonomy, and between mastery and harmony. Eastern countries are found to value hierarchy, conservatism, and harmony, whereas most Western countries value intellectual and affective autonomy and egalitarianism. Nisbett *et al.* (2001) focus on cultural cognition in making East–West comparisons and describe the East as holistic and, the West, as analytic. Holistic cognition has an orientation toward the whole field, with special attention to the relationship between the object and the context. Holistic thought is also dialectical, involving multiple perspectives. Analytic thought is characterized by detaching the object from its context and by applying abstract rules rather than attending to specific contextual details. Markus and Kitayama (1991) compare self construal between Eastern and Western cultures. An independent self construal derives from inherent separateness of distinct persons in mostly Western cultures. Self-construal of Westerners focuses on the inner feelings, thoughts, and actions of the self rather than comparing oneself to the feelings, thoughts, and actions of others. The Eastern interdependent construal sees the self as part of an encompassing social relationship within which everyone's behavior is determined by and contingent on the thoughts, feelings, and actions of others in the relationship. The concept of an interdependent self is also associated with an understanding of the world as an inter-connected whole rather than reducible parts (Bond 1986), which also aligns with Eastern dialectic and holistic philosophy (Nisbett *et al.* 2001).

These cultural theories of East–West differences converge on the distinction between social learning by involving others and individual learning by engaging the self. The necessary condition under which social learning can take place is working with others. Individuals may copy or learn from others either by directly interacting with them or by studying their ideas. In either case, the minimum requirement is the existence and involvement of others without whom there is no social learning. The necessary condition for individual learning, on the other hand, is to engage oneself in trial and error. In the process, one may seek help from or work with others but such behaviors are unnecessary, and engaging in such behaviors reverts to social learning. Thus, working with others and working by oneself are the necessary conditions for social and individual learning, respectively. Stemming from these two fundamental learning styles are evolved cultural values and belief systems that center around the same theme of working with others or engaging oneself. These include national value systems that distinguish between individualism focusing on the self and collectivism focusing on in-group others (Hofstede 1980), self-evaluative systems that distinguish between independent and interdependent self construal (Markus and Kitayama 1991), and social relationships that emphasize independence, autonomy, and equality (Schwartz 1999), or inter-personal relatedness (Cheung *et al.* 2003), social hierarchy, and authority (Hofstede 1980; Schwartz 1999). These various East–West cultural dichotomies converge well on the distinction between social learning by working with others and individual learning by trial and error of the self. The contingent factor is environmental change vs. stability which, as we have shown, affects Asians and Westerners consistently differently, resulting in East–West cultural differences.

Specific cultural elements can be found in social or individual learning. An Eastern interdependent self construal defines the self in relation to others. A holistic and dialectical thinking style relates parts (e.g., self) to the whole (e.g., others) and attends to contextual

details or different views of others. A collectivistic orientation and value system emphasize conservatism, harmony, and hierarchy. These cultural characteristics facilitate two sets of behaviors central to social learning as the primary adaptation to the relatively stable environment of the East. The first set concerns learning behavior that is oriented toward copying, memorizing, and attending to details. The second set refers to psychological enablers of the social-learning style, including conformity, compliance, and relatively low self-concept, all of which facilitate getting along with and copying others. These are adaptive when others provide solutions that are relevant across relatively unchanging situations. As shown in this review, these two sets of attributes are prevalent and active, affecting the Chinese and Asian populations more than individuals from Western cultures. The West is characterized by an individualistic cultural orientation and related value systems that assert autonomy, equality, and individual detachment from groups. The cultural self construal is similarly independent and individualistic, drawing reference internally to one's own attributes rather than externally by comparison to group norms. The cultural thinking tends to be decontextualized and rule based, favoring universal principles rather than context-dependent solutions. These cultural characteristics are conducive to individual learning and engaging the self as the main cultural adaptive strategy in dealing with the relatively more variable environment of the European and American continents in the historical past and today. As shown in this review, the Western cultural framework activates and brings to the surface such individual learning-related attributes as innovativeness, critical thinking, and creative intensions, as well as such personality attributes as independence, self-confidence, and the lack of compliance and conformity. Both sets of attributes are important in perpetuating individual learning through self-engaging trial and error.

Although they define the contemporary Eastern and Western cultures, these culture-defining attributes nonetheless form universal repertoires of various human traits, including values, personalities, and cognitive styles. Human beings employ mixtures of social and individual learning to solve specific adaptive challenges. Contingent on environmental variability, social or individual learning becomes more widespread within groups of individuals living in certain times and locations. The corresponding personality and cognitive attributes become more or less active among different groups of individuals to result in the cross-cultural differences that are observed across times and locations (Mesoudi 2009). In this respect, cultural adaptations follow the same logic by which genetic adaptations are formed. That is, both are contingent on environmental variability. When the environment is more variable and less predictable, cultural adaptive behaviors tend to be individualistic and innovative to respond to the environmental change. When the environment is fixed, cultural adaptations follow domain-specific routes to yield more rigid and definite behaviors that are copied by the masses. In the process, different behavioral characteristics become activated to form behavioral norms of different human groups. These processes of mapping behavior to the environment provide ultimate answers to how cultures evolved and why, with respect to the goal of this review, East–West cross-cultural differences exist in the ways we observe.

The same cultural evolution of social and individual learning that produce the contemporary East–West differences among human groups has been part of species evolution from the beginning, as evidenced by brain enlargement especially in the frontal lobes of most Cenozoic mammals (Jerison 1973). Observations of learning in most mammals and in birds and fish (Lefebvre and Palameta 1988; Dugatkin 1996; Laland and Williams 1997) also suggest that learning and cultural evolution are not human specific. Because of the unique human brain, which resulted from humans' ever-expanding habitat

range since the beginning of human evolution (Boyd and Richerson 2005), human cultural evolution has reached a level unparalleled by any other animals. However, during the Pleistocene and earlier, hominids and later human groups lived in much less diverse and smaller habitats (mainly along the Eastern Rift Valley) than today. Thus, we do not see as many cultural differences then as we do today. Cultural evolution thus has been more recent, starting probably between 100,000 and 40,000 years ago (Cavalli-Sforza *et al.* 1994; Underhill *et al.* 2001) or as recently as 10,000 years ago (Stringer and McKie 1996), when human groups started to explore and settle in vastly different environments across the continents. Once cultures are formed as the result of human adaptation to different environments and their different extents of change and stability, they become an increasingly dominant part of the human habitat environment. Human groups continue to employ social and individual learning strategies to adapt to their now culture-rich environments. In this process, derived cultures such as Eastern and Western cultures also directly affect human behavior, resulting in the widely studied socialization and acculturation processes and outcomes. Whereas these processes have been a main focus of psychology and social sciences in the past 100 years (Cosmides and Tooby 1992), the goal of this article has been to explain how cultures are formed and why East and West have different cultural and socialization processes.

There are socialization and educational implications of this work. First, in a number of studies, Asian students tend to outperform American students. This relatively lower academic achievement of American students has multiple explanations, with most focusing on concurrent social (e.g., education policy and methods) and personal (e.g., achievement motivation and family background) influences. Based on the thesis of the present paper, the lower achievement of American students may reflect more distant forces due to cultural traditions that emphasize social and individual learning differently. Schooling is clearly a form of social learning which should fit better with Asian social learners than with American individual learners. American efforts to improve educational achievement may need to address broader cultural issues rather than focusing solely on funding and other operational issues. For example, memorization in simple mathematics or word reading activities in the early grades may be desirable and promote future academic success; constructivist, problem-based learning by itself may not be as successful as a combination of both constructivist problem solving and memorization together. Second, despite a somewhat unfavorable level of academic achievement on the part of its primary and secondary school students compared to those from other countries, America remains a world leader in scientific, technological, and business innovations in both academia and industry. Indeed, scientists from other countries often make their scientific discoveries after they move to the USA. This unprecedented single-country achievement in science and technology may be attributable in part to, among other beneficial conditions including admittedly already high levels of technological development, a socio-cultural climate that is more individual than social learning based. These two education implications present a clear tradeoff between social and individual learning. America seems to have both benefited and lost to its strong individualistic cultural orientation.

Despite the seemingly strong and self-perpetuating effects, cultures are not static but change as functions of environmental change vs. stability. Such cultural change has become increasingly important to contribute to the contemporary human ecology. As an ongoing example, the unprecedented social transformation that has been taking place in China may have evoked a significant shift in the national culture from hard core collectivism to an emerging individualist cultural bend. On the other hand, to the early settlers of Americas, the new world presented a rapidly changing environment. Indeed, this environment

continued to change and diversify through immigration to create a culture that is probably among the most individualistic in human history. However, as the social and economic structure and operations become increasingly self-regulated and formulated, American culture may be starting to shift to a social-learning orientation. On a global level, unprecedented cross-cultural exchange and sharing of technology bring about increasingly similar information patterns to result in cultural changes that should see reduced rather than increased East–West differences. In short, cultures or styles of doing things respond to environmental change versus stability, the patterns of which may either self-perpetuate locally or change quickly and converge across regions; cultures change accordingly.

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