Culture, Education, and the Attribution of Physical Causality

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Two studies investigated the impact of culturally instilled folk theories on the perception of physical events. In Study 1, Americans and Chinese with no formal physics education were found to emphasize different causes in their explanations for eight physical events, with Americans attributing them more to dispositional factors (e.g., weight) and less to contextual factors (e.g., a medium) than did Chinese. In Study 2, Chinese Americans' identity as Asians or as Americans was primed before having them explain the events used in Study 1. Asian-primed participants endorsed dispositional explanations to a lesser degree and contextual explanations to a greater degree than did American-primed participants, although priming effects were observed only for students with little physics education. Together, these studies suggest that culturally instilled folk theories of physics produce cultural differences in the perception of physical causality.

Keywords: *culture; attribution; ethnic identity; physical causality*

Of all the thorny issues confronted by cultural psychologists, one foundational question has consistently furrowed researchers' brows: How should culture itself be operationalized? Different theoretical traditions have coalesced around different answers to this question. Two approaches in particular—the value tradition and the "self" tradition—have come to dominate cultural psychology. The value tradition (Hofstede, 1980; Schwartz, 1994; Triandis, 1995) sees culture as a shared set of core values that regulate behavior in a population; Triandis's (1995) theory of individualism-collectivism is perhaps the preeminent example of this approach. The self tradition (Heine & Lehman, 1997, 1999; Markus & Kitayama, 1991; Singelis, 1994) identifies culture with the particular type of self-conception predominant in a population; Markus and Kitayama's (1991) theory of interdependent versus independent self-construals is an important example of this tradition. Recently, a number of cultural psychologists have adopted a third conception of culture—that of culture as "knowledge structure" (Chiu, Morris, Hong, & Menon, 2000; Hong, Morris, Chiu, & Benet-Martinez, 2000; Peng, Ames, & Knowles, 2001; Peng & Nisbett, 1999). This approach portrays culture as a constellation of knowledge structures, or folk theories, that embody individuals' basic beliefs about the world and guide inferences in different domains.

Much of the research within the culture-as-theory framework (and cultural psychology generally) has focused on cultural differences in social perception. For example, cultural differences in dispositional bias (i.e., the tendency of lay perceivers to overattribute observed behavior to an actor's personal dispositions) have been traced to divergent folk theories of personal agency (Choi, Nisbett, & Norenzayan, 1999; Knowles, Morris, Chiu, & Hong, 2001; Menon, Morris, Chiu, & Hong, 1999; Morris, Menon, & Ames, 2001; Morris & Peng, 1994; Norenzayan & Nisbett, 2000). The influence of culture, however, may reach beyond social perception. In this article, we argue that different cultures instill their members with different folk theories of physical phenomena and that these theories produce cultural differences in the perception of physical events. Specifically, we argue that East Asians possess a contextual folk theory

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of physics emphasizing the role of external and relational factors (e.g., gravity) in determining an object's behavior. On the other hand, we argue that members of Western cultures, such as the United States, possess a more dispositional physical theory emphasizing the internal causes of an object's behavior (e.g., weight). In Study 1, we present evidence that cross-national differences in physical attributions—specifically, between those of American and Chinese individuals—reflect the application of dispositional or contextual physical theories. In Study 2, we investigate the causal impact of folk physical theories among individuals likely to possess both dispositional and contextual folk theories—namely, Chinese Americans. Before describing the studies, however, we review evidence for and against the proposition that culture affects perceptions of physical events.

CULTURE AND FOLK PHYSICS

Psychologists and other scholars have disagreed as to whether culture shapes individuals' causal understandings of physical events. We briefly review work supporting and refuting the impact of culture on physical attribution and then propose a partial resolution that affirms the role of culture yet places limits on the circumstances under which cultural differences will appear.

Evidence for Cultural Variation in Folk Theories of Physics

Scholars in the humanities have long argued for the existence of fundamental differences between Eastern and Western folk theories of physics. Joseph Needham (1954), a historian of the science and civilization of ancient China, argued that the ancient Chinese possessed a much richer and more "advanced" folk understanding of physics than did ancient Westerners (e.g., the Greeks) and that this understanding more closely resembles modern physics. According to Needham (1954; see also Capra, 1975; Zukav, 1979), the core concepts of Eastern folk physics, Yin and Yang, are inherently relational, contextual, and dialectical, and thus resemble features of contemporary quantum physics. The contextual Eastern folk theory, it is argued, emphasizes forces that act over distance (e.g., gravity or magnetism) and forces exerted on objects by a medium (e.g., air or water).

Kurt Lewin (1935), a founding father of modern social psychology and former physics student, was perhaps the first psychologist to address the dispositional nature of the Western folk understanding of physics:

> The kind and direction of the physical vectors in Aristotelian dynamics are completely determined in advance by the nature of the object concerned. In modern physics, on the contrary, the existence of physical vectors always depends upon the mutual relations of several physical factors, especially upon the relation of the object to its environment. (p. 28)

Thus, in Western (i.e., Aristotelian) folk physics, the behavior of objects is understood almost exclusively in terms of the object itself: A stone sinks when placed in water because it is heavy, and a piece of wood floats because it buoyant (Lewin, 1935). On this understanding, the behavior of objects is caused by their discrete properties alone rather than by those properties in conjunction with states of the environment.

Evidence for Universality in the Perception of Physical Causality

In contrast to the work just cited, cognitive psychologists investigating the impact of culture on the perception of physical events have generally failed to uncover dramatic cultural differences (Michotte, 1963; Morris, Nisbett, & Peng, 1995; Morris & Peng, 1994). For instance, Michotte (1963) and his students had participants from Europe, Africa, and various Pacific Islands explain mechanistic (i.e., "billiard-ball") interactions between inanimate objects, finding no significant cultural differences. More recent cross-cultural studies have identified seemingly universal rules guiding the interpretation of physical phenomena. In general, if the motion of an object follows, in a straightforward and visible way, the Newtonian law of conservation (i.e., that objects remain at rest or in uniform motion along a straight line until acted on by a outside force), then the motion is seen as externally caused (Stewart, 1984). Only if the motion appears to deviate from the law of conservation is it seen as internally caused (Morris et al., 1995; Morris & Peng, 1994; Stewart, 1984).

Research in cognitive development suggests that the perception of physical events is largely "hardwired" and innate and might therefore be resistant to the influence of culture. Even very young infants have been shown to possess firm and reliable expectations about objects' possible movements and interactions (Baillargeon, 2000; Kotovsky & Baillargeon, 2000; Spelke, 2000). Of particular relevance, infants younger than 3 years old expect objects to behave according to the forces of gravity (an external, relational factor) and inertia (an internal, dispositional factor) (I. Kim & Spelke, 1999). The emergence at an early age of such physical expectations suggests that these expectations could not be altered by experience in one's culture. However, the early emergence of expectations concerning both contextual and dispositional factors does not rule out the possibility that culture-specific theories emphasize these understandings to varying degrees and thus lead individuals to favor one type of factor over the other in their explanations for physical events.

The Role of Formal Physics Education

The research reviewed above reveals disagreement among scholars concerning culture's impact on causal attributions for physical events. We propose a partial resolution to this debate. We argue that Lewin (1935) and Needham (1954) are correct in their portrayal of Western folk physics as dispositional and of Eastern folk physics as more contextual. However, we propose that this difference will only be reflected in the judgments of those with little formal physics education. If, as we have claimed, intuitions about physical phenomena are guided by theory-like knowledge structures, then formal education in physics could supplant the Western folk theory with the more contextual understanding of modern physics and thus obscure any cultural differences. The cross-cultural similarities found in previous research might then be an artifact of education because many of the participants in the studies of Michotte (1963) and others were college students. Hence, it becomes important to separate the effects of culture and physics education in studying causal attributions in the physical domain. The studies reported here either involve participants with no formal physics education (Study 1) or measure physics education to examine its influence on physical judgments (Study 2).

ASSESSING THE CAUSAL IMPACT OF CULTURE-SPECIFIC FOLK THEORIES

In addition to documenting cultural differences in individuals' folk theories of physics, it is important to show that culture-specific folk theories exert a causal influence on individuals' perceptions of physical phenomena. In virtue of its portrayal of culture as a constellation of knowledge structures, the culture-as-theory approach suggests a way to investigate the causal impact of folk theories on inferences. The technique of cultural priming makes use of the fact that some individuals (e.g., biculturals) often possess multiple culture-derived theories for the same domain of phenomena and that these individuals can be experimentally induced to rely on a given theory in interpreting stimuli.

Cultural Priming

If cultures are indeed associated with divergent knowledge structures, then cultural knowledge should be subject to well-documented rules of knowledge acquisition and use (for a review, see Higgins, 1996). Most important, it should be possible for individuals to acquire multiple culture-derived theories for the same domain, even if the theories contradict one another; however, only one theory at a time can influence judgments (Hong et al., 2000). Which theory guides cognition at a given time will depend on the relative cognitive accessibility of the theories. According to the principle of accessibility, a knowledge structure will affect judgments to the extent that it is available, or activated, in the perceiver's mind (Higgins, 1996). Thus, the currently most accessible theory for a given domain will be the one that influences judgment in that domain.

The current accessibility of a theory can be experimentally manipulated through priming, in which the activation level of the construct is increased through the presentation of a stimulus semantically related to the construct (Higgins, 1996). It follows that an experimenter can, by priming selected theories, manipulate which of two or more conflicting folk theories will influence judgments in a domain. In so doing, it can be shown that the primed knowledge structures exert a causal influence on judgments.

Researchers working within the culture-as-theory framework have used cultural symbols to prime culture-specific knowledge structures. Hong and colleagues (2000) presented individuals who had extensive experience in both East Asian and American culture with either East Asian cultural icons (e.g., a Chinese flag, the Great Wall of China, a picture of Stone Monkey) or American cultural icons (e.g., the American flag, the Capitol Building, a picture of Superman). These researchers found that priming affected attributions for social behavior, such that individuals exposed to East Asian primes interpreted behavior as more externally caused than did individuals in the American prime condition.[1] In our research, we primed culture-specific folk theories using a cultural identity prime in which Asian American participants were asked to reflect on their identity as Asians or as Americans. These identity primes were intended to increase the level of activation of related networks of cultural knowledge, including East Asian and Western folk theories of physics.

Bicultural Individuals

The cultural priming technique used here relies on the possibility that some individuals possess more than one culture-bound folk theory of physics. Bicultural individuals—individuals who identify with more than one culture—may possess multiple folk theories. There is good reason to believe that ethnic cultures within the United States possess cultural knowledge similar to that of their countries of origin. For instance, there is evidence that Japanese Americans possess social attributional tendencies consistent with the contextual theory of social behavior thought to be dominant within Japanese culture, attributing success and failure more to situational factors than do European Americans (Narikiyo & Kameoka, 1992; Whang & Hancock, 1994).

The congruence between the attributional tendencies of Asian Americans and members of Asian national cultures may be due to the fact that Asian Americans possess some of the same values and cultural knowledge prevalent in the national cultures (U. Kim & Choi, 1994). We suggest that, as with folk theories of social behavior, Asian Americans may possess both Asian and Western folk theories of physics.

THE CURRENT RESEARCH

The current research had two goals. First, we sought to demonstrate that American and Chinese national cultures are associated with different folk theories of physics. Specifically, we hypothesized that whereas Americans have a dispositional physical theory that locates the causes of physical phenomena in the discrete dispositions of objects (e.g., weight), Chinese perceivers have a contextual theory that places greater emphasis on relational factors—specifically, forces over distance (e.g., gravity) and the influence of mediums (e.g., air or water). Toward this end, in Study 1, we asked Chinese and American nationals with no formal physics education to identify the causes of a variety of physical events.

Our second goal was to investigate the causal impact of culture-specific folk physical theories on attributions for physical events. Thus, in Study 2, we attempted to prime dispositional (Western) or contextual (East Asian) folk theories of physics in the minds of Asian Americans, who presumably possess both theories. Participants were subsequently asked to identify the causes of the same physical events as were used in Study 1. To test our hypothesis that folk theories will affect inferences only for individuals who have had little formal instruction in physics, we measured participants' level of physics education.

STUDY 1

Method

PARTICIPANTS

Fifteen American participants, all of them female, were drawn from the Psychology Department subject pool at the University of Michigan; they participated in return for course credit. Participants were selected who reported having had no formal education in physics and who had declared majors in the arts or humanities. Fifteen female spouses of visiting Chinese graduate students at the University of Michigan were recruited and paid $10 for their participation in this study.[2] All of these participants were Chinese citizens and, similar to their American counterparts, were college educated, reported no formal physics education, and had majored in the arts and humanities. The mean ages of American and Chinese participants were 19.1 and 22.7 years, respectively. All of the Chinese participants had been in the United States for less than a year because their visas only permitted them to remain in the country for a short time.

PHYSICAL CAUSALITY DISPLAYS

Eight animated displays of physical events were created using Macromind Director for Macintosh by Macromedia Software, a computer animation program. All displays depicted a white object interacting in various ways with a black object or a medium (i.e., air or water) (see Figure 1 for schematic representations of the displays):

1. White object interacting with black object
   a. "Launching" event (i.e., elastic collision). The black object collides with the stationary white object and stops, causing the white object to move.
   b. "Launching at a distance" event. This display was identical to the launching interaction except that the black object stops short of the white object before the white object begins moving.
   c. "Entraining" event (i.e., inelastic collision). The black object collides with the stationary white object, after which both objects move together.
   d. "Balance" display depicting objects balancing on a lever. In this event, the black and white circles are in balance at two ends of a platform resting on a fulcrum.
   e. "Magnetic" display depicting objects' motions in a magnetic field. In this event, the black and white circles appear to be magnetically attracted to one another, converging slowly at first, and then more quickly as the distance between them narrows.
2. White object interacting with a medium
   a. "Hydrodynamic—floating" event. The white object bobs on the surface of a pool of water.
   b. "Hydrodynamic—dropping" event. The white object drops into the pool, rises to the surface, and bobs for a moment.
   c. "Aerodynamic" display depicting an object's motion in the air. In this event, the white object looks like a balloon, dropping gradually while buffeted by air currents.

The program was set to present the displays either in the order listed above or the reverse, as determined randomly.

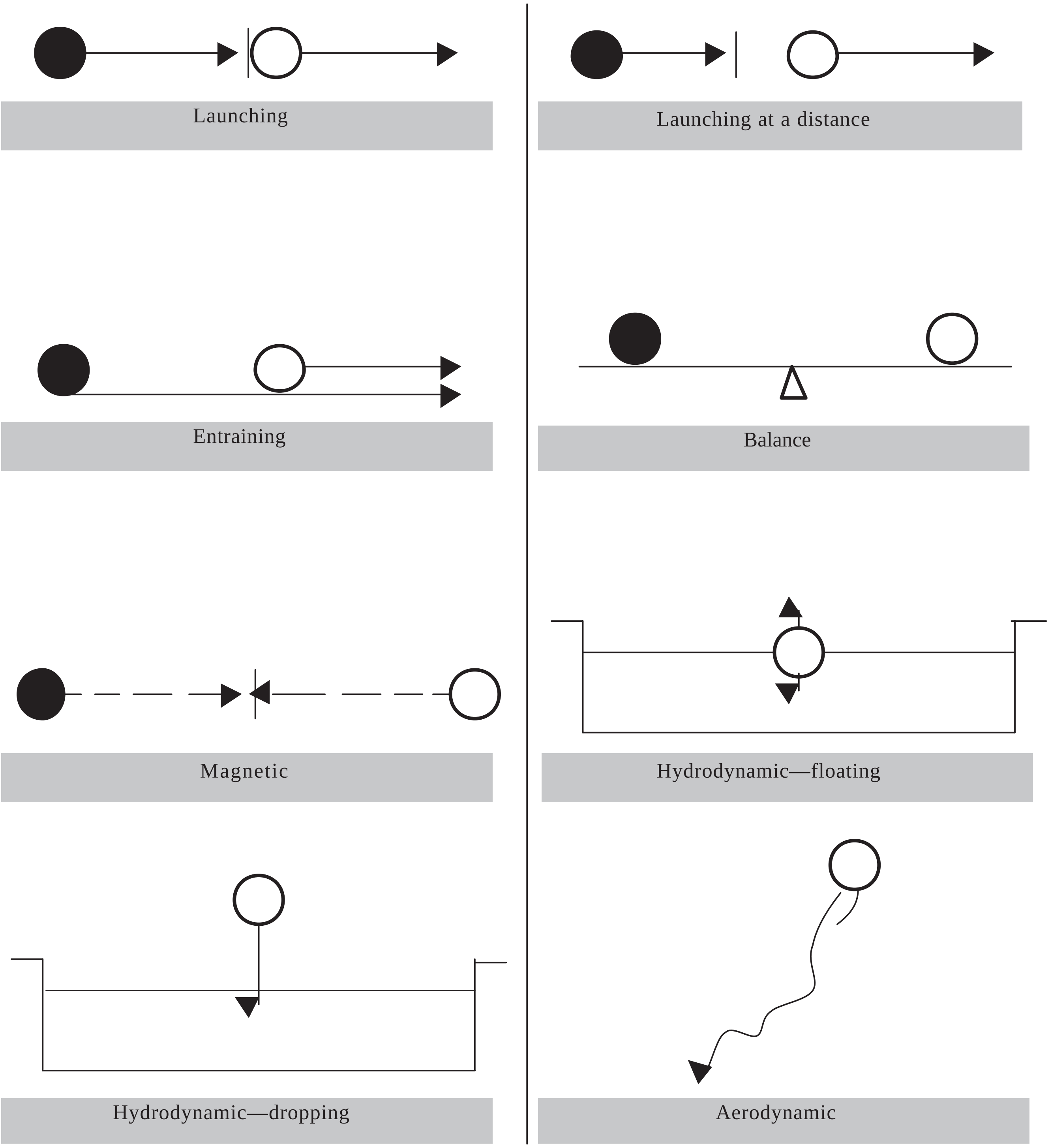

Figure 1 Schematic representations of displays used in Studies 1 and 2.

PROCEDURE

Participants were run one at a time. The experimenter, who was European American and fluent in both English and Chinese, brought the participant into a testing room and seated her in front of a computer. All instructions were given in English for American participants and in Chinese for Chinese participants. The experimenter introduced the study as an investigation of visual perception, in which the participant would be shown a number of displays depicting physical events and asked questions about her perceptions of each. Participants were instructed to think of the physical events as independent episodes, such that objects in one display were not the same objects as in any other display. The experimenter then played the displays, pausing after each to ask the participant the following physical causality question: "Please explain in your own words why the white object moved in the way it did. Even if you don't have a strong opinion, please take a guess." Participants were given as much time as needed to respond to the questions. Responses were tape-recorded. The procedure typically lasted an hour, after which the participant was debriefed and dismissed.

Results

CODING OF OPEN-ENDED RESPONSES

Participants' answers to the free-response causality question were transcribed and content analyzed by two psychology graduate students at the University of Michigan. Both coders were blind to the experimental hypothesis. One coder was European American and the other Chinese American, and each was fluent in both English and Chinese. Each coder coded all of the responses. For each open-ended response, coders tallied dispositional explanations (e.g., weight, shape) and contextual explanations (e.g., gravity, liquid) for the white object's movement as well as the perceived nature of the object (e.g., ball, balloon). Table 1 shows the complete coding scheme. Interjudge reliability was assessed by Kendall's coefficient of concordance; good reliability was achieved ($W = .90$, $p < .001$).

THE PERCEIVED NATURE OF THE EVENTS

Because the current research assesses the impact of culture on perceptions of physical causality, we intended for participants to interpret the animated events as physical interactions between inanimate objects. However, in light of research showing that moving geometrical figures can give the impression of animacy and personality (Heider, 1944; Michotte, 1963), it is possible that some participants saw the objects as representing organisms and their movements as social in nature. However, our coding of participants' impressions of the nature of the objects (refer to Table 1 for the coding scheme) indicated that all participants perceived the animated circles as balls or (in the aerodynamic display) as a balloon, not as animals or as humans. These findings are consistent with cross-cultural studies in judgments of animacy showing that across cultures, people as young as 3 years old make similar judgments in distinguishing animals from objects (Carey, 1991).

TABLE 1: Coding Scheme for Open-Ended Physical Causality Judgments in Study 1

Property Type	*Categories*
Nature of the white object	Ball
	Balloon
	Animal
	Human
	No mention
	Could not categorize
Dispositional causes of white object's movements	Weight or mass
	Composition
	Inertia
	Shape
	Energy
	Electricity
	Magnetism
	Internal dynamics (e.g., heat, engine)
	Other disposition (e.g., size, color)
	Could not categorize
Contextual causes of white object's movement	Other object
	Gravity
	Friction
	Air or wind
	Invisible matter
	Liquid or current
	Field
	Outside physical conditions (e.g., smoothness of surface)
	Other forces (e.g., human intervention)
	Other contextual cause
	Could not categorize

CAUSAL EXPLANATIONS FOR THE PHYSICAL EVENTS

Having established that all participants perceived the animated displays as physical in nature, we next compared American and Chinese participants' preferences for dispositional and contextual explanations of the events. To isolate the effect of nationality on participants' preferences for different types of explanations, we sought to control for any influence of nationality on the total number of causes cited. Thus, for each of the eight physical events, we calculated the percentage of American and Chinese explanations that referred to dispositional and contextual factors. For all events, we predicted that American participants would give proportionally more dispositional explanations than would Chinese but that Chinese participants would give proportionally more contextual explanations than would Americans. For each display, we conducted a z test comparing the percentage of American versus Chinese explanations that referred to dispositional causal factors. (Note that separate z tests comparing rates of contextual explanations would have results identical to the tests of dispositional explanations and are thus unnecessary.) Because our hypothesis was clearly directional, we used one-tailed tests of significance. The differences between American and Chinese rates of dispositional and contextual explanations were significant for the Launching, Magnetic, and Aerodynamic displays and marginally significant for the Hydrodynamic dropping display, such that Americans gave more dispositional explanations than did Chinese. Averaging across all displays, the predicted effect of nationality on percentage of dispositional explanations was marginally significant, $p < .10$. American and Chinese percentages of dispositional and contextual explanations, and the corresponding z statistics, are presented in Table 2.

TABLE 2: Percentage of American and Chinese Explanations Coded as Dispositional or Contextual in Study 1

	Dispositional Explanations		*Contextual Explanations*		
Display	*American*	*Chinese*	*American*	*Chinese*	z
Launching	55% (12)	25% (5)	45% (10)	75% (15)	1.95*
Launching at a distance	53% (8)	37% (7)	47% (7)	63% (12)	0.96
Entraining	46% (11)	28% (5)	54% (13)	72% (13)	1.19
Balance	58% (11)	41% (7)	42% (8)	59% (10)	1.00
Magnetic	82% (14)	47% (8)	18% (3)	53% (9)	2.15*
Hydrodynamic-floating	35% (6)	27% (4)	65% (11)	73% (11)	0.53
Hydrodynamic-dropping	38% (13)	20% (4)	62% (21)	80% (16)	1.39†
Aerodynamic	64% (18)	31% (5)	36% (10)	69% (11)	2.11*
Average	54% (11.6)	32% (10.4)	46% (5.6)	68% (12.1)	1.39†

NOTE: Values enclosed in parentheses represent the absolute number of explanations coded as dispositional or contextual for a given display. †$p < .10$. *$p < .05$, one-tailed.

Discussion

Study 1 provides partial evidence that members of different cultures possess divergent folk theories of physical causality. In their open-ended explanations for the physical events, American participants exhibited a greater preference for dispositional explanations than did Chinese participants on three of the eight displays, whereas Chinese participants emphasized contextual explanations more than did Americans. This suggests that, as argued by Needham (1954), Capra (1975), and Zukav (1979), the Eastern folk theory of physics places more importance on contextual factors (such as other objects, forces over distance, and mediums) and less importance on dispositional causes (such as shape and weight) than does the American folk theory of physical causality.

For all the displays, cultural differences were in the predicted direction—with Chinese being more contextual than Americans in their explanations of physical motions. Nonetheless, the cultural difference was statistically significant only for the Launching, Magnetic, and Aerodynamic displays and marginal for the Hydrodynamic dropping display. Although this discrepancy could be a result of the small sample size, it is interesting to note that cultural differences were stronger for displays that depicted salient energy transitions from one object to another object or a medium (Launching, Hydrodynamic dropping, Magnetic, and Aerodynamic) than for displays in which the energy transition is less salient (Balance, Launching at a distance, Hydrodynamic floating, and Entraining). We had no a priori reason to expect cultural differences to be limited to displays depicting salient energy transitions, and further research should examine the reliability of this finding.

Inspection of Table 2 suggests a possible alternative framing of our findings. The analyses reported above examined the effect of culture on participants' tendency to give dispositional versus contextual explanations for the physical displays. However, the data also can be analyzed by comparing differences in dispositional and contextual explanation within culture. It is clear that Chinese participants favored contextual explanations over dispositional explanations; however, Americans showed a relatively small preference for dispositional explanations. Therefore, it is possible that whereas Chinese possess a markedly contextual folk physical theory, Americans have a more or less evenhanded theory emphasizing the importance of both types of explanation. This alternative interpretation should be viewed with caution, however. Americans' unexpectedly high reliance on contextual explanations is driven largely by responses on only two of the eight physical displays, Hydrodynamic dropping and Hydrodynamic floating, in which there is a visible medium that exerts an obvious influence on the behavior of the white object. Thus, interpretation of property use within culture is vulnerable to idiosyncrasies of the particular displays participants were shown, some of which demanded mention of important contextual causes.

Having found evidence in Study 1 that American and Chinese cultures are associated with divergent folk theories of physics, we next sought to demonstrate a causal connection between culture-specific knowledge structures and patterns of physical attribution. If culture-specific lay theories are indeed responsible for the cultural differences observed in Study 1, then it should be possible to temporarily increase the cognitive accessibility of different theories and thus increase their influence on attributions. In Study 2, we tapped a population likely to possess both Asian and Western lay theories—specifically, Chinese Americans—and attempted to influence their attributions by priming one or other of these theories. We primed Chinese Americans' identity either as Asians or as Americans before having them explain the same series of physical events used in Study 1. We predicted that participants receiving the Asian identity prime would prefer dispositional causes to a lesser degree, and contextual causes to a greater degree, than would participants receiving the American prime.

The results of Study 1 may be seen to conflict with findings in cognitive psychology revealing no effects of culture on perceptions of physical causality (e.g., Michotte, 1963). We argued earlier that formal physics education may sometimes supplant or obscure folk theories and thus prevent cultural differences from emerging. In Study 1, we were careful to choose participants with no formal education in physics—and thus whose inferences are likely to be based on their folk physical theories—allowing the observed cultural difference to emerge.

In addition to examining the causal influence of folk physical theories, Study 2 was intended as a more direct test of the idea that formal physics education may supplant or obscure individuals' folk theories of physical phenomena. Participants in Study 2 reported the amount of physics instruction they have received and rated their physics expertise. We predicted that the effect of cultural identity priming on attributions would be qualified by an interaction with participants' amount of physics education such that only participants with little physics background would be affected by the identity prime. Participants high in physics education, who presumably rely on a formally inculcated theory of physics rather than a culture-specific folk theory, should not be affected by the identity prime.

STUDY 2

Method

PARTICIPANTS

Sixty-five students (44 women) at the University of California, Berkeley, participated in fulfillment of psychology course requirements. The mean age of the participants was 19.7 years. Participants were selected who had reported their ethnicity to be Chinese American during a mass data collection at the beginning of the semester.

MATERIALS

Cultural identity primes. Primes of Asian and of American identity consisted of a short questionnaire asking participants to reflect, in writing, on several aspects of their ethnic identity. First, participants were asked to "recall an experience you had that made your identity as an *American* [*Asian*] apparent to you." (Brackets indicate wording in the Asian prime condition.) Participants then answered the following questions about the experience: "When did you have this experience?" "How old were you when you had this experience?" "Briefly describe the experience," and "Why do you think the experience made your *American* [*Asian*] identity apparent?"

Physical displays. Study 2 employed the same eight physical displays as did Study 1 (Launching, Launching at a distance, Entraining, Hydrodynamic floating, Hydrodynamic dropping, Balance, Magnetic, and Aerodynamic) (see Figure 1). Displays were presented using Flash by Macromedia Software, a computer animation program.

Rating packets. Participants made their ratings of the physical displays in a packet containing Likert-type questions corresponding to several causal factors. For each of the eight displays, participants rated the extent to which the white object's movement was due to five dispositional factors of the white object (shape, weight, composition, buoyancy, and inertia) and four contextual factors acting on the white object (gravity, friction, air/wind, and water). All ratings were made on a 5-point scale from 1 (*not at all responsible*) to 5 (*completely responsible*).

Ratings of physics background. A short questionnaire was created to gauge different aspects of participants' background in physics. As a measure of formal instruction in physics, participants reported the total number of physics classes they had taken in high school and college. As a measure of physics expertise, participants rated their current physics expertise on a 5-point scale from 1 (*none*) to 5 (*expert*).

PROCEDURE

Participants were run in groups of 5 to 10 in a large testing room outfitted with computers. As each participant entered the testing room, he or she was handed an Asian or American identity prime from an alternating stack, thus randomizing assignment of participants to the Asian and American prime conditions. Participants were then seated at computers and asked to spend 3 minutes filling out the identity primes, after which the primes were collected.

Next, participants viewed each of the eight physical events in random order. The computer displayed each event twice, after which participants were referred to the appropriate page in their rating packets where they rated the degree to which each causal factor was responsible for the event. After completing ratings for all eight displays, participants completed the questionnaire gauging the amount of physics instruction they had received and their self-reported physics expertise.

The entire procedure typically lasted an hour, after which participants were debriefed and dismissed.

Results

DERIVATION OF AGGREGATE ATTRIBUTION SCORES

For use in the analyses reported below, we created aggregate measures of dispositional and contextual attribution across all physical displays. Each participant's aggregate dispositional attribution score was calculated by averaging his or her endorsement of dispositional causal factors (i.e., shape, weight, composition, buoyancy, and inertia); aggregate contextual attributions were calculated by averaging each participant's endorsement of contextual causal factors (i.e., black object, gravity, friction, air/wind, and water).

EFFECTS OF IDENTITY PRIMING AND PHYSICS EDUCATION

We tested two hypotheses in this study. First, we predicted that the identity priming manipulation would influence Chinese American participants' attributions for the physical events, such the participants receiving the Asian prime would attribute the physical events more to contextual causes, and less to dispositional causes, than would participants receiving the American prime. Second, we predicted that priming effects would occur only for participants with little formal education in physics. To test these hypotheses, we followed Aiken and West's (1991) procedure for testing Categorical × Continuous interactions using multiple regression. Unlike analysis of variance (ANOVA), the regression method has the advantage of not requiring a split (such as a median split) to be performed on the continuous variable, which discards useful variance. We began by standardizing the dummy-coded prime condition variable, the measure of physics education (i.e., number of physics classes taken), and self-reported physics expertise to create three main effect terms (see Table 3 for the correlations between these variables and aggregate dispositional and contextual attribution scores). Next, we multiplied the main effect terms together to create interaction terms for each two- and three-way interaction (i.e., Prime × Physics Classes, Prime × Physics Expertise, Physics Classes × Physics Expertise, and Prime × Physics Classes × Physics Expertise). We then performed two simultaneous multiple regression analyses, one to test the influence of these main effect and interaction terms on dispositional attribution and one to test effects on the contextual attribution. Because dispositional and contextual attributions were highly correlated, $r = .68$, $p < .01$,[3] we controlled for this relationship by adding standardized contextual attribution score as a predictor in the analysis of dispositional attributions and standardized dispositional attributions scores as a predictor in the analysis of contextual attributions. Tables 4 and 5 summarize the regressions analyses.

TABLE 3: Pearson Correlations Between Variables in Study 2 (*N* = 65)

	1	*2*	*3*	*4*	*5*
1. Prime condition	—	.10	–.13	.17	.03
2. Physics classes taken		—	.48**	–.11	–.11
3. Self-reported physics expertise			—	–.05	–.18
4. Aggregate dispositional attribution				—	.68**
5. Aggregate contextual attribution					—

*$p < .05$. **$p < .01$, two-tailed.

Identity priming. As can be seen in the first row of Table 4, participants receiving the Asian prime made significantly less extreme dispositional attributions for the physical events than did participants receiving the American prime. Moreover, whereas the Asian prime decreased dispositional attribution among Chinese Americans, it increased contextual attribution (see Table 5, first row).

Physics education. As shown in the fourth row of Table 4, the effect of identity priming was qualified by a marginally significant interaction with the number of physics classes, such that the influence of priming on dispositionism decreased as physics instruction increased. Likewise, the effect of identity priming on contextualism decreased as physics instruction increased (see Table 5, fourth row).

To visualize the interactions between physics education and identity priming, we plotted the interactions according to the procedure recommended by Aiken and West (1991), with levels of dispositionism and contextualism predicted based on the regression equations. Figure 2 represents the predicted effects of the priming manipulation on dispositional attribution among participants one standard deviation above and below the mean on physics education. Similarly, Figure 3 represents the predicted effects of priming on contextual attributions for participants high and low in physics education.

Self-reported physics expertise. An unexpected finding emerged involving participants' self-reported physics knowledge. Specifically, we observed a significant Prime × Physics Knowledge interaction in our analysis of dispositional attributions, such that the American prime increased dispositional attribution among participants who self-reported a great deal of physics knowledge, but not among self-rated nonexperts (see Table 4, fifth row).

Discussion

The results of Study 2 provide evidence for our hypotheses concerning the causal impact of folk physical

TABLE 4: Summary of Simultaneous Multiple Regression Analysis of Aggregate Dispositional Attribution in Study 2 ($N = 65$)

Predictor	B	SE B	β
Prime (P)	–.26	.10	–.26**
Physics classes (PC)	–.16	.10	–.16
Physics expertise (PE)	.16	.10	.16
P × PC	.19	.10	.19*
P × PE	–.17	.10	–.17*
PC × PE	.08	.11	.08
P × PC × PE	.15	.11	.15
Contextual attribution score	.72	.09	.72**

NOTE: The Prime variable was dummy coded such that 1 and 2 corresponded to American Prime and Asian Prime conditions, respectively. Main effects were standardized before being entered into the regression analysis and interaction terms were created by multiplying standardized main effects.
†$p < .10$. *$p < .05$. **$p < .01$, one-tailed.

TABLE 5: Summary of Simultaneous Multiple Regression Analysis of Aggregate Contextual Attribution in Study 2 ($N = 65$)

Predictor	B	SE B	β
Prime (P)	.09	.05	.18*
Physics classes (PC)	.07	.05	.14
Physics expertise (PE)	–.11	.05	–.22*
P × PC	–.09	.05	–.19*
P × PE	.07	.05	.15
PC × PE	–.03	.05	–.06
P × PC × PE	–.07	.05	–.15
Dispositional attribution score	.36	.04	.76**

NOTE: The Prime variable was dummy coded such that 1 and 2 corresponded to American Prime and Asian Prime conditions, respectively. Main effects were standardized before being entered into the regression analysis and interaction terms were created by multiplying standardized main effects.
†$p < .10$. *$p < .05$. **$p < .01$, one-tailed.

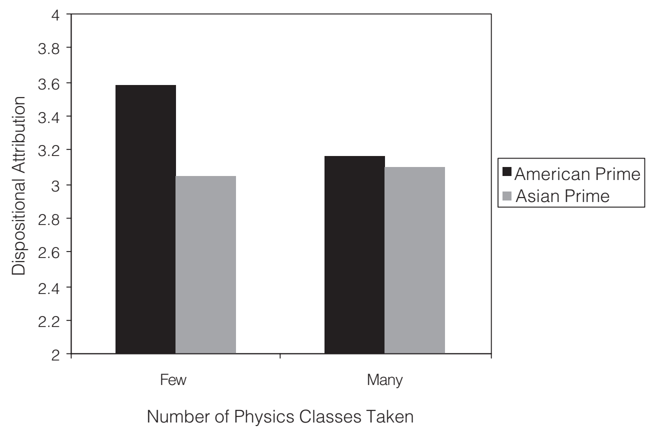

Figure 2 Level of dispositional attribution for physical events as a function of identity prime condition and physics education in Study 2.

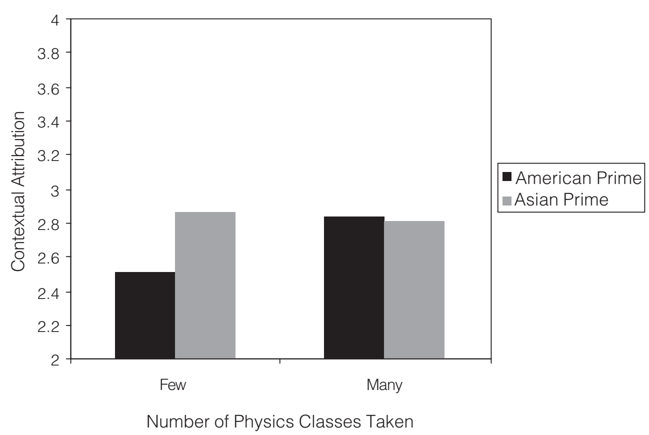

Figure 3 Level of contextual attribution for physical events as a function of identity prime condition and physics education in Study 2.

theories on attributions of physical causality. Chinese American participants who received the Asian identity prime, which was theorized to activate a contextual folk theory of physics, endorsed dispositional causes to a lesser extent, and contextual causes to a greater extent, than did participants receiving the American identity prime. The success of our priming manipulation supports the notion that the interpretation of physical phenomena is guided by knowledge structures acquired through experience in one's culture. Contributing further support to the knowledge-structure account, we found that priming only affected attributions for participants with little formal instruction in physics (see Figures 2 and 3). If physical attribution is guided by learned, culture-specific knowledge structures, then it should be possible to supplant these folk theories with formal scientific theories acquired through education.

An unexpected finding emerged, such that identity priming had an effect for individuals rating themselves as relatively expert in physics but not for individuals self-reporting little physics knowledge. Given that we had intended self-reported physics expertise, like physics education, to gauge the extent to which participants have internalized formal physics theories, this finding seems to contradict the observed Prime × Physics Classes interaction. However, we believe that this finding may have arisen because self-rated physics expertise is a less-pure measure of an individual's actual physics knowledge than is the number of physics classes he or she has taken. Specifically, we believe that the self-rated expertise measure may have been confounded with individuals' motivation to self-enhance (i.e., to portray themselves in a positive light); self-enhancement motivation, in turn, may have been negatively related to participants' level of identification as Asians. Because East Asians tend to self-enhance to a lesser degree than do European Americans (Heine & Lehman, 1997), it may be that self-rated physics nonexperts were less American-identified than were self-rated experts. If this is so, then it may make sense that self-rated nonexperts, being not very American identified—and thus less likely to possess a dispositional folk physical theory—would not have been susceptible to the American prime. It follows from priming theory (Higgins, 1996) that one cannot prime a knowledge structure that an individual does not possess.

GENERAL DISCUSSION

The current research employed the knowledge-structure conception of culture in an examination of cultural influences on perceptions of physical events. First, we argued that different cultures instill their members with different folk theories of physics. Study 1 provided evidence for this claim: American and Chinese individuals were found to differ in their explanations for a number of physical events, with Americans favoring dispositional explanations compared to Chinese. Second, we argued that folk theories exert a causal influence on physical attributions. We tested this claim in Study 2 using a procedure designed to temporarily increase the accessibility of dispositional or contextual theories in individuals presumed to possess both (i.e., Chinese Americans). Chinese Americans whose Asian identity was primed were found to endorse dispositional explanations for physical events to a lesser extent, and contextual explanations to a greater extent, than did Chinese Americans whose American identity was primed.

Our findings concerning the role of formal instruction in physics help to reconcile the current results with previous psychological research in which no cultural differences in physical attribution were found (e.g., Michotte, 1963). In keeping with the folk theories approach, formal education might supplant or obscure the operation of folk theories and thus prevent the cultural difference from manifesting itself. In Study 1, we argued that cultural differences in folk physical theories emerged in part due to the fact that participants had no formal physics education. In Study 2, participants' background in physics was measured, consistent with the idea that physics instruction blocks the operation of folk physical theories, priming effects were found only for individuals who had taken few physics classes.

Continuity of Cultural Differences in Social Attribution and Physical Attribution

The present research provides evidence for a cultural difference in physical attribution analogous to a known cultural difference in social attribution. The dispositional-contextual (or internal-external) distinction, used here to distinguish between different kinds of attributions for objects' physical behavior, has a long history in the study of attributions for individuals' social behavior. Researchers studying social explanation often distinguish between internal attributions, which trace behavior to personal dispositions (e.g., personality traits or attitudes), and external attributions, which trace behavior to forces in the social environment (e.g., pressure from peers or authorities) (Gilbert & Malone, 1995).

Researchers studying social attribution have argued for the existence of robust biases in social explanation. For instance, lay perceivers often have been observed to favor internal (dispositional) explanations for others' behavior over situational explanations—an inferential tendency known as the "correspondence bias" or the "fundamental attribution error" (Ross & Nisbett, 1991). Although this tendency was once seen as a universal bias in social judgment (Heider, 1958; Ichheiser, 1949; Ross, 1977), more recent work in cultural psychology has recast dispositional bias as a culture-bound phenomenon (e.g., Miller, 1984; for a review, see Peng et al., 2001). Cross-cultural research suggests dispositional bias is less marked in East Asian cultures than in Western cultures, where most social psychological research has been conducted. A growing body of research using a variety of methods has demonstrated that East Asians are less apt to attribute behavior to an actor's personal dispositions, and more apt to attribute behavior to the situational context, than are members of Western cultures (Kitayama & Masuda, 1997; Knowles et al., 2001; Lee, Hallahan, & Herzog, 1996; Morris & Peng, 1994).

Analogous to this Asian-Western cultural difference in social attribution, the current research suggests that Americans favor internal/dispositional explanations for nonsocial events more than do Chinese, whereas Chinese prefer external/contextual explanations more than do Americans. Whether the parallel between cultural differences in social and physical perception reflect the operation of domain-general cognitive factors—such as dialectical versus linear (Peng & Nisbett, 1999) or holistic versus analytic (Nisbett, Peng, Choi, & Norenzayan, 2001) modes of thought—is an important question for future research.

Reconciling Developmental and Cultural Models of Causal Understanding

At first blush, the current studies might seem at odds with research into the development of physical understanding, which points to the existence of universal constraints guiding individuals' perceptions of physical events from a very early age (Carey & Spelke, 1994; Spelke, 1990). We argue, however, that no inherent tension exists between these developmental and cultural perspectives. First, the existence of cultural differences among adults in no way rules out the existence of universals among infants. Indeed, models of the development of social-causal explanation have explicitly included both early universals and later cultural differences. For instance, Miller (1984) argued that whereas early social inference may be constrained by universal cognitive processes, the influence of culture—as carried by folk theories—increases as individuals mature within their culture (Miller, 1984). The development of physical understanding might follow a similar pattern, in which cultural differences emerge only relatively late in development.

Second, as the influence of folk theories on physical perceptions increases over development, it need not be the case that universal perceptual and cognitive mechanisms stop operating. Indeed, there is no inherent contradiction between the types of cognitive constraints identified by developmental psychologists (e.g., the innate understanding, observed by Spelke, 1994, that two objects cannot occupy the same volume of space) and the types of divergent beliefs embodied in folk physical theories (i.e., that the behavior of objects is attributable primarily to their dispositions or to forces impinging on them from without). In other words, dispositional and contextual folk physics are equally consistent with the sorts of basic perceptual constraints identified by developmentalists.

Conclusion

The current research contributes to our understanding of how development within a particular social milieu (i.e., a culture) molds an individual's perceptions of his or her environment. Past research in the culture-as-theory tradition (e.g., Hong et al., 2000; Morris & Peng, 1994) suggests that culture—both national and ethnic—may profitably be construed as a constellation of folk theories governing one's basic understanding of the social world. The current research suggests that the influence of culturally instilled folk theories may extend further—specifically, to one's causal understanding of nonsocial (i.e., physical) events. At the same time, the current studies place caveats on when folk theories can and cannot be expected to exert influence on causal attributions. When formal theories in a domain are acquired, the influence folk understandings may wane.

NOTES

1. It should be noted that priming techniques have not been limited to research in the culture-as-theory tradition. Working within the self approach, Brewer and Gardner (1996; Gardner, Gabriel, & Lee, 1999) used linguistic cues to prime personal, relational, or collective self-definitions. Value theorists, in turn, have primed different cultural values using value-related cues (e.g., Trafimow, Triandis, & Goto, 1991).

2. Female spouses of Chinese students were selected due to the difficulty of finding Chinese students with no formal education in physics.

3. We see two possible artifactual reasons for the strong positive correlation between dispositional and contextual attribution scores. First, participants may have differed in the degree to which they saw the physical displays as requiring explanation; that is, some participants may have seen many causal factors at work in the displays (leading to relatively high ratings for all causes), whereas other participants saw only a few factors at work (leading to relatively low ratings for all causes). Second, participants may have differed in terms of acquiescence bias, leading them to favor either high ratings or low ratings across all causal factors. Thus, the positive association between dispositional and contextual attribution scores does not invalidate our claim that these modes of explanation are distinguishable and independent.

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