Cross-Cultural Sensitivity to Context when Reasoning about the Impossible

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Abstract

When judging the relative difficulty of impossible actions within the context of a magical world like that of Harry Potter, individuals honor real-world causal principles (e.g., assuming that heavier objects would be harder to levitate than lighter ones even though levitation itself is impossible; Shtulman & Morgan, 2017). We examined whether this effect persists when events are presented outside of this context. U.S. (Studies 1 and 2) and Chinese (Study 2) adults were asked to rate the relative difficulty of two impossible events that varied according to an irrelevant causal principle in one of three contexts: present science, future science, or magical. Though Chinese and U.S. adults honored irrelevant causal principles to a similar degree across the three contexts, Chinese adults' confidence in their judgments varied by context. Additionally, individual differences in cognitive reflection (U.S.) and fantasy engagement (Chinese) related to judgments. Findings indicate that adults honor irrelevant causal constraints when reasoning about the impossible across multiple contexts, though subtle differences exist at both the cultural and individual level.

Keywords: causal reasoning; scientific reasoning; magical reasoning; individual differences; cultures; possibility

Introduction

Novels, plays, and movies frequently depict impossible events: superheroes flying, objects disappearing, and potions making people fall in love. Although all of these events are impossible, we tend to view some of their variants as "more impossible" than others (Shtulman & Morgan, 2017). For example, it's impossible for a potion to make two people fall in love, but even more impossible if the two people are enemies. Shtulman and colleagues investigated this phenomenon in studies set in the magical world of Harry Potter (Shtulman & Morgan, 2017; Gong & Shtulman, 2020). Participants were asked to rate the relative difficulty of two spells from the Hogwarts curriculum that were impossible for the same reason (*primary causal principle*), but that differed on another feature related to common causal knowledge (a *secondary and thus irrelevant causal principle*). Participants regularly rated one spell as more difficult than another, even when they had the option to rate the two spells as equally difficult. Importantly, participants' tendency to do so tracked the secondary, irrelevant causal principle. For example, levitating a bowling ball was rated as more difficult than

levitating a basketball, which tracked the irrelevant principle that heavier objects are more difficult to lift. Related work by McCoy and Ullman (2019) found that individuals tend to rely on their intuitive theories of the world (e.g., intuitive physics) when judging the relative effort required for magical spells that cause various physical violations. These data provide valuable insight into our use of causal knowledge, indicating that we apply such knowledge even when reasoning about the impossible, at least within a magical context. Important follow-up questions are: (1) Does our application of this knowledge differ across contexts; (2) To what extent does this application vary across individuals and cultures?

A notable feature of the work by Shtulman and colleagues (though not that by McCoy & Ullman, 2019) is that participants were asked to reason about impossible events within the context of the Harry Potter universe—a magical world familiar to many (Shtulman & Morgan, 2017; Gong & Shtulman, 2020). Many possess knowledge of this context from the associated books and movies, where magic is presented as a skill taught in school, implying that some spells are harder than others. Evoking this context may therefore predispose participants to apply irrelevant causal constraints when reasoning about impossible events. Accordingly, in the present study we expanded on this work by decontextualizing participants' reasoning about impossible events from a school context to a more general magical world.

In addition, although some may be very familiar with the Harry Potter universe, we have no direct experience within it (e.g., as much as certain fans might hope otherwise, we have never tried to lift a bowling ball or a basketball using magic in Hogwarts Castle). We may therefore apply our causal knowledge differently within this context (and others outside of our experience) as compared to contexts with which we have more direct personal experience. This proposition aligns with the Construal-Level Theory (CLT) of psychological distance (Liberman & Trope, 1998; Trope & Liberman, 2010). According to CLT, psychological distance is egocentric, with the self in the present context
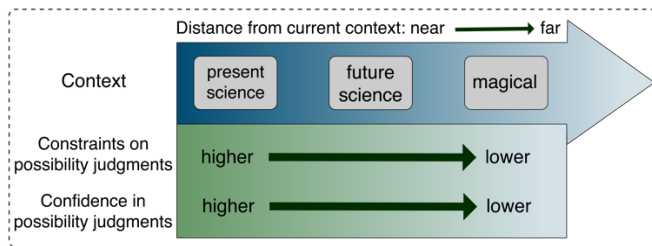
Figure 1: Schematic showing how psychological distance from one's current context may track perceived constraints on, and confidence in, possibility judgments.

constituting the reference point. Individuals think about events removed from this point (e.g., events that are temporally or hypothetically distant) by forming abstract mental representations of them. More distant events tend to be represented more schematically and concretely, with irrelevant or inconsistent details omitted (Fiske & Taylor, 1991; Trope & Liberman, 2010). CLT suggests that individuals may be less likely to apply real-world constraints when reasoning about contexts that are perceived as more distant (see relevant work by Bowman-Smith et al., 2019). We examined this possibility across two studies by comparing adults' tendency to honor irrelevant causal principles when reasoning about impossible events in three different contexts: *present science*, *future science*, and *magic*.

Importantly, we chose three contexts that lend themselves to a consideration of the extraordinary or impossible (many scientific breakthroughs were once considered impossible), but that differ in their psychological distance from the current context (i.e., participants' present experience). This difference between the contexts may impact perceived constraints on, and confidence in, possibility judgments within them (Figure 1). On the other hand, the stable mechanisms thought to underlie causal knowledge (Garcia-Retamero, 2007; Gopnik et al., 2004) may lead individuals to deploy their causal knowledge similarly across contexts. Testing these alternative predictions should provide additional insight into humans' use of causal knowledge when reasoning about the impossible.

The second goal of the present work was to examine individual (Studies 1 and 2) and cultural (Study 2) differences in reasoning about impossible events across contexts. We predicted greater cognitive reflection, engagement with make-believe/fantasy, and openness to experience would relate to less consideration of irrelevant causal principles. Greater cognitive reflection may help individuals correct intuitive responses based on irrelevant constraints, while greater make-believe/fantasy engagement and openness may help individuals engage with—and more accurately think about—contexts removed from the here and now.

We also reasoned that cultural differences in thinking styles may be impactful. In a prior study, Gong and Shtulman (2020) found that Chinese and U.S. adults honor irrelevant causal principles to a similar extent when reasoning about impossible events within the specific context of the Harry Potter universe. However, research indicates that East Asians and Westerners differ in how they assign causal attributions. Specifically, East Asians are more apt to consider a perceptual and conceptual field, basing their causal attributions more on the broader context. In contrast, Westerners tend to attend predominantly to a single focal object and its categorization when making causal attributions (Nisbett & Masuda, 2003). Based on these differences, we predicted that Chinese adults may be more sensitive to our context manipulation compared to U.S. adults, exhibiting greater variance in their tendency to honor irrelevant causal principles when reasoning about impossible events.

Study 1

Method

Participants Participants were 150 U.S. adults (M_{age} = 34.45, SD_{age} = 10.54, 70 female) recruited through Amazon Mechanical Turk (MTurk). An additional 62 were excluded for failing to pass attention check questions or complete the majority of study questions. Participants self-identified as White (75%), Hispanic or Latino (7%), Asian American (7%), Black (3%), and multiracial or "other" (8%). Participants received $1.50 for completing the study.

Materials and Procedure Participants first completed a *Reasoning Task* during which they were asked to reason about the relative difficulty of impossible events occurring within a specific context. The context they were asked to reason about was determined according to random assignment to one of three between-subjects conditions: a present scientific, future scientific, or magical context (see Table 1 for instructions by context condition).

After reading instructions, participants were shown 15 pairs of impossible events adapted from Shtulman and Morgan (2017) one at a time. Event pairs involved principles spanning three domains, consistent with the previous study:

Table 1: Reasoning task instructions by context condition.

Context condition	Instructions
Present science	Science is rapidly advancing. Today's scientists have a way to do all sorts of things that we previously could not. In this task, you will be presented with paired statements describing different things that scientists might be able to do in today's world. For each pair, please indicate which would be more difficult for scientists to do.
Future science	Consider a future world, where scientists have a way to do all sorts of things that we cannot. In this task, you will be presented with paired statements describing different things that scientists might be able to do in that future world. For each pair, please indicate which would be more difficult for scientists to do.
Magical	Consider a magical world, where wizards have a way to do all sorts of things that we cannot. In this task, you will be presented with paired statements describing different things that wizards might be able to do in that magical world. For each pair, please indicate which would be more difficult for wizards to do.

five involved principles of physics (e.g., making a tree vs. a bush invisible), five involved principles of biology (e.g., turning a person into a pig vs. into a monkey), and five involved principles of psychology (e.g., making a person forget their own name vs. their phone number). Each pair violated a deep-seated causal principle (making the two events impossible for the same reason), but differed on a surface property related to a subsidiary principle (the irrelevant causal principle). For each pair, participants made a difficulty judgment, judging which of the two events would be more difficult to perform, or whether they would be equally difficult. They then indicated their confidence in their judgment (selecting whether they were "not at all sure", "a little sure", or "very sure" of their answer).

Reasoning Task responses were given causal principle scores, reflecting the degree to which participants honored the irrelevant causal principle in accordance with Shtulman and Morgan (2017). Responses identifying the more extreme event as more difficult (e.g., reporting it would be more difficult to make a bowling ball versus basketball float) received a '1', since this response honors the irrelevant causal principle (i.e., bowling balls are heavier than basketballs). All other responses received a score of '0' (e.g., reporting the reverse, or that the two events would be equally difficult). Independent of these scores, confidence ratings were scored '0' if not at all sure, '1' if a little sure, and '2' if very sure.

Following the Reasoning Task, participants completed a battery of four *Individual Difference Measures* in a fixed order. This battery included a modified version of the three-item Cognitive Reflection Task (CRT; Frederick, 2005), which was administered to assess the tendency to engage in cognitive reflection. During this task, participants were asked to solve three word problems. Importantly, the correct response for each problem required overriding an incorrect intuitive response to reflect on what the problem was actually asking. Participants' responses were scored '0' (incorrect) or '1' (correct), with the mean across the three questions constituting their overall CRT score.

Three additional measures were used to assess participants' engagement with make-believe, engagement with fantasy content, and openness. To assess engagement with make-believe, we administered the make-believe subscale of the Creative Experiences Questionnaire (CEQ; Merckelbach, et al., 2001). It consists of five statements describing make-believe thoughts, feelings, and behaviors. Participants reported how much they agreed with each statement on a 5-point Likert scale ranging from '1' (strongly disagree) to '5' (strongly agree). Their mean response across items constituted their CEQ make-believe score, with higher scores reflecting greater engagement with make-believe.

To assess engagement with fantasy content, we created a Fantasy Engagement Questionnaire, which included three questions probing the frequency with which individuals read fantasy books, watched fantasy media, and participated in fantasy role-playing games such as Dungeons and Dragons. Participants responded to each question on a 5-point Likert scale ranging from '1' (never) to '5' (more than weekly).

Their mean response across questions constituted their fantasy engagement score, with higher scores reflecting greater engagement with fantasy.

Finally, the openness subscale of the Big Five Inventory-10 (BFI-10; Rammstedt & John, 2007) was administered to assess imaginativeness, curiosity, and open-mindedness. It consists of two items describing these personality features. Participants reported the degree to which each statement described themselves on a 5-point Likert scale ranging from '1' (strongly disagree) to '5' (strongly agree). The mean response across items constituted their openness score, with higher scores reflecting greater openness.

Results and Discussion

Preliminary analyses confirmed experimental groups were similar in age, gender, and education level ($ps \geq .212$).

Reasoning Task Performance We first examined whether participants honored irrelevant causal principles when reasoning about impossible events collapsing across context and domain conditions (see Table 2, Study 1 for descriptives). A one-sample *t*-test on causal principle scores showed that they did so at rates significantly greater than chance (33%), $t(149) = 7.62$, $p < .001$, replicating the findings of Shtulman and colleagues (Shtulman & Morgan, 2017; Gong & Shtulman, 2020).

Having established that participants honored irrelevant causal principles, we next examined whether their tendency to do so differed by context and domain. Causal principle scores were entered into a 3 (context: present science, future science, magical) x 3 (domain: biology, physics, psychology) mixed-effects ANOVA. Results showed no significant effect of context ($F(2,147) = 1.85$, $p = .161$, $\eta_p^2 = .030$), domain ($F(2,147) = 0.51$, $p = .603$, $\eta_p^2 = .003$), or their interaction ($F(4,294) = 0.62$, $p = .646$, $\eta_p^2 = .008$).

Though our manipulation did not affect participants' tendency to honor irrelevant causal principles in their difficulty judgments, it could still have influenced their confidence in these judgments. We examined this possibility by entering mean confidence ratings into a 3 (context: present science, future science, magical) x 3 (domain: biology,

Table 2: Proportion of participants who honored an irrelevant causal principle in their judgments of event difficulty.

Study	Sample	Domain	Context		
			Present Science	Far Science	Magical
1	U.S. MTurk	Physics	0.43	0.48	0.47
		Biology	0.41	0.55	0.50
		Psychology	0.44	0.53	0.47
		Overall	0.42	0.52	0.48
2	U.S. students	Physics	0.45	0.46	0.46
		Biology	0.52	0.55	0.48
		Psychology	0.49	0.45	0.45
		Overall	0.49	0.49	0.46
	Chinese students	Physics	0.36	0.37	0.36
		Biology	0.49	0.53	0.55
		Psychology	0.58	0.61	0.57
		Overall	0.47	0.50	0.49

physics, psychology) mixed-effects ANOVA. Results showed no significant effect of context (present science: M=1.47, SD=.40, future science: M=1.46, SD=.29, magical: M=1.39; SD=47; $F(2,147) = 0.62$, $p = .539$, $\eta_p^2 = .008$), domain (biology: M=1.42, SD=.47, physics: M=1.46, SD=.45, psychology: M=1.45, SD=.40; $F(2,147) = 0.35$, $p = .707$, $\eta_p^2 =.002$), or their interaction ($F(4,294) = 0.32$, $p = .863$, $\eta_p^2 = .004$) on mean confidence ratings.

In summary, participants honored irrelevant causal principles similarly and with comparable confidence across different contexts and domains.

Examination of Individual Differences We next examined whether individual differences in cognitive reflection, make-believe engagement, fantasy engagement, and openness predicted participants' tendency to honor irrelevant causal principles when reasoning (see Table 3, Study 1 for descriptives).

Table 3: Means and SDs for individual difference measures by study and sample, plus the effect of culture in Study 2.

Table 4: Mean scores and SDs (in parenthesis) for secondary measures reported by study and sample, as well as the effect of culture in Study 2.

Measure	Study 1	Study 2		
	U.S. MTurk	U.S. students	Chinese students	Effect of culture (p)
CRT	0.63 (0.39)	0.44 (0.40)	0.68 (0.31)	< 0.001
CEQ make-believe	2.70 (0.88)	2.77 (0.85)	3.03 (0.88)	0.004
fantasy engagement	2.23 (0.84)	2.02 (0.69)	1.82 (0.70)	0.004
openness	3.21 (0.57)	3.28 (0.78)	2.86 (0.57)	< 0.001

Note. CRT scores ranged from 0 (incorrect) to 1 (correct). Scores for all other variables ranged from 1 (low) to 5 (high).

Since the influence of these factors could vary by the context about which one is reasoning, we took a model comparison approach. Our base linear regression model included age CRT, CEQ make believe, fantasy engagement, openness, and context condition (present science, far science, magical) as predictors of causal principle scores. We compared this base model against an interaction model that added interactions between the individual difference measures and context condition. Adding these interaction terms did not result in a better model fit ($p = .176$). The best fitting model was therefore our base model (Table 4), which showed that CRT

Table 4: Linear model results for predicting causal principle scores in Study 1.

Variable	Estimate	*SE*	*t*-value
(Intercept)	0.49	0.03	15.51***
age	0.00	0.00	-1.13
CRT	0.16	0.05	3.05**
CEQ make-believe	-0.01	0.02	-0.28
fantasy engagement	-0.01	0.02	-0.54
openness	-0.04	0.03	-1.27
context *(reference: magical)*			
present science	-0.07	0.05	-1.45
far science	0.03	0.04	0.66
F-value		2.59*	
Adjusted R2		0.07	

Note: SE = standard error. ***p <.001. **p <.01. *p <.05.

positively predicted causal principle scores ($p = .003$). Participants who engaged in greater cognitive reflection were more apt to honor the irrelevant causal principles when reasoning. No other predictors were significant ($ps > .148$).

Study 2

The goal of Study 2 was to examine potential cross-cultural differences in reasoning about impossible events across contexts.

Method

Participants Participants were 226 U.S. college students in Austin, TX and 183 Chinese college students in Wuhan, China ($M_{age}= 20.27$, $SD_{age}= 2.03$, 314 female). An additional 69 were excluded for failing to pass attention check questions or complete the majority of study questions. Approximately half (44%) of the U.S. participants opted not to identify their racial or ethnic background, with the remaining proportion self-identifying as White (22%), Hispanic or Latino (13%), Asian American (10%), Black (2%), Middle Eastern or North African (1%), and multiracial or "other" (8%). The Chinese participants self-identified as Han (90%), Hui (2%), Man (2%), Miao (2%), Zhuang (2%), and either Gelao, Menggu, Tu, or Yao (<1% each). All participants were recruited through psychology courses, primarily pursuing non-STEM degrees, and received extra credit for their participation.

Materials and Procedure Materials and procedure were identical to those in Study 1. A Chinese version of all materials was created with the assistance of a Chinese native fluent in Chinese and English.

Results and Discussion

Our analytic approach was identical to that of Study 1 with the exception that the effect of culture was also examined. Preliminary analyses confirmed that experimental groups were similar in age, gender, and education level ($ps \geq .179$).

Reasoning Task Performance Analyses of Reasoning Task Performance first examined whether both U.S. and Chinese students honored irrelevant causal principles when reasoning about impossible events collapsing across context and domain conditions (see Table 2, Study 2 for descriptives). A one-sample t-test on the causal principle scores for each culture showed that they both did so at rates significantly greater than chance (33%), $ts(182-225) \geq 9.72$, $ps < .001$.

Having established that U.S. and Chinese students honored irrelevant causal principles, we next examined whether their tendency to do so differed by culture, context, and domain. Causal principle scores were entered into a 2 (culture: U.S., Chinese) x 3 (context condition: present science, future science, magical) x 3 (domain: biology, physics, psychology) mixed-effects ANOVA. We found a main effect of domain ($F(2,806) = 38.90$, $p < .001$, $\eta_p^2 = .09$) that was further qualified by a domain x culture interaction, $F(2,402) = 26.27$,

$p < .001$, $\eta_p^2 = .12$ (Figure 2). Simple effects analyses showed a difference in the extent to which the U.S. and Chinese students honored the irrelevant causal principles within the psychology and physics domains (ps $<$ .001), but not the biology domain ($p = .932$). Compared to U.S. students, Chinese students honored the irrelevant causal principle more in the psychology domain and less in the physics domain.

The patterns within each culture also differed. Chinese students honored the irrelevant causal principle to a different degree within each of the three domains—doing so most in the psychology domain, less so in the biology domain, and least in the physics domain (psychology > biology, $p = .005$; psychology & biology > physics, ps $< .001$). In contrast, U.S. students were less varied across the three domains. While they honored the irrelevant causal principle more in the biology domain compared to the physics and psychology domains (ps $\leq .002$), they did so to a similar extent within the latter two domains ($p = .308$).

In summary, U.S. and Chinese students honored irrelevant causal principles similarly across contexts, but differed in the extent to which they did so across domains. Compared to U.S. students, Chinese students honored the irrelevant causal principle more in the psychology domain and less in the physics domain. They were also more sensitive to differences between domains compared to U.S. students.

We next examined whether the confidence with which participants reasoned about events differed by culture, context, and domain. Mean confidence ratings were entered into a 2 (culture: U.S., Chinese) x 3 (context condition: present science, future science, magical) x 3 (domain: biology, physics, psychology) mixed-effects ANOVA. We found a significant effect of culture ($F(1,403) = 16.18$, $p < .001$, $\eta_p^2 = .04$) that was further qualified by a culture x context interaction ($F(2,403) = 3.78$, $p = .024$, $\eta_p^2 = .02$) (Figure 3). Simple effects analyses showed that Chinese students were more confident than U.S. students when reasoning about both scientific contexts (ps $\leq .001$), but not when reasoning about a magical context ($p = .909$). Chinese students' confidence ratings also differed by context ($F(2,180) = 3.80$, $p = .024$, $\eta_p^2 = .04$) such that they were more confident when reasoning about both scientific contexts than
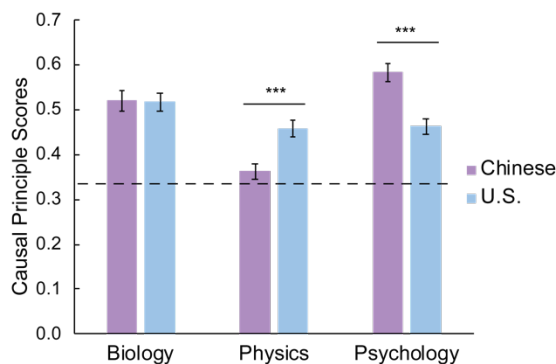

Figure 2: Culture x domain interaction on causal principle scores. Mean $\pm$ SE. Dashed line represents chance performance. ***$p < .001$.
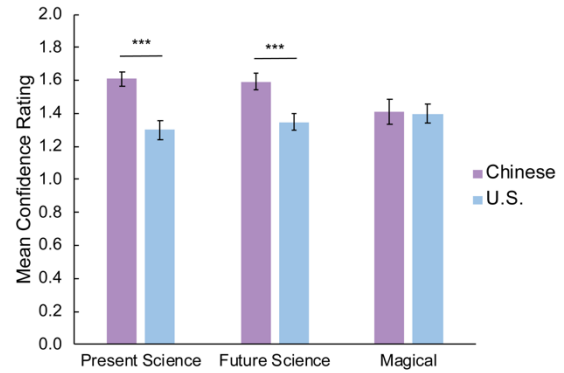

Figure 3: Culture x context interaction on mean confidence rating. Mean $\pm$ SE. ***$p \leq .001$.

the magical context (ps $\leq .046$). In contrast, U.S. students were similarly confident across all three contexts ($F(2,223) = 0.76$, $p = .469$, $\eta_p^2 = .01$).

We also found a main effect of domain ($F(2,806) = 7.55$, $p = .001$, $\eta_p^2 = .02$) that was further qualified by a domain x culture interaction ($F(2,402) = 7.94$, $p < .001$, $\eta_p^2 = .04$). Though Chinese students were more confident than U.S. students overall, they were especially so within the biology and psychology domains (ps $< .001$ vs. $p = .049$ for the physics domain). The patterns also differed within each culture. Chinese students' confidence ratings were sensitive to domain ($F(2,364) = 13.61$, $p < .001$, $\eta_p^2 = .07$) such that they were more confident within the biology and psychology domains compared to the physics domain (ps $< .001$). In contrast, U.S. students were similarly confident across domains ($F(2,450) = 0.30$, $p = .742$, $\eta_p^2 = .001$). No other effects were significant (ps $\geq .117$).

In summary, the confidence with which Chinese students reasoned was sensitive to both context and domain, whereas U.S. students were similarly confident across contexts and domains. In addition, Chinese students were more confident than U.S. students when reasoning about scientific—but not magical—contexts, especially within the biology and psychology domains.

Examination of Individual Differences We next examined whether individual differences in cognitive reflection, make-believe engagement, fantasy engagement, and openness predicted participants' tendency to honor irrelevant causal principles when reasoning (see Table 3, Study 2 for descriptives). Given our cross-cultural sample, we examined whether the influence of these factors varied by both context condition and culture. We again took a model comparison approach. Our base linear regression model included age, CRT, CEQ make believe, fantasy engagement, openness, context condition (present science, far science, magical), and culture (U.S., Chinese) as predictors of causal principle scores. We compared this base model against models that added interactions between the individual difference measures and other variables. Model 1 added two-way interactions with context condition, model 2 added two-way

Table 5: Linear model results for predicting causal principle scores in Study 2.

Predictor	Estimate	SE	t-value
(Intercept)	0.40	0.04	8.88***
age	0.01	0.01	1.97*
CRT	0.02	0.04	0.60
CEQ make-believe	0.02	0.02	1.19
fantasy engagement	0.03	0.02	1.41
openness	-0.03	0.02	-1.82+
culture *(reference: U.S.)*			
Chinese	0.01	0.04	0.27
context *(reference: magical)*			
present science	0.02	0.04	0.65
far science	0.02	0.04	0.56
culture x context *(reference: Chinese x magical)*			
Chinese x present science	-0.05	0.05	-1.02
Chinese x far science	0.00	0.05	-0.06
culture x CRT	0.04	0.06	0.65
culture x CEQ	-0.03	0.03	-1.23
culture x fantasy engagement	-0.09	0.03	-2.87**
culture x openness	0.00	0.03	-0.02
F-value			1.67+
Adjusted R2			0.02

Note: SE = standard error. ***p <.001. **p <.01. *p <.05. +p <.10.

interactions with culture, and model 3 added three-way interactions with context condition and culture. We found that model 2 resulted in a marginally better fit than the base model (p = .050). Model 1 did not result in a better fit than the base model, and model 3 did not result in a better fit than model 2 (ps > .687). The best fitting model was therefore model 2 (Table 5), which revealed a significant negative interaction between culture and fantasy engagement on causal principle scores (p = .004). According to this interaction, Chinese students who engaged more with fantasy content were less apt to honor the irrelevant causal principles when reasoning overall. Age also emerged as a significant predictor (p = .049), indicating that older students were more likely to honor the irrelevant causal principles. A nonsignificant trend for openness to negatively predict causal principle scores suggests that this variable may have also been impactful (p = .069). No other predictors approached significance (ps > .161).

General Discussion

Across two studies, we replicated prior work (Shtulman & Morgan, 2017; Gong & Shtulman, 2020) showing that individuals honor irrelevant causal principles when reasoning about impossible events within magical contexts, leading to graded notions of impossibility. We also extended this work by showing that individuals do so not only within the context of a specific magical world, but also within both present and far scientific contexts. That both U.S. and Chinese participants applied irrelevant causal knowledge similarly across these three contexts suggests that humans are strongly inclined to evoke causal knowledge—even if irrelevant—when reasoning about impossibility in general. This is perhaps reasonable given that a touted benefit of causal knowledge is the ability to make predictions about actions without ever having observed them (Buchsbaum et al., 2012),

and that the "impossible" is by definition something we have never observed. Indeed, impossible events may be especially likely to evoke such knowledge.

Though Chinese students' difficulty judgments were similar across contexts, their confidence in these judgments was not. They reported higher confidence in scientific vs. magical contexts, demonstrating a sensitivity to context that was absent in both U.S. samples. One possible explanation is that this difference reflects underlying differences in the cultures' attitude toward science. While a growing proportion of the U.S. population distrusts science (Miller et al., 2006), over 90% of Chinese individuals view scientists as role models (Li, 2011). This difference in scientific attitude may also explain why Chinese students' confidence ratings were higher than those of Americans within the two scientific contexts. Another possibility is that the confidence ratings of the two cultures varied due to underlying differences in reasoning styles. This possibility aligns with research showing that East Asians are often more apt to consider the broader context when making causal attributions, whereas Westerners tend to focus predominantly on one focal object, attending less to the context (Nisbett & Masuda, 2003). This difference may explain why only the Chinese students' confidence ratings were sensitive to context.

Chinese students also demonstrated greater sensitivity to the domain manipulation than did U.S. students. While Chinese students' causal principle scores and confidence ratings varied based on whether physical, biological, or psychological principles were invoked, those of U.S. students did so only minimally (and only in Study 2). This pattern provides additional support for a potential difference in reasoning style between the two cultures, with the U.S. sample less likely to take into account a conceptual field (i.e., scientific domain) when reasoning about the impossible.

A final goal of this study was to examine whether individual differences in cognitive processes and experiences relate to reasoning about the impossible. Study 1 found that Americans who engaged in greater cognitive reflection were more likely to honor irrelevant causal principles. This was surprising, as we had expected that greater cognitive reflection would enable participants to override or correct intuitive responses based on irrelevant constraints. Study 2 did not replicate this finding. Study 2 did, however, show that greater engagement with fantasy content in Chinese students predicted less consideration of irrelevant causal principles. However, this relation was not observed in US participants. Future work is needed to clarify the role of these factors in reasoning about the impossible.

Though the impossible is absolute, our findings suggest that reasoning about it is not. There appears to be a strong and widespread tendency to honor irrelevant causal constraints when reasoning about the impossible across multiple contexts. And yet, subtle differences exist at both the cultural and individual level. Future work that examines the functional consequences of this variability could provide valuable insight into how differences in reasoning about the impossible impact the world in which we live.

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