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The Plausible Impossible: Chinese Adults Hold Graded Notions of Impossibility

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Abstract

Events that violate the laws of nature are, by definition, impossible, but recent research suggests that people view some violations as "more impossible" than others (Shtulman & Morgan, 2017). When evaluating the difficulty of magic spells, American adults are influenced by causal considerations that should be irrelevant given the spell's primary causal violation, judging, for instance, that it would be more difficult to levitate a bowling ball than a basketball even though weight should no longer be a consideration if contact is no longer necessary for support. In the present study, we sought to test the generalizability of these effects in a non-Western context – China – where magical events are represented differently in popular fiction and where reasoning styles are often more holistic than analytic. Across several studies, Chinese adults (n = 466) showed the same tendency as American adults to honor implicit causal constraints when evaluating the plausibility of magical events. These findings suggest that graded notions of impossibility are shared across cultures, possibly because they are a byproduct of causal knowledge.

Keywords

causal reasoning – magical reasoning – imagination – intuitive theories

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1 Introduction

Magical events, popular in fictional works from Disney animations to the Harry Potter novels, reveal the richness and inventiveness of the human imagination. Humans are able to conceive of events that have not occurred – and could never occur – because they violate the laws of nature. Talking animals, flying carpets, and invisibility potions may fill the pages of storybooks, but they are possible only in the imagination.

Acts of imagination may be fanciful but they are not random or unpredictable. From an early age, we apply causal principles to imaginary events, such as when we apply our knowledge of liquids to the act of pouring imaginary tea into a teacup (Harris, 2000), and we use imaginary events to learn more about causal principles, such as when we exercise our theory of mind by interacting with imaginary companions (Weisberg & Gopnik, 2013). Children as young as two can infer the causal implications of a series of pretend actions, recognizing that if a paintbrush is dipped into pretend paint and then brushed over a toy pig, the pig will now be covered in paint (Harris, Kavanaugh, & Meredith, 1994). Children as young as three can model complex causal systems in their pretend play, readily substituting pretend objects for real objects and discriminating causally efficacious actions from ineffective ones (Buchsbaum, Bridgers, Weisberg, & Gopnik, 2012).

Adults honor causal constraints in their reasoning about imaginary events as well. When reasoning about imaginary worlds, we assume that scientific facts remain true even if conventional or circumstantial facts do not (Weisberg & Goodstein, 2009), and we find it harder to imagine worlds with different mathematical rules, such as a world where 5 + 7 no longer equals 12, than worlds with different empirical regularities, such as a world where Woolley Mammoths terrorize Las Vegas (Barnes & Black, 2016). When generating examples of imaginary creatures, we import the properties of real creatures, like bilateral symmetry and cephalization (Ward, 1994), and when generating examples of imaginary toys, we import the properties of real toys, like balls and remotes (Smith, Ward, & Schumacher, 1993).

Adults apply causal constraints to imaginary events even when those constraints are logically precluded by the events under consideration. Consider the imaginary event of levitating an object above the ground. This event violates the principle of support – that unsupported objects fall – and is impossible regardless of the object's weight, but depictions of levitation in fiction imply that heavy objects are harder to levitate than light ones. In the Star Wars movies, Luke Skywalker learns to levitate stones before learning to levitate

a starship, and in the Harry Potter novels, Harry learns to levitate a feather before learning to levitate a book.

Shtulman and Morgan (2017) explored the prevalence and consistency of this intuition in American adults. They created pairs of spells that violated a primary causal principle (e.g., support, in the case of levitation) but varied with respect to a secondary causal principle (e.g., weight). They then asked participants which spell would be more difficult to learn, if the spells were part of the curriculum at Hogwarts School of Witchcraft and Wizardry from the Harry Potter novels. Most adults took the secondary causal principle into consideration, judging that a spell for levitating a bowling ball would be more difficult to learn than a spell for levitating a basketball. And they expressed that judgment under many circumstances: when asked to select which of the two spells would be more difficult, when asked to rate the difficulty of each spell side-by-side, when asked to rate the difficulty of each spell on its own, when asked to explain why one spell would be more difficult than the other, and when asked to generate their own examples of easy-to-difficult spells.

The participants in Shtulman and Morgan's study made these judgments for spells that violated a wide range of principles, including physical principles (e.g., shrinking an object to half it size, making an object invisible), biological principles (e.g., growing an extra organ, reversing the aging process) and psychological principles (e.g., instantly increasing a person's mental capacities, endowing an animal with human-like mental capacities). Across domains and principles, participants consistently viewed some causal violations as more plausible than others.

The animator Walt Disney recognized this intuition in his audience and termed it a preference for "the plausible impossible" (Lane, 2006). Here, we assess whether Chinese adults, like American adults, also hold intuitions about plausible impossibility. One reason they may not is that Chinese adults are exposed to a very different tradition of fiction. Magical events are present in East Asian fiction, just as they are in Western fiction, but they do not cluster in a distinct genre (Gu, 2006; Idema & Haft, 1997). The genre characterized by magical events in Western fiction is known as "fantasy," which is a form of "speculative fiction." Other genres of speculative fiction include science fiction, gothic fiction, dystopian fiction, apocalyptic fiction, horror, cyberpunk, and alternate history. Each genre has its own norms and prototypes, and exposure to those genres shapes expectations about the kinds of events encountered therein (Kibbe, Kreisky, & Weisberg, 2018). Graded notions of impossibility may be common in the US because they are common in Western fantasy, and individuals with less exposure to that genre may not hold the same intuitions.

Another reason Chinese adults may not view impossible events similarly to American adults is that Easterners and Westerners often adopt different thinking styles in general (Nisbett, Peng, Choi, & Norenzayan, 2001). Westerners gravitate toward an analytic style, approaching problems or observations by decomposing them into smaller parts and analyzing each component with formal logic, while Easterners gravitate toward a holistic style, situating the same phenomena in the entire field and figuring out the continuity and relationship among objects and events. For instance, Easterners are more likely to detect the covariation among objects in a series of events, while Westerners are more adept at orienting a focal object independent of its background (Ji, Peng, & Nisbett, 2000). With respect to fiction, analytic and holistic thinking styles may lead to different ways of evaluating magical events. Those who adopt a holistic thinking style may be less inclined to dissect magical events into their component parts and thus less inclined to notice or care about peripheral considerations, such as whether a levitated object is heavy or light.

That said, a reason to suspect cross-cultural similarities in the evaluation of magical events is that these evaluations may draw upon shared forms of knowledge, namely, causal knowledge. Causal knowledge is what allows us to discriminate possible events from impossible ones (Shtulman & Carey, 2007; Shtulman & Phillips, 2018), and this knowledge may also be responsible for the intuition that some impossible events are more impossible than others. Research on the structure of causal knowledge suggests that it is organized in coherent networks of domain-specific beliefs, known as "intuitive theories" (Carey, 2009; Shtulman, 2017). Intuitive theories support a variety of inferences, from explanation to prediction to counterfactual reasoning (Gopnik & Wellman, 2012). They are constructed early in development and share many similarities across cultures (Vosniadou, 2008).

Intuitive theories are used to understand natural events, but they might also be used to understand magical events. Levitation, for instance, likely triggers our intuitive theories of motion. Such theories encompass expectations about several factors that influence motion, including force, speed, momentum, weight, contact, and support. If one expectation is violated, such as the expectation that objects require contact to be set in motion, people may continue to apply other expectations to the same event, such as the expectation that heavy objects are harder to move than lighter objects. On this account, impossible events are deemed plausible if they continue to conform to the larger network of causal expectations encompassing the specific expectation violated.

In the present research, we investigated the cross-cultural consistency in how people reason about magical events by replicating Shtulman and

Morgan's (2017) spell-judgment experiments in a Chinese sample. We used the same spells to preserve the fidelity of the replication. Those spells were translated into Chinese and then back-translated into English by two Chinese natives proficient in both Chinese and English. The final Chinese version was then improved by discussing discrepancies between the original and back-translated versions. The English and Chinese versions of each spell are listed in Table 1.

TABLE 1 The six pairs of spells in each domain and their Chinese translation. Spells are grouped by the irrelevant causal constraint they embody.

Domain	Causal constraint	Spell
Physics	Object size	Making a (bush, tree) invisible 让 (灌木丛, 树林) 隐形
	Object weight	Making a (basketball, bowling ball) float in the air 让 (篮球, 保龄球) 漂浮在空中
	Object shape	Turning a broom into a (shovel, bucket) 把扫帚变成 (铲子, 桶)
	Object complexity	Shrinking a (chair, computer) to half its size 将 (椅子, 电脑) 缩小成原先的一半
	Object density	Walking through a wall made of (wood, stone) 穿过由 (木头, 石头) 制成的墙壁
	Object value	Turning a lump of coal into a lump of (silver, gold) 把一块煤变成一块 (银, 金)
Biology	Evolutionary similarity	Turning a person into a (monkey, pig) 把一个人变成一只 (猴子, 猪)
	Developmental similarity	Turning an adult back into a (teenager, child) 把一个成年人变回 (青少年, 儿童)
	Ailment severity	Curing a person's (hiccups, arthritis) 治愈一个人的 (打嗝, 关节炎)
	Organ size	Mending a broken (finger, arm) 修复一个断掉的 (手指, 手臂)
	Organ complexity	Growing an extra (toe, eye) 长出一只额外的 (脚趾, 眼睛)
	Organ plasticity	Making a person's (hair, teeth) grow longer 让一个人的 (头发, 牙齿) 变长

TABLE 1 The six pairs of spells in each domain and their Chinese translation (*cont.*)

Domain	Causal constraint	Spell
Psychology	Knowledge entrenchment	Making a person forget his own (phone number, name) 让一个人忘记自己的 (手机号, 名字)
	Knowledge complexity	Teaching a monkey to do (arithmetic, calculus) 教猴子做 (算数, 微积分)
	Skill difficulty	Teaching a cow how to (skip, tap dance) 教奶牛 (跳跃, 踢踏舞)
	Affect intensity	Making someone (smile, laugh) 让一个人 (微笑, 狂笑)
	Trait stability	Increasing a person's (memory, intelligence) 增加一个人的 (记忆力, 智力)
	Language comprehension	Teaching a person to (read, speak) a foreign language 教一个人 (阅读, 说) 一门外语

The spells were selected to represent six causal constraints in each of three causal domains: physics, biology, and psychology. The motivation behind sampling a variety of constraints and domains was to establish the generality of the target intuition. We do not explore differences between domains because the items were selected for coverage, not discriminability, and we had no expectation that the target intuition would differ by domain. That said, we did explore the consistency of item effects from one study to another, to determine whether differences in the strength of participants' intuitions remained constant across different task demands.

Shtulman and Morgan recruited samples of 32 per study (or condition), which we increased to 50 following a power analysis in G*Power, assuming a medium size effect (d = .5) and a power of 0.90. Additional participants were recruited for Study 4 because the task was open-ended, and we wanted to establish a sufficiently large database of codable responses. Participants were recruited through social-media advertisements. All participants were undergraduate or graduate students from universities in China, studying engineering, science, medicine, or the liberal arts. They completed the study online and were paid for their participation. No participant took part in more than one study. Data for all studies can be found on the Open Science Framework: https://osf.io/vk6am/.

2 Study 1

2.1 *Method*

One-hundred students participated in Study 1 (M_{age} = 21.92, SD_{age} = 2.65, 69 female), half in Study 1A and half in Study 1B. They were shown the 18 pairs of spells in Table 1, described as part of the curriculum at Hogwarts School of Witchcraft and Wizardry, and were asked to indicate which spell in each pair would be more difficult to learn – for instance, whether it would be more difficult to learn a spell for growing an extra toe or a spell for growing an extra eye. Spell pairs were presented in one of two random orders, and the ordering of spells within those pairs was randomized as well. Half the participants were required to make a forced choice (Study 1A), and half were given the option of selecting "equally difficult" (Study 1B). The spells were designed to embody an implicit causal constraint – a constraint not violated by the spells but potentially seen as relevant to them – and participants were expected to honor that constraint in their judgment.

2.2 *Results and Discussion*

In Study 1A, participants' judgments of spell difficulty aligned with the spells' implicit causal ordering 79% of the time for physical spells, 81% of the time for biological spells, and 74% of the time for psychological spells (see Table 2). All percentages were greater than 50%, or that expected by chance (physics: $t(49) = 10.97$, $p < .001$; biology: $t(49) = 10.14$, $p < .001$; psychology: $t(49) = 8.50$, $p < .001$). Most participants (78%) demonstrated the anticipated effect for a significant number of spell pairs (13 or more, binomial probability < .05), and most spell pairs (89%) elicited the anticipated effect for a significant number of participants (32 or more, binomial probability < .05).

In Study 1B, participants' judgments of spell difficulty aligned with the spells' implicit causal ordering 42%, 54% and 61% of the time for physical, biological, and psychological spells, respectively (see Table 2). All percentages were greater than 33%, which constituted chance-responding given the third option of "equally difficult" (physics: $t(49) = 2.40$, $p < .05$; biology: $t(49) = 5.25$, $p < .001$; psychology: $t(49) = 6.99$, $p < .001$). Fifty percent of participants demonstrated the anticipated effect for a significant number of spell pairs (10 or more, binomial probability < .05), and 72% of spell pairs elicited the anticipated effect for a significant number of participants (23 or more, binomial probability < .05). In sum, participants used ostensibly irrelevant causal constraints to evaluate magical events, both in the forced-choice test (Study 1A) and in the more stringent test where they could skip that evaluation if they saw no basis for making it (Study 1B).

TABLE 2 The proportion of participants who honored an irrelevant causal constraint in their judgments of spell difficulty. Proportions greater than that expected by chance (50% for Studies 1A and 5, 33% for Studies 1B and 2) are marked with asterisks.

Domain	Causal constraint	Study 1A	Study 1B	Study 2
Physics	Object size	.76*	.54*	.66*
	Object weight	.84*	.46*	.58*
	Object shape	.88*	.32	.42
	Object complexity	.68*	.28	.52*
	Object density	.90*	.68*	.50*
	Object value	.68*	.24	.30
Biology	Evolutionary similarity	.68*	.16	.32
	Developmental similarity	.74*	.38	.52*
	Ailment severity	.80*	.80*	.76*
	Organ size	.76*	.60*	.60*
	Organ complexity	.92*	.50*	.74*
	Organ plasticity	.94*	.80*	.86*
Psychology	Knowledge entrenchment	.86*	.64*	.74*
	Knowledge complexity	.92*	.72*	.92*
	Skill difficulty	.78*	.70*	.86*
	Affect intensity	.50	.48*	.42
	Trait stability	.76*	.64*	.58*
	Language comprehension	.62	.50*	.52*

3 Study 2

3.1 *Method*

Study 2 was designed to replicate Study 1B's results, while also verifying that participants based their judgments on the causal constraints listed in Table 1 and not some other consideration. Fifty participants (M_{age} = 21.58, SD_{age} = 1.64, 32 female) judged the difficulty of 18 spells, with the option of selecting "equally difficult," and then provided an explanation for their judgments.

Explanations were coded for reference to the target causal constraint. For example, explanations for the spell pair "shrinking a (chair, computer) to half its size" were coded for reference to the relative complexity of chairs versus computers; "computers contain more precise components than chairs" was

coded as meeting this criterion, while "both spells involve the volume decrease" was not. Explanations for the spell pair "turning an adult back into a (teenager, child)" were coded for reference to the developmental similarity between adults, teenagers, and children; "adults and teenagers are different only mentally while adults and children are different both mentally and physically" was coded as meeting this criterion, while "time is irreversible, so both spells are impossible" was not. Two judges coded all explanations independently. They agreed on 88% of their codes (Cohen's kappa = .75), and disagreements were resolved through discussion.

3.2 *Results and Discussion*

Participants' judgments of spell difficulty aligned with the spells' implicit causal ordering more often than expected by chance (33%): 50% of the time for physical spells ($t(49) = 3.81$, $p < .001$), 63% of the time for biological spells ($t(49) = 7.96$, $p < .001$), and 67% of the time for psychological spells ($t(49) = 11.00$, $p < .001$). Seventy-two percent of participants demonstrated the anticipated effect for a significant number of spell pairs (10 or more, binomial probability < .05), and 78% of spell pairs elicited the anticipated effect for a significant number of participants (23 or more, binomial probability < .05). Difficulty judgments for each spell are displayed in Table 2.

In their explanations, participants mentioned the target causal constraint 49% of the time for physical spells, 48% for biological spells, and 53% for psychological spells. Critically, when participants gave the anticipated answer, judging the more-extreme spell as more difficult to learn, they cited the target constraint in their explanation 72% of the time. When they judged the less-extreme spell as more difficult or judged both spells as equally difficult, they cited the target constraint only 17% of the time. A paired *t* test showed that the proportion of causality-based judgments followed by causality-based explanations was significantly higher than the proportion of other judgments followed by causality-based explanations ($t(49) = 11.58$, $p < .001$).

4 Study 3

4.1 *Method*

Study 3 aimed to replicate the findings of Studies 1 and 2 with a more nuanced measure of comparison: Likert-type ratings. Participants were asked to rate the difficulty of each spell on a 7-point scale, from "slightly difficult" to "extremely difficult." In Study 3A, participants saw the 36 spells organized by spell type, such that the two versions of each type were presented consecutively. In Study

3B, participants saw the 36 spells in a random order. In Study 3C, participants saw only 18 spells – either the more-extreme version of each type or the less-extreme version – and their ratings were compared to the ratings of participants who saw the other version. Two-hundred students participated in these studies (M_{age} = 20.41, SD_{age} = 2.01, 126 female), 50 in Study 3A, 50 in Study 3B and 100 in Study 3C (which employed a between-participants design).

4.2 *Results and Discussion*

In Study 3A, participants' difficulty ratings for the more-extreme spells were significantly higher than their difficulty ratings for the less-extreme spells in all three domains (physics: M = 4.0 vs. 3.5, $t(49)$ = 6.03, p < .001; biology: M = 4.3 vs. 3.5, $t(49)$ = 8.47, p < .001; psychology: M = 4.5 vs. 3.2, $t(49)$ = 12.84, p < .001). Participants rated the more-extreme spell in each pair as significantly more difficult than the less-extreme spell for 67% of pairs (12 of 18), as shown in Table 3. The same domain differences were observed in Study 3B (physics: M = 3.5 vs. 3.0, $t(49)$ = 6.03, p < .001; biology: M = 3.9 vs. 3.3, $t(49)$ = 6.61, p < .001; psychology: M = 3.6 vs. 2.9, $t(49)$ = 6.20, p < .001). Participants rated the more-extreme spell in each pair as significantly more difficult than the less-extreme spell for 72% of pairs (13 of 18).

Contrary to expectation, these effect were not significant in Study 3C. Participants who saw the more-extreme version of each spell did not rate those spells as more difficult than participants who saw the less-extreme version (physics: M = 2.8 vs. 3.2, $t(98)$ = -1.72, p = .089; biology: M = 3.6 vs. 4.0, $t(98)$ = -1.54, p = .127; psychology: M = 3.6 vs. 3.6, $t(98)$ = -0.04, p = .964). Overall, the mean rating for less-extreme spells was similar to the mean ratings in other studies (Study 1A: 3.4, Study 1B: 3.1, Study 1C: 3.6), but the mean rating for more-extreme spells was noticeably smaller (Study 1A: 4.3, Study 1B: 3.7, Study 1C: 3.3). A linear contrast confirmed that ratings for the more-extreme spells dropped with each change in how the spells were presented ($F(1,147)$ = 5.01, p < .001). Participants who saw only the more-extreme spells in Study 3C did not benefit from the calibrating effects of seeing the less-extreme versions of the same spells, particularly in close conjunction.

Despite the lack of difference between the two versions of each spell, participants rated the 18 spells they saw as more or less difficult, and that variance patterned similarly to the variance observed in previous studies. For instance, participants in Study 3C rated the spells "curing a person's hiccups" and "curing a person's arthritis" more differently than they rated the spells "turning a broom into a shovel" and "turning a broom into a bucket" (M difference = 0.92 vs. 0.02), just as the participants in Study 3A had (M difference = 1.78 vs. 0.38) and the participants in Study 3B had (M difference = 1.58 vs. 0.56).

TABLE 3 Mean differences in difficulty ratings between more- and less-extreme versions of the same spell. Differences significantly greater than zero ($p < .05$) are marked with asterisks.

Domain	Causal constraint	Study 3A	Study 3B	Study 3C
Physics	Object size	1.14*	0.40*	0.22
	Object weight	0.28	0.76*	−0.62
	Object shape	0.38*	0.56*	0.02
	Object complexity	0.76*	0.56*	−0.44
	Object density	0.38	1.02*	−0.68
	Object value	0.20	0.02	−1.06
Biology	Evolutionary similarity	0.30*	−0.54	−1.74
	Developmental similarity	0.12	−0.02	−1.32
	Ailment severity	1.78*	1.58*	0.92*
	Organ size	0.60*	0.42*	−0.18
	Organ complexity	0.74*	0.98*	−0.14
	Organ plasticity	1.68*	1.38*	0.52
Psychology	Knowledge entrenchment	2.12*	1.02*	0.12
	Knowledge complexity	2.56*	2.08*	0.82*
	Skill difficulty	1.78*	0.82*	0.48
	Affect intensity	0.42	−0.54	−1.34
	Trait stability	0.70*	0.80*	0.26
	Language comprehension	0.28	−0.20	−0.40

This correspondence was systematic. Across the 18 spells, ratings differences from Study 3C were strongly correlated with ratings differences from both Study 3A ($r = .79$, $p < .001$) and Study 3B ($r = .84$, $p < .001$). They were correlated with the judgment differences from Studies 1 and 2 as well. Table 4 displays correlations between the item-specific proportions from Table 2 and item-specific ratings differences from Table 3. All fifteen correlations were significant, averaging $r = .72$. These correlations indicate not only that item effects were consistent across studies but also that they were present in Study 3C even if within-item effects were not detectable using a between-subjects design.

TABLE 4 Correlations among the 18 item effects in Studies 1–3. Correlations significantly greater than zero ($p < .05$) are marked with asterisks.

	Study 1A	Study 1B	Study 2	Study 3A	Study 3B	Study 3C
Study 1A	1.00	0.48*	0.60*	0.47*	0.81*	0.58*
Study 1B		1.00	0.82*	0.70*	0.73*	0.77*
Study 2			1.00	0.86*	0.81*	0.83*
Study 3A				1.00	0.76*	0.79*
Study 3B					1.00	0.84*
Study 3C						1.00

5 Study 4

5.1 *Method*

Study 4 aimed to replicate the finding of Studies 1–3 using a more open-ended task. Participants (n = 116, M_{age} = 20.55, SD_{age} = 2.26, 89 female) were asked to generate their own examples of introductory, intermediate, and advanced spells, respectively. They generated spells using the nine frames in Table 5. The frame "bringing a dead ___ back to life" prompted participants to identify three animals that would be differentially difficult to raise from the dead, and the frame "enchanting a person to like ___" prompted participants to identify three foods that would be differentially difficult to convince a person to eat. Participants generated spells that violated a variety of principles, including physical principles (levitation, transmutation, teleportation, conjuring), biological principles (necromancy, healing) and psychological principles (divination, enchantment, hexing).

Listed beside each frame in Table 5 is the causal constraint we expected participants to honor when generating their spells. To assess whether they did, we scrambled participants' responses and asked two judges, blind to the original data, to order the responses in accordance with the target constraint. For instance, the three animals generated to fill the necromancy frame were ordered by size, whereas the three foods generated to fill the enchantment frame were ordered by disgustingness. We then compared the judges' orderings to the participants' orderings. Ninety response triads could not be ranked by the coding criteria because the responses were too broad or too vague. They were regarded as mismatches in the analyses below. Two judges independently ordered the remaining 954 spell triads. They agreed on 76% of their ordering

(Cohen's kappa = .72), and disagreements were resolved through discussion. Sample response triads are provided in Table 6.

TABLE 5 The frames presented to participants in Study 4, and their Chinese translation. With each frame is the causal constraint participants were expected to honor when generating spells of varying difficulty.

Spell type	Frame	Causal constraint
Levitation	Making a ___ float in the air (object) 让 ___ 悬浮在空中 (物体)	Weight
Divination	Predicting when the next ___ will occur (event) 预测下一次 ___ 何时发生 (事件)	Probability
Transmutation	Turning ___ into gold (material) 把 ___ 变成黄金 (物质)	Density
Teleportation	Teleporting a package from Beijing to ___ (location) 把一个包裹从北京瞬移到 ___ (地点)	Proximity to Beijing
Enchantment	Enchanting a person to like ___ (food) 迷惑一个人喜欢上吃 ___ (食物)	Disgustingness
Necromancy	Bringing a dead ___ back to life (animal) 让死去的 ___ 回生 (动物)	Size
Conjuring	Conjuring a ___ out of thin air (object) 凭空造出一个 ___ (物体)	Size
Healing	Making a potion that cures ___ (disease) 制作治疗 ___ 的药水 (疾病)	Severity
Hexing	Hexing a person to lose their ___ (possession) 施法让一个人失去他的 ___ (拥有的东西)	Personal value

TABLE 6 Examples of spell triads generated in Study 4

Spell type	Causal constraint	Examples		
Levitation	Weight	Coin	Ping-pong ball	Feather
		Car	Television	Apple
		Building	Car	Cat
Divination	Probability	Network drop	Ball game	Rain
		Lottery win	Earthquake	Typhoon
		Mass extinction	Doomsday	Planetary annihilation

TABLE 6 Examples of spell triads generated in Study 4 (*cont.*)

Spell type	Causal constraint	Examples		
Transmutation	Density	Silver	Copper	Diamond
		Bronze	Iron	Water
		Wood	Stone	Air
Teleportation	Proximity	Shanghai	Shandong	Tianjin
		Himalaya	Shanghai	Southern
		Mars	Hong Kong	Hemisphere
				Moon
Enchantment	Disgustingness	Dessert	Garlic	Apple
		Sour food	Raw meat	Lime
		Grass	Soil	Cotton
Necromancy	Size	Rat	Jellyfish	Bird
		Dog	Cat	Dolphin
		Tiger	Human	Mammoth
Conjuring	Size	Bubble	Money	Tree
		Bread	House	Moon
		Building	Nation	Sun
Healing	Severity	Scratch	Cold	Cough
		Myopia	Appendicitis	Inflammation
		Cancer	AIDS	Tumor
Hexing	Personal value	Toy	Ornament	Tooth
		Hair	Money	Appearance
		Eyesight	Intelligence	Life

5.2 *Results and Discussion*

The judges' orderings matched the participants' orderings for 78% of levitation spells, 56% of divination spells, 53% of transmutation spells, 86% of teleportation spells, 50% of enchantment spells, 61% of necromancy spells, 49% of conjuring spells, 70% of healing spells, and 59% of hexing spells. All percentages were significantly greater than that expected by chance (17%, binomial probability < .05). These data indicate that participants' responses were shaped by unnamed causal constraints, each of which should have been rendered irrelevant by the spells' primary causal violation.

6 General Discussion

In six of seven studies, we replicated Shtulman and Morgan's (2017) finding that American adults use real-world causal knowledge to interpret magical events, even when that knowledge is ostensibly irrelevant. Chinese adults consistently viewed some impossible events as more plausible than others, regardless of whether the events violated physical principles, biological principles, or psychological principles and regardless of whether their views were elicited with pairwise comparisons, Likert-type ratings, open-ended explanations, or self-generated exemplars. Graded notions of impossibility appear to be shared by Easterners and Westerners alike.

The similarity between Chinese adults' judgments and American adults' judgments extends beyond the distinction made between less-extreme and more-extreme versions of the same spell. The magnitude of that distinction varied consistently across cultures. Differences in the strength of Chinese adults' intuitions from one spell pair to another tracked differences in the strength of American adults' intuitions. Item-level correlations between the current studies and the studies from Shtulman and Morgan (2017) were $r = .31$ for Study 1A, $r = .50$ for Study 1B, $r = .64$ for Study 2, $r = .58$ for Study 3A, $r = .64$ for Study 3B, and $r = .64$ for Study 3C. All correlations were significant ($p < .05$), except for Study 1A, indicating that spell pairs that elicited strong intuitions of differential difficulty for Chinese adults, such as the pair "making a bush invisible" versus "making a tree invisible" or the pair "making a person's hair grow longer" versus "making a person's teeth grow longer," also elicited strong intuitions for American adults.

Despite the overall similarity between Chinese and American samples, there were also some notable differences. Unlike American adults, Chinese adults rarely viewed a spell for turning a person into a pig as more difficult than a spell for turning a person into a monkey, and they rarely viewed a spell for making someone laugh as more difficult than a spell for making someone smile. These inconsistencies may be due to cultural associations that run counter to the target causal considerations. In Study 2, where participants provided explanations for their judgments, many indicated that pigs are more similar to humans because pigs are a common metaphor for laziness (e.g., "once people become lazy and less active themselves, they are no different from pigs"), and many indicated that smiles are harder to evoke than laughter because smiles are more genuine (e.g., "only people who feel happy from the bottom of their heart will smile, while a joke can make people laugh"). While graded notions of impossibility may be common across cultures, the metrics used to grade impossibility may differ by event.

Taken together, our findings resonate with the cross-cultural literature on memory for ontological violations, or violations of high-level conceptual commitments. Ideas that violate one or two ontological commitments (e.g., a flying pig) are remembered better than those that violate no such commitments (e.g., a dirty pig) or several such commitments (e.g., a flying, talking, invisible pig). This finding has been replicated in several countries, including France, Gabon, Nepal, Mexico, the US, the UK, and China (Atran & Norenzayan, 2004; Boyer & Ramble, 2001; Gregory & Greenway, 2017). While these findings suggest that causal violations have widely-shared consequences for an idea's memorability, our findings suggest that they have widely-shared consequences for an idea's plausibility.

It remains an open question, though, whether intuitions about plausibility arise independently of exposure to impossible events in fiction. Sensitivity to the norms of fiction develops early. Three-year-olds in the US recognize that a fact encountered in a fantasy story is less likely to be true than if the same fact were encountered in a realistic story (Walker, Gopnik, & Ganea, 2015), and four-year-olds in the US recognize that characters in a fantasy story (about castles, dragons, and witches) are more likely to ride winged coaches than rocket ships, but characters in a science fiction story (about moon walks, space suits, and robots) are more likely to ride rocket ships than winged coaches (Kibbe et al., 2018). US four-year-olds also recognize that some impossible events are more plausible than others, à la the findings documented here (Shtulman & Morgan, 2017). Future research is needed to determine whether preschoolers with less exposure to Western fiction, such as Chinese children, share intuitions about plausible impossibility with their American counterparts or whether these intuitions develop later.

To conclude, Chinese adults, like American adults, appear to hold graded notions of impossibility, evaluating the plausibility of ontologically impossible events on the basis of secondary causal considerations. Differences in Eastern and Western culture may shape the particular considerations brought to mind, but the general tendency holds in both cultures. Knowledge that allows us to discriminate possible events from impossible events also encourages us to make distinctions among impossibilities, even though such events are precluded by the laws of nature and can only be entertained in the human imagination.

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