Culture, Lay Science, and Analogies:
Westerners think X → Y, Easterners think X :: Y

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Abstract

Myriad research establishes that Easterners think more holistically (i.e., attend to the "big picture" of how the world fits together and rely more on intuition) than Westerners do. Yet little is known about how Easterners integrate, structure, and make sense the information gleaned through holistic thinking. This paper proposes that, compared to Westerners, Easterners may rely more on analogical reasoning to integrate information and gain a sense of understanding their worlds. Four studies provide evidence that Easterners rely more on analogical reasoning that Westerners do. Compared to Westerners, Easterners found it easier to generate analogical explanations for understanding an outcome, preferred analogical to non-analogical explanations, showed some evidence of being more likely to spontaneously apply analogical solutions to the Duncker ray tumor problem, and tended to use more individual analogies in cultural products like children's stories. Easterners, however, did not show evidence of being better at highly structured analogical reasoning (e.g., the Raven's matrices) than Westerners. These findings suggest that Easterners and Westerners may both be able to reason analogically when required, but Easterners may spontaneously rely more on analogical reasoning to gain a sense of understanding of the world.

Keywords: analogical reasoning, cultural differences, explanations, East Asia, causal reasoning, counterfactuals

Table of Contents

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This dissertation is premised on the assumption that people are lay scientists who regularly and spontaneously employ reasoning strategies to help them gain a sense of understanding of the world around them. For Westerners (i.e., people from societies historically marked by European influences including the United States, Germany, and Australia) a sense of understanding often comes from assessing causation. Called "the cement of the universe" (Mackie, 1974), causation is fundamental to understanding how and why things work and events happen. Understanding causation is functional; by evaluating the environment's causal structure, patterns, and mechanisms, people are able to make predictions and refine their behavior in order to achieve good future outcomes (e.g., Epstude & Roese, 2008; Heider, 1958). Moreover, a sense of causal understanding is psychologically satisfying (see Chiu, Morris, Hong, & Menon, 2000; Pennebaker, 1997; Wilson & Gilbert, 2008). Decades of psychological research illuminate how Westerners assess causation and make sense of their worlds.

Much less, however, is known about how Easterners (i.e., people from societies historically marked by Chinese influence including Korea, Japan, and Taiwan) gain a sense of understanding. It is well documented that Easterners and Westerners diverge in the way they perceive and judge their worlds generally (see Chiu & Hong, 2007; Kirkman, Lowe, & Gibson 2006; Nisbett, Peng, Choi, & Norenzayan, 2001) and in the way they assign causation in particular (e.g., Choi, Dalal, Kim-Prieto, & Park, 2003; Choi, Nisbett, & Norenzayan, 1999; Maddux & Yuki, 2006). Easterners, for instance, are generally described as thinking "holistically"—meaning that they consider more factors and connections between things when perceiving and evaluating their worlds than do their "analytic" Western counterparts. Yet

relatively little is known about the underlying processes that Easterners use to interpret and make sense of all these factors and connections. Moreover the small amount of research that does exist suggests that one of the main processes that Westerners use to make sense of situations through causal assessment—counterfactual reasoning (i.e., imagining how some outcome would change "if only" some prior had been different)—may be used less by Easterners (Bloom, 1984; Gilbert, Sparkman, & Spellman, *in prep*).

How then do Easterners gain a sense of understanding their worlds? I propose a specific process: analogical reasoning. Analogical reasoning—that is, "mapping" information and relationships from a relatively well-understood domain onto a lesser-understood domain in order to make inferences about the latter—is functional and, I would suggest, also psychologically satisfying. Additionally, it is consistent with the values highlighted by Eastern philosophies, such as the importance of connections and relationships.

This dissertation begins by briefly outlining the different values highlighted by Western and Eastern philosophies and how these values are reflected in cultural differences in psychology generally. Next it argues that these cultural differences in philosophy and cognition are reflected in how people gain a sense of understanding. Specifically, Westerners rely heavily on counterfactual and causal reasoning whereas Easterners may not. Finally, it proposes that instead of relying on counterfactual and causal reasoning, Easterners are particularly likely to rely on analogical reasoning. To examine this proposition, I present evidence from four studies finding that, compared to Westerners, Easterners are better at generating analogical explanations, find analogical explanations more satisfying, and may use analogies more in everyday cultural communication, even though they are not necessarily better at structured analogical pattern recognition.

Western and Eastern Philosophies Are Reflected in General Cultural Differences in Psychology

General Philosophical and Psychological Cultural Differences

General philosophical differences. Different historical philosophies permeate Western and Eastern cultures and thinking styles. Ancient Greek philosophy emphasized individual personal agency and control, and it developed a system of deductive logic that pervades the West to this day. Conversely, ancient Eastern philosophies such as Buddhism, Confucianism, and Taoism highlight the importance of relationships with others, encourage finding a "middle way" when presented with apparent conflict, emphasize pragmatism over "truth," and suggest that human reasoning is incapable of fully understanding the dynamic and interconnected world. (For a summary, see Table 1.) These philosophies likely developed alongside other environmental influences on culture that solidified differences in general philosophy. For example, historically Westerners were more likely to be herders and wheat farmers, subsistence styles that could be successful in relative isolation from others, whereas Easterners were more likely to rely on community-based rice farming that required large-scale irrigation coordination (Berry, 1967; Nisbett et al., 2001; Talhelm, Zhang, Oishi, Shimin, Duan, Lan, & Kitayama, 2014).

Table 1.

Some Relevant Cultural Differences between Western and Eastern Philosophies.

Western Philosophy	**Eastern Philosophy**
Focus on individuals	Focus on relationships
Personal agency, control	Coexisting, non-interference
Basic science, truth-seeking	Pragmatic
Truth is stable	Everything is dynamic
Contradiction not accepted	Contradiction expected
Science used to find truth	People cannot truly understand the world

General psychological differences: Individualism-collectivism and analytic-holistic thinking. These different general philosophies are reflected in numerous general cultural differences in psychology (for reviews, see Hofstede, 1980/2001; Nisbett, Peng, Choi, & Norenzayan, 2001; Triandis, 1995). Westerners tend to be more individualistic (i.e., they emphasize personal independence and control) whereas Easterners tend to be more collectivistic (i.e., they value inter-dependence with others in a shared community) (Hofstede, 1980/2001; Kanawaga, Cross, & Markus, 2001). For example, compared to Westerners, Easterners define themselves more by their group relationships (Hong, Ip, Chiu, Morris, & Menon, 2001; Markus & Kitayama, 1991); consider social relationship information to be more predictive of individual behavior (Gelfand, Spurlock, Sniezek, & Shao, 2000); live in more structured social environments and strive more to maintain group harmony (Triandis, Bontempo, Villareal, Asai, & Lucca, 1988); and use relational language, in particular verbs, more than Westerners do (Choi, 2000; Tardif, Shatz, & Naigles, 1997).

Cultural differences extend to cognitive and attentional measures of thinking, too. Westerners tend to think more analytically (i.e., to isolate individual features, use abstract categories, and use formal logical reasoning) than Easterners, who tend to think more holistically (i.e., to attend to the "big picture" of how things fit together and rely on intuition) (e.g., Chua, Boland, & Nisbett, 2005; Kuwabara & Smith, 2012; Masuda, Ellsworth, Mesquita, Leu, Tanida, & Van de Veerdonk, 2008; Masuda & Nisbett, 2006). For example, compared to Westerners, Easterners' eyes literally move around more when scanning a scene consisting of focal and background objects (Chua, Boland, & Nisbett, 2005); they remember more about non-focal supporting characters and judge such non-focal characters to be more relevant to outcomes (Chua, Leu, & Nisbett, 2005); they remember object pairings better than Westerners when the

objects have no particular relationship to one another except for being presented together (Ji, Peng, & Nisbett, 2000); and they are better at incorporating but worse at intentionally ignoring contextual information during perception tasks (Kitayama, Duffy, Kawamura, & Larsen, 2003 (framed-line test)). Additionally, compared to Westerners, Easterners are more likely to expect change to occur and more willing to accept apparent contradictions (for a review, see Spencer-Rodgers, Williams, & Peng, 2010); more likely to rely on intuition when evaluating syllogisms even when intuition leads to a logically incorrect conclusion (Norenzayan, Smith, Kim, & Nisbett, 2002); and are more likely to pair items in a list like "banana, monkey, bear" based on functional relations versus categories (Ji, Zhang, & Nisbett, 2004). And although Westerners tend to believe they can control their environments, even when they objectively cannot, Easterners do not appear to have the same illusion of control (see, e.g., Presson & Benassi, 1996).

Specific Differences Relevant to Lay Philosophies of Science

I argue that these general philosophical and psychological differences lead to different lay philosophies of science—that is, they lead Easterners and Westerners to have different everyday assumptions about the world and to use different processes to understand it.

Western lay philosophy of science: Isolating testable causes. Ancient Western philosophy provides the basis for the modern (Western) philosophy of science, which values parsimony, analysis, consistency, and falsifiability (Iaccarino, 2003; Popper, 1992). Research shows that Westerners, acting as "lay scientists," often spontaneously apply reasoning processes consistent with this philosophy.

In particular, Westerners rely heavily on isolating specific causes in order to understand their worlds. And to assess causation, Westerners turn regularly to the use of counterfactual

thinking, that is, imagining how some outcome or fact in question could be different than it actually is (Roese, 1997). After doing poorly on an exam, for instance, negative affect may trigger imagining counterfactuals like "if only I had studied harder," or "if only the teacher were more clear," which in turn affect one's understanding of what caused the poor grade. If studying harder changes the outcome, then the student was the cause; if the teacher being clearer changed the outcome, the teacher is the cause (see, e.g., Epstude & Roese, 2008; Petrocelli et al, 2011; Spellman, 1997). Such reasoning is functional; in addition to providing a psychological feeling of understanding, it provides guidance on how to achieve better outcomes such that one can better control their future fate (e.g., study more, avoid bad teachers).

This type of reasoning relies on parsing potential causal factors and mentally falsifying them as a more formal scientist would. As Kray, Galinsky, and Wong (2006) explain, counterfactual thinking provides a means for mentally simulating an experiment.

> Constructing a counterfactual thought implicitly involves laying out a causal chain of events in an action sequence and mutating one step in the process to construct an alternate reality. As such, running a counterfactual simulation in one's head is the mental equivalent of conducting an experiment. (p. 34)

Such thinking occurs spontaneously after near misses or negative outcomes (see generally Roese, 1997). And of course it can also be used intentionally. Generating counterfactuals may decrease some cognitive biases (e.g., Kray & Galinsky, 2003 (confirmation bias); Roese & Olson, 1996 (hindsight bias)) and may increase both negative and positive affect (Koo, Algoe, Wilson, & Gilbert, 2009; Markman, Gavanski, Sherman, & McMullen, 1993). It has also been shown to influence causal understanding in political, historical, legal, and other contexts (e.g., Branscombe, Owen, Garstka, & Coleman, 1996; Fearon, 1991; Tetlock & Belkin, 1996).

Eastern lay philosophy of science: Relational thinking and analogical modeling.

Despite its importance in the West, however, the spontaneous use of counterfactual reasoning to understand the world appears to be relatively uncommon in East Asia. Early work, for instance, found that when presented with a story that could be interpreted counterfactually or non-counterfactually, Americans interpreted it counterfactually over 90% of the time whereas Taiwanese did so less than 10% of the time (Bloom, 1984). More recent work suggests that Chinese people may struggle to understand counterfactuals involving unfamiliar factual content (Yeh & Gentner, 2005), and they may be less likely to spontaneously reason counterfactually even when they could easily generate counterfactuals if prompted (Gilbert, Sparkman, & Spellman, *in prep*). These findings are not surprising considering that counterfactual reasoning relies on formal "if, then" logical reasoning and isolating individual potential causes, which may be inconsistent with general Eastern philosophies.

But if Easterners are not relying on counterfactual reasoning to assess causation and make sense of the world, how do they gain a satisfying understanding? Of course, one possible answer would be that Easterners assess causation through holistic reasoning.

Conceptions of holistic thinking suggest that Easterners consider a multitude of inter-related causal factors to be important in affecting outcomes (Choi, Dalal, Kim-Prieto, & Park, 2003; Choi, Nisbett, & Norenzayan, 1999; Morris & Peng, 1994). For example, compared to Westerners, Easterners may be less biased by the fundamental attribution error, instead considering more non-dispositional, situational explanations for outcomes rather than focusing only on individuals (Morris & Peng, 1994). In work by Choi and colleagues (2003) Korean, Asian American, and other American participants were asked to mark which of 100 pieces of information of varying relevance were relevant to solving a crime. Compared to their American

counterparts, Koreans considered more pieces of information to be relevant. Moreover, the degree to which participants scored high on a measure of holistic reasoning (a 10-item test asking how much participants agreed with statements like "Everything in the universe is somehow related to each other") mediated these effects, such that as people scored higher on holism they also judged more causes to be relevant.

Yet I believe that although holistic thinking style may help explain *why* Easterners are more likely to consider multiple factors to be relevant to causation (e.g., compared to more analytic thinkers, holistic thinkers look at more background information, notice more relationships between objects, and consider the universe to be more inter-connected), holistic thinking does not clearly explain *how* more holistic thinkers integrate all this information into something helpful in gaining a sense of understanding.

Thus, I propose an alternative explanation for how Easterners understand how their worlds are cemented (or perhaps loosely tied) together: analogical reasoning. Successful analogical reasoning crucially relies on one of the characteristic of holistic thinkers—seeing relationships and similarities between objects rather than isolating them. And although analogical thinking is a more flexible way of understanding causal relationships than counterfactual reasoning, analogical reasoning does provide a structure to these relationships that can help provide a sense of understanding. Specifically I suggest that Easterners, even more than Westerners, may use analogical thinking to organize and understand their worlds.

What is Analogical Reasoning?

"Analogies decide nothing, that is true, but they can make one feel more at home."

– Sigmund Freud

An analogy is a correspondence between relationships. One simple analogy, for instance, is that "man is to boy as woman is to girl." Here, the relationship between man and boy—that the former is the adult version of the latter—is the same as the relationship between woman and girl. Analogical reasoning describes the ability to see how relationships or characteristics in one subject or situation (called the source or base analog) are similar to—or can be "mapped on" to—another situation (called the target analog). Such reasoning is particularly helpful when the target analog is not well understood: by "aligning" the two situations based on their similarities, the source can "project inferences" onto the target. Such projecting enables people to use their knowledge about the source to better understand the target, and promotes the generation of more general schemas and relational abstractions (e.g., Gentner, 1983; Gick & Holyoak, 1980, 1983; Holyoak, Lee, & Lu, 2010). Thus, unlike counterfactual reasoning which provides inferences through hypothesis testing, analogical reasoning provides inferences based on prior knowledge and relational pattern completion.

Many analogies involve surface similarity, that is, the objects in the analogy come from similar categories or have other similar external characteristics (e.g., in the example above, both man and woman belong to the category of types of adult humans and they resemble each other physically). And research suggests that the most obvious and most commonly generated analogies may involve sources and targets that share similar properties (Dunbar, 1999; Ross, 1987). However, the source and target in an analogy need not share surface similarity. Indeed, many influential analogies do not (e.g., "an electron revolves around the nucleus like the earth

revolves around the sun"). Such analogies rely solely on their underlying relational structure. In the case of the solar system and nucleus, for instance, an atom does not look like the solar system and is probably not even in the same object category.[1] But people may use their knowledge that the solar system consists of multiple smaller objects orbiting around a stable center object to infer the same underlying structure makes up an atom. This relational similarity, rather than surface similarity or object attributes, is what is generally used during mapping (Gentner, 1983; Gick & Holyoak, 1980; Ratterman & Gentner, 1987), and such analogies may help people create more helpful hypotheses about the underlying structure and causes of the world (Dunbar, 1995, 2001).

Like Causal Reasoning, Analogical Reasoning is Functional

Importantly, like causal reasoning, analogical reasoning is functional. With its reliance on prior knowledge, analogical reasoning allows one to quickly assess a new situation and provides guidance about what may be a good way to respond. Analogical thinking sometimes even revolutionizes the understanding of a target by providing people a new way to conceptualize a problem, and it can aid learning, problem solving, and hypothesis formation (Dunbar & Klahr, 2012; Holyoak & Thagard, 1995).

Aiding inferences, flexibly. Analogical reasoning is functional largely because it helps people make new inferences. As noted above, analogical mapping aligns two analogs, allowing inferences to be projected from the source to the target. For instance, the politician evaluating whether to enter the First Gulf War might analogize Saddam Hussein's invasion of Kuwait to Hitler's invasion of Poland. In this particular case people probably know that Hitler invaded Poland, and there is general agreement that intervention was the right choice (something that

[1] Though of course this is not a particularly good analogy, because, among other things, it incorrectly implies that electrons have individual orbits.

might be mapped as Hitler : Poland : Intervene). Thus, if Hitler : Poland maps on to Saddam : Kuwait, people may in turn infer that there is a need to intervene in the case of Saddam (i.e., Saddam : Kuwait : Intervene). (See generally Spellman & Holyoak, 1992.)

This example highlights how one's choice of source analog can strongly influence which projection is made—suggesting that entering into war with Saddam would be analogous to the Vietnam War would lead to a very different inference. Thus, unlike traditional Western causal and counterfactual reasoning, analogical reasoning is not deductive; it is not based on applying clear rules and is not falsifiable. Instead, it is inductive; given some similarities between a source analog and a target, users may infer that another fact or outcome is likely. In this sense, it limits an infinite set of possibilities down to a relatively manageable set of possible inferences, but it is flexible because numerous inferences could be reasonable.

Problem solving. Analogical reasoning may also help provide new ideas to help solve problems (Bassok, 1990; Chen, Sanchez, & Campbell, 1997). For instance, Gick and Holyoak (1980) asked participants to solve the famous Duncker (1945) tumor problem, in which a patient has a deadly but inoperable tumor. A special ray can destroy the tumor, but the strength of ray needed would also destroy the healthy tissues it passes through on the way to the tumor. Presented alone, only about 10% of participants are able to solve this problem of destroying the tumor without destroying the healthy tissue (by splitting up the special ray into multiple weaker rays that simultaneously converge at the tumor). However, when first told an analogous story about a general who avoided setting off landmines by splitting his army into several smaller units to attack a fortress from many angles, the solve rate tripled to around 30%. And when participants were prompted to consider whether the fortress story could provide a hint, the solve rate increased even more to around 75%.

Moreover, the use of analogies is not limited to recently-learned information. For example, knowing the childhood story of Hansel and Gretel, who left bread crumbs as a trail to not get lost in the forest, increases performance on a problem about not getting lost in a cave (e.g., Chen et al., 2004, Study 2).

Hypothesis development and scientific advances. Analogies have similarly been credited for numerous scientific advances—ranging from the understanding that sound is produced by waves to natural selection[2] (see Gentner et al., 1997; Holyoak & Thagard, 1995). Analogies do not provide definitive answers, but they help advance knowledge by providing clues about possible new features or relationships relevant to a target. As such, they help with hypothesis formation. If, for instance, a biologists thinks that a particular virus A is analogous to a different virus B (due to surface similarities or known relational similarities or even just on a hunch), and she knows that virus A is killed by cure C, then this could serve as the basis of the hypothesis that that cure C also kills virus B (Dunbar, 1995). Even when an analogy is flawed—as in the case of using the solar system as a model for an atom—the analogy provides a structure for testing hypotheses. Indeed, studies of real-world scientific labs establish that scientists frequently use analogies when generating hypotheses (Blanchette & Dunbar, 2001; Dunbar, 2001).

Steps Necessary for Successful Analogical Reasoning

Of course, to be helped by analogical reasoning, people must do it. To successfully employ analogical reasoning, people generally must complete multiple steps: retrieval, mapping, and evaluation (see generally Carbonell, 1983; Gentner & Smith, 2012; Gick & Holyoak, 1980).

[2] Holyoak and Thagard (1995) lay out many others, including the earth as a small magnet (Gilbert, 1600), the earth as a ship (Galileo, 1630), light as sound (Huygens, 1678), the planets as projectiles (Newton, 1687), heat as water (Carnot, 1824), natural selection as artificial selection (Darwin, 1859), chromosomes as beaded strings (Morgan, 1915), and the mind as computer (Turing, 1950).

Retrieval requires that a relevant relationship was previously encoded and describes the process of recalling that relationship (i.e., retrieving a source from short- or long-term memory). As discussed above, mapping describes aligning the known relationships from the familiar source to the lesser-known target. Evaluation involves assessing whether the analogy and its inferences are reasonable.

Unfortunately, even though analogical reasoning can be helpful, people often fail to complete these steps (e.g., Gick & Holyoak, 1980, showing that even when presented with a helpful analogy, the majority of people failed to apply it until prompted to do so). However, the successful use of analogical thinking may be increased to even non-surface-similar analogs by encouraging people to consider relationships and compare potentially analogous situations more, rather than thinking about them individually during learning. For instance, in one study, business students who were asked to compare and discuss commonalities between two analogous (but surface-dissimilar) business cases were more than twice as likely to use the successful business strategy involved in the cases during a later negotiation than were students who previously simply read and summarized the cases one at a time (Loewenstein, Thompson, & Gentner, 1999). This relational and comparative focus may help develop an awareness and understanding of structural similarities and general schemas, so that people are later more likely to retrieve them (Gentner & Namy, 1999; Gick & Holyoak, 1983).

Cultural Differences in Analogical Reasoning

Though analogical reasoning has been studied in the West for decades, very little research has been conducted on analogical reasoning cross-culturally. Moreover, I argue that there could be meaningful cultural differences in the reliance on analogical reasoning, such that

Easterners use it more than Westerners as a primary source of understanding their worlds and of gaining a sense of epistemological certainty.

Why might Easterners rely more than Westerners on analogical thinking? Previous research supports at least two related explanations. First, as noted earlier, Easterners generally are more relational thinkers than Americans. Compared to Westerners, Easterners' interpersonal relationships may be more important to them and more tightly connected (e.g., Triandis et al., 1988), and cognitively they are more likely to spontaneously attend to the "big picture" of how things go together (e.g., Chua et al., 2005). Such relational analysis during learning has been shown to increase analogical retrieval and is primary to analogical mapping (e.g, Gentner & Namy, 1999). Second, analogical reasoning is not reliant on formal logic and instead fits with the Eastern preferences for complexity, flexibility, comfort with apparent contradiction (e.g. Spencer-Rodgers et al, 2010). Analogical thinking can lead to multiple possible inferences, which could be inconsistent and often are non-falsifiable, but which confine the otherwise infinite number of possibilities. This flexible way of assessing a situation also may allow Easterners to find a "Middle Way" between opposing arguments and may allow for indirect communication, which may promote harmony and preserve social relationships.

Indeed, consistent with the proposal that Easterners rely more on analogical reasoning, preliminary research suggests that Easterners may be better at analogical reasoning than Westerners. For instance, Chinese children have been shown to be better than American children at analogical reasoning involving more than one relationship (Richland, Chan, Morrison, & Au, 2010). And Japanese children have been shown to be better than American children at solving analogies involving visually rich stimuli pictures, presumably because Western children are drawn to focus on the individual visually rich objects whereas Japanese children continued to see

the relationships between the objects (Kuwabara & Smith, 2012). Easterners may also—at least in the classroom setting—more effectively express analogies in a way that supports use of analogical reasoning (Richland, Zur, & Holyoak, 2007).

The Present Studies

Given preliminary evidence that, compared to Westerners, East Asian children may be better at analogical reasoning and East Asian teachers may use analogies more effectively in the classroom, this dissertation attempts to evaluate whether Easterners generally rely more on analogies to gain a sense of understanding about their worlds. Specifically, four studies aim to:

1. Be the first to systematically conduct basic research on analogical thinking with an adult non-Western population (Experiments 1–3);
2. Investigate whether Easterners are more comfortable generating analogical explanations than Westerners (Experiment 1) and believe that analogical (versus non-analogical) explanations are better than Westerners do (Experiment 2);
3. Investigate whether Easterners are better at actively recognizing and using analogies to solve problems and complete patterns (Experiment 3), and
4. Document differences in the prevalence of analogies in cultural artifacts like newspaper opinion pieces and children's books (Experiment 4).

I hypothesized that Easterners would be better at generating analogical explanations, would believe analogical explanations to be better, would be better at analogical problem solving and pattern completion than their Western counterparts, and would be more likely to use analogies in their cultural products.

Study 1

Study 1 examined whether Singaporeans and Americans would differ in how easy they find it to generate analogies for understanding an outcome. Participants read a prompt encouraging them to list up to four analogies or causal factors for understanding how to be successful at university. Given prior research showing that Easterners are more likely to think relationally (e.g., Ji, Zhang, & Nisbett, 2004) and that Eastern children performed better on analogical reasoning problems (e.g., Richland, Chan, Morrison, & Au, 2010), I predicted that Easterners would find it easier to generate analogies than their American counterparts.

Additionally, in contrast to the more traditional interpretation of holistic thinking—which generally presumes that Easterners consider more factors to be relevant to an outcome than do Westerners (e.g., Choi, Nisbett, & Norenzayan, 1999)—I hypothesized that, if anything, Americans would find it easier to generate multiple causal factors, because doing so relies on more traditional logical reasoning involving isolating causes. Moreover, given evidence that analogical reasoning relies on assessing relationships and making intuitive inferences, I hypothesized that three independent tasks that are often claimed to be associated with reasoning styles—the Triad Task (Ji, Zhang, & Nisbett, 2004), the Cognitive Reflection Task (Frederick, 2005), and the Mind in the Eyes Test (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001)—may predict differences in ease of generating analogies.

Method

Design. Study 1 was a 2 (Culture: American v. Singaporean) x 2 (Prompt: Factors v Analogies) between-subjects design. The dependent variables were (1) the self-reported difficulty of generating analogies or factors and (2) the number of actual analogies or factors that

participants were able to generate for understanding an outcome. Participants were randomly assigned to the Analogies or Factors condition.

Participants. Sixty-nine Singaporean participants from Nanyang Technological University, recruited from a university research list-serve, completed the study in groups of up to 8 in return for approximately $6 USD. Mean age was 23.2 years (*SD* = 2.1), and gender breakdown was approximately equal (54% female). Two hundred sixty-five American participants from the University of Virginia completed the study in groups of up to 3 in return for partial course credit. Mean age was 18.7 years (SD = 2.1), and participants were predominantly female (76% female).

Materials. All materials were completed in English, which is the primary language in both the United States and Singapore.

Factors versus analogies condition prompt. All participants read the following prompt to generate either factors or analogies (in italics) for understanding how to be a successful university student:

> Imagine that you are studying how to be academically successful at university. Can you think of any factors (*analogies)* that could be helpful to understanding how to be successful? For instance, one factor (*analogy*) might be "try hard on your homework" (*"you can grind even an iron rod down to a needle"*[3]).
>
> Please take a moment to think about whether you know any other factors (*analogies*) that could be relevant to academic success.

Participants were then provided numbered spaces to list up to four factors or analogies.

[3] Forty American participants were instead provided the sample analogy "the early bird gets the worm," to ensure that having a non-familiar analogy did not decrease American's ability to generate analogies. There were no significant differences between participants who read the different analogies and thus their results were combined during analysis.

Primary dependent variable: Ease of generation. To measure generation difficulty, participants were asked, "How difficult was it for you to think of factors (*analogies*) that could be relevant to academic success?" (where 1 = *Very Easy* and 7 = *Very Difficult*).

Measures of reasoning style. Participants also completed three potentially related measures of general thinking style and social cognition, the Triad Task, the Cognitive Reflection Task, and the Mind in the Eyes Test.

The Triad Task of Relational (versus Categorical) Thinking. The Triad Task is a measure of relational versus categorical thinking (Ji et al., 2004). For the task, participants see sets of three words—for instance "monkey", "bear", and "banana"—and are asked "which two of the three are most closely related." Two of the words belong to the same abstract category (e.g., animals), whereas two are related by a functional relationship (e.g., monkeys eat bananas). A measure of "relational thinking" was calculated by counting the number of times participants chose the relational versus categorical relationship. A relational thinking score of 0% indicated that a participant always chose the categorical pairing, whereas a score of 100% indicated that the participant always chose the relational pairing.

Cognitive Reflection Task of Intuitive (versus Logical) Thinking. The Cognitive Reflection Task (Frederick, 2005) is a set of three brainteasers designed to assess reliance on intuitive thinking (which leads to a wrong answer) or slower logical reasoning (which leads to the correct answer). For instance, one question reads, "In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?" Many people immediately intuit that the answer is 24 days, however the logical (and correct) answer is 47 days. Percentage of intuitive answers was calculated, such that a score of 0% indicated that participants provided the

intuitive answer for all three questions, whereas a score of 100% indicated that participants provided the logical (i.e., correct) answer for all three questions.

Mind in the Eyes Test. The "Reading the Mind in the Eyes" test was developed to assess whether people may have basic social cognitive deficits related to autism or Asperger syndrome, but it has been used as a more general test of "social sensitivity" (see Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). Moreover, there is some evidence of cross-cultural differences in accuracy, perhaps because Asian cultures are less likely to attribute behaviors to others' internal states (Prevost, Carrier, Chowne, Zelkowitz, Joseph, & Gold, 2013). The task consists of 36 images of Caucasian-looking eyes expressing a different emotion, and participants pick which emotion they believe it is from four options. An abbreviated 18-item version of the test was used. Percentage of correct answers was calculated.

Results and Discussion

The results of Study 1 support the hypothesis that Easterners find it easier to generate analogies than Westerners. Also Easterners attempted to generate more analogies and trended towards actually being able to generate more analogies. Additionally, intuitive (versus logical) thinking predicted ease of and ability to generate analogies.

Ease of generating factors and analogies by culture. As expected, there was a significant interaction between culture (Singaporean versus American) and condition (generating analogies versus factors) when predicting self-reported ease of generation, $F(2, 325) = 36.92$, $p < .001$, $\eta_p^2 = .102$, Singaporean participants reported that they found it easier (i.e., less difficult) ($M = 4.35$, $SD = 1.48$) to generate analogies than did Americans ($M = 5.76$, $SD = 1.23$), $t(187) = 5.81$, $p < .001$, $d = 1.05$. Conversely, Americans reported that they found it easier to generate

causal factors (M = 2.20, SD = 1.11) than did Singaporeans (M = 2.84, SD 1.22), $t(138) = 2.80$, p = .006, d = .55. See Figure 1.

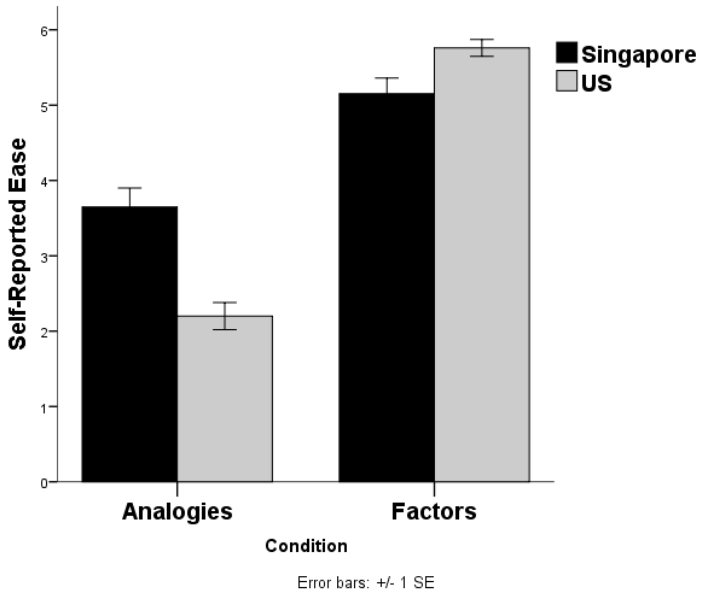

Figure 1. Self-reported ease of generating analogies and causal factors for Singaporeans and Americans. Scale is reversed such that higher numbers indicate higher self-reported ease.

Number of factors/analogies generated by culture.

***Counting and coding*.** The number of factors or analogies attempted (up to four) was counted for each participant. Additionally, one hypothesis-blind coder and one condition-blind coder categorized each analogy for whether it actually was an analogy. The following definition was used: "An analogy explains or predicts something by comparing a relationship in one domain to a relationship in another domain. So a piece of advice or explanation alone would not be enough—to count as an analogy it has to include or imply a comparison of some relationship." Inter-rater reliability was originally 83%, and disagreements were decided after discussion between the raters. Samples of what were and were not counted as analogies are available in Table 2.

Table 2.

Examples of Analogies Generated.

Counted as Analogies	**Not Counted as Analogies**
You miss 100% of the shots you don't take	Success can be attributed to the amount of time and effort you put into something
A rolling stone gathers no moss	Practice makes perfect
Like a bamboo reed, always snap back after being bent	If at first you don't succeed, try again
Time is money	Work hard, play hard
Shoot for the moon, because even if you fail you'll land among the stars	If you work hard enough, you can do anything

Generation of analogies and factors by culture. Singaporeans (M = 2.35, SD = 1.10) generated more answers to the analogies prompt than did Americans (M = 1.75, SD = .95), $t(188) = 3.27$, p = . 001, d = .58. Singaporeans also trended towards generating more answers that were coded as actual analogies (M = .59, SD = .89) than did Americans (M = .34, SD = .71), $t(188) = 1.76$, p = .081, d = .31.

There was no statistical difference in the number of factors generated by culture, perhaps because factor generation was near ceiling (since participants were only give space to write up to four factors) (Singaporeans: M = 3.63, SD = .77; Americans: M = 3.76, SD = .47), $t(142) = 1.23$, p = .221).

Triad Task, Cognitive Reflection Task, and Mind in the Eyes as predictors of ease of analogy generation. All three tasks showed differences in the expected direction**.** Compared to Americans, Singaporeans scored marginally more relationally (versus categorically) on the Triad Task (M_{Sing} = .71, SD = .31; M_{US} = .65, SD = .35), $t(329) = 1.41$, p = .160, d = .18); more intuitively (less logically) on the Cognitive Reflection Task (M_{Sing} = .40, SD = .41; M_{US} = .62,

SD = .38), $t(329) = 1.41$, $p < .001$, $d = .56$); and less accurately on the Mind In The Eyes Test ($M_{Sing} = .70$, $SD = .15$; $M_{US} = .78$, $SD = .12$), $t(329) = 4.89$, $p < .001$, $d = .59$).

Additionally, across Singaporeans and Americans, there was an interaction between condition (analogies or factors) and Cognitive Reflection Task score on predicting ease, $F(2, 327) = 2.77$, $p = .027$. As participants scored more intuitively (versus logically) on the Task, they found it easier to generate analogies, B = .54, $SE = .25$, $t(187) = 2.14$, $p = .034$, $r^2 = .02$, and they trended towards finding it harder to generate causal factors, B = .47, $SE = .25$, $t(138) = 1.85$, $p = .067$, $r^2 = .02$. Moreover, as participants scored more intuitively, they also generated more actual analogies, B = .28, $SE = .14$, $t(187) = 2.03$, $p = .043$, $r^2 = .02$. However, Cognitive Reflection Task score was not a significant mediator of the relationship between culture and ease. The estimated indirect effect with 5,000 bootstrapped samples was .04 ($SE = .08$), 95% CI [-.10, .22].

No similar patterns were found for the Triad Task or the Mind in the Eyes Test.

Summary of Study 1

Overall, the results of Study 1 are consistent with the general hypothesis that Easterners may rely more on analogies when understanding their worlds. Singaporeans found it easier than Americans to generate analogies for understanding an outcome, and they trended towards being able to actually generate more analogies than Americans. Additionally, Americans found it easier than Singaporeans to generate causal factors, suggesting that Easterners may not simply think about many causal factors when assessing how the world works (at least compared to the extent that Westerners think about causal factors). Some evidence also suggests that intuitive (versus logical) thinking style may positively predict the ease of and ability to generate analogies.

Study 2

Preference for Analogical vs. Non-Analogical Explanations

Study 1 found evidence that, compared to Westerners, Easterners find it easier to generate analogical explanations for understanding outcomes. Study 2 expands on this finding by assessing preferences for analogical (versus non-analogical) explanations. If it is true that Easterners feel more of a sense of understanding from analogies than do Westerners, then Easterners should prefer analogical to matched non-analogical explanations more than Westerners do. In Study 2a participants read explanations for everyday objects or occurrences (e.g., what is bandwidth, why is procrastination bad), whereas in Study 2b participants read about a social situation involving explaining a life event or idea to others. In both studies participants read and rated an analogical explanation and a matched non-analogical explanation and chose which of the two explanations they thought was better.

Participants

Power calculations. Study 1 suggests that whereas some cultural differences in analogical reasoning may be large (e.g., self-rated ease, *d*s = .55 and 1.05), others may be smaller (e.g., actual analogies generated, $d = .31$). Thus, to ensure 80% power to detect a small effect size ($d = .30$) for simple between-participants tests, Study 2 (and Study 3) aimed to collect data from 180 Singaporean participants and 180 American participants or as many as could be collected during one semester.

Demographics. One hundred forty-six Singaporean participants ($M_{age} = 20.7$, $SD = 1.8$; 61% female) were again recruited from a research mailing list at Nanyang Technological University in Singapore and compensated approximately $10 USD per hour. The majority of Singaporean participants racially identified as Chinese (87%; Malay, Indian, or other Asian:

11%; Other: 1%), and the most common majors represented were business (40%) and engineering (24%). One hundred ninety-one American participants (M_{age} = 18.5, *SD* = 1.0; 63% female) were again recruited from the University of Virginia to participate in return for partial course credit. The majority of American participants racially identified as white (60%; Black: 5%; Chinese or other East Asian: 23%; Hispanic/Latino(a): 3%; Other: 10%), and the most common majors represented were natural sciences (29%) and social sciences (26%).

General Procedure

Participants completed both Study 2a and Study 2b in random order on a computer in groups of up to 8.

Study 2a: General Explanations

Background and Hypothesized Results

Participants rated matched pairs of analogical and non-analogical explanations about a series of everyday things (e.g., what is bandwidth?) for how good and easy-to-understand they were. They also picked which of each matched pair of explanations they thought was better and they liked more. I predicted that, compared to Americans, Singaporeans would both choose and rate the analogical (versus non-analogical) explanations as better and easier to understand.

Materials and Procedure

Explanation pairs. Five pairs of short explanations—one analogical and one non-analogical—for everyday topics were developed. Topics were computer bandwidth, fighting in relationships, the cell nucleus, procrastination, and exercise. The order of the topics was randomized, but for each topic the analogical explanation was presented first. The explanations were matched, as much as possible, for language difficulty and length (based on the Flesh-Kincaid Grade Level formula; Kincaid, Fishburne, Rogers, & Chissom, 1975). See Table 3 for

two sample explanation pairs. See Appendix A for all materials and their Flesh-Kincaid Grade Level score.

Table 3.
Sample of Two Analogical and Non-analogical Explanation Pairs.

Analogical Explanation	**Non-analogical Explanation**
Explanation of bandwidth B: Bandwidth in computer networking is like a series of highways, and information is cars on the highway. If there's only one car on the highway, that car will travel quickly and easily. If there are many cars, however, traffic can build up and slow things down.	Explanation of bandwidth A: Bandwidth in computer networking describes the amount of data that can be carried by a network. The amount of data that can be carried at any one time is limited. So if only one person is downloading one file, the transfer should happen fairly quickly. If several people are trying to download the same file, though, the transfer can be much slower.
Explanation of why some married couples fight B: Love is like a deep river. On top it can be rocky, but underneath it is deep and calm.	Explanation of why some married couples fight A: Even couples who experience a lot of conflict can still have good relationships, because they are still very committed to each other and content overall.

Explanation preference. Participants rated each explanation for how "good" they thought it was (from 1 = *not at all good* to 7 = *extremely good*) and how easy it was for them to understand (from 1 = *very difficult* to 7 = *very easy*). After rating all 5 pairs, participants were again shown each pair and asked to choose which of the two options was "better" and which they liked more.

Results

Explanation ratings. Ratings for analogical and non-analogical explanations were averaged across the five topics, such that higher scores indicated that participants rated the explanations as better (i.e., more "good") and more understandable. As predicted, Singaporean participants rated the analogical explanations as better on average than did the American participants. (See Table 4 for means, standard deviations, and statistics.) Consistent with my hypotheses, American participants tended to rate non-analogical explanations as better and easier

to understand than did Singaporeans, but they unexpectedly also rated analogical explanations as non-significantly easier to understand than did Singaporeans.

Table 4.
Singaporean and American Ratings of How Good and Easy to Understand Non-Analogical and Analogical Explanations Were (1-7 Scale).

Rating	Singapore Mean (and SD)	American Mean (and SD)	t	p	d
Good					
Analogical	6.25 (1.69)	5.68 (1.61)	-3.10	.002	.35
Non-analogical	7.62 (1.58)	7.92 (1.49)	1.76	.079	-.20
Understandable					
Analogical	5.56 (.87)	5.68 (.87)	1.23	.221	-.14
Non-analogical	5.51 (.82)	5.71 (.74)	2.35	.019	-.26

Explanation choices. The proportion of times participants chose the analogical explanations as being better and liked more than non-analogical was calculated, such that a score of 1 meant a participants always chose the analogical explanation. As predicted, compared to the Americans, Singaporean participants liked the analogical explanations more (M_{Sing} = .52, *SD* = .25 versus M_{US} = .45, *SD* = .23) and thought they were better (M_{Sing} = .31, *SD* = .26 versus M_{US} = .19, *SD* = .19) than the non-analogical explanations, $t(334) = -5.00$, $p < .001$, $d = .29$ and $t(334) = -2.62$, $p = .009$, $d = .53$, respectively.

Study 2b: Social Situation Explanations

Whereas Study 2a involved preferences for general explanations, Study 2b aimed to assess explanations in more personal contexts, in which communicating a sense of understanding might be particularly important in social life. Participants read about social situations. They then choose which of two explanations was better and rated each explanation for how satisfying, comforting, helpful, and good it was.

Materials and Procedure

Social situations and explanation pairs. Five short stories about social situations were developed, in which a character did not understand an event or outcome or needed to better understand something. Topics addressed a variety of social situations, including children wondering what a bird's nest is (from Holyoak & Thagard, 2007) and explaining to one's spouse why it is better to buy a cheap car than an expensive one. See Table 5 for a sample story and explanations. (See Appendix B for a list of all stories.)

Table 5.
Sample Social Situation Story and Explanatory Responses.

Situation:	
Imagine a young child asks you what a bird's nest is and why birds are always in the trees. Which of the following explanations do you think would be better to say?	
Analogical choice:	Non-analogical choice:
Many birds are born in little houses called nests located in the trees. The rest of the tree is the bird's back yard, and birds often spend time there.	Many birds are born in little nests made of twigs located in the trees. The rest of the tree helps protect the nest, and birds often spend time there.

.

Choosing and Rating. After reading each social situation, participants chose which of two brief explanations—one of which was analogical and the other non-analogical—was better. They then rated each explanation for how psychologically satisfying ("How psychologically satisfying do you think [Response A] is?"), comforting ("How comforting do you think this explanation is?"), helpful ("How helpful do you think this explanation is to understanding the situation?"), and good ("How good do you think this response is?") it was from 1 (*Not at all [attribute]*) to 7 (*Extremely [attribute]*).

Results

Explanation choices. Again, the proportion of times participants chose the analogical explanations as being better was calculated, such that a score of 1 meant a participant always chose the analogical explanation. As predicted, Singaporean participants chose the analogical (versus non-analogical) explanation (M = .35, SD = .24) more often than did the American participants (M = .29, SD = .21), $t(334) = -2.48$, p = .014, d = .27.

Ratings. Ratings for analogical and non-analogical explanations were averaged across the five situations, such that higher scores indicated that participants rated the explanations as more satisfying, comforting, helpful, and good, respectively. As predicted, Singaporean participants rated the analogical explanations as better (i.e., more "good") (M = 3.76, SD = 1.08) on average than did Americans (M = 3.47, SD = .89), $t(334) = -2.73$, p = .007, d = .29. Conversely, American participants rated the non-analogical explanations as better (M = 4.99, SD = .70) than did Singaporeans (M = 4.77, SD = .87), $t(334) = 2.59$, p = .010, d = .28. However, cultural differences in ratings for satisfaction, comfort, and helpfulness were less consistent, as shown in Table 6.

Table 6.
Mean Rating of how Psychologically Satisfying, Comforting, and Helpful to Understanding each Explanation (Analogical and Non-analogical) was for Singaporean and American Participants (1-7 scale).

Rating	Singapore Mean (and SD)	American Mean (and SD)	t	p	d
Satisfying					
Analogical	3.95 (1.13)	3.82 (1.00)	-1.06	.291	.12
Non-analogical	4.41 (.98)	4.49 (.75)	.93	.353	-.09
Comforting					
Analogical	3.92 (1.13)	3.92 (.96)	-.04	.965	<.01
Non-analogical	4.16 (.99)	3.91 (.83)	-2.58	.010	.27
Helpful					
Analogical	3.75 (1.08)	3.62 (.92)	-1.12	.263	.13
Non-analogical	5.00 (.93)	5.25 (.73)	2.76	.006	-.30

Summary of Study 2

Studies found that, when given a dichotomous choice, Singaporean participants were more likely than American participants to choose analogical (versus non-analogical) explanations as being more liked (2a) and better (2a and 2b). Moreover, despite inconsistent cultural differences in ratings of how understandable, satisfying, comforting, and helpful explanations were, across both studies Singaporeans rated analogical explanation as being better (i.e., more "good") than did Americans.

Study 3

Structured Analogical Reasoning

Studies 1 and 2 provide evidence that, compared to Westerners, Easterners find analogical (versus non-analogical) explanations easier to generate and preferable for a variety of topics and situations. Do the relative ability to generate and the preference for analogical explanations, however, mean that Easterners are objectively better at identifying analogies and applying them to solve problems? That is, does a penchant for analogical explanations mean that Easterners are also better at structured analogical reasoning? Study 3 examines this question.

One possibility—and my hypothesis prior to running Study 3—is that Easterners would be better at detecting analogical relationships and score higher on analogical reasoning tasks than Westerners, because Easterners are generally more likely to identify analogies and "think analogically" more frequently. This hypothesis is consistent with research finding that Easterners are more likely to see relationships among objects rather than simply focal objects in the environment (e.g., Chua et al., 2005), as understanding relationships is a cornerstone of deep analogical reasoning (Gentner & Namy, 1999; Gick & Holyoak, 1983).

Alternatively, however, it is possible that Westerners are just as good at analogical reasoning as Easterners when analogical reasoning is required to deduce a "correct" answer, and Easterners may not rely on analogical thinking more than Westerners when there is an obvious non-analogical option. This hypothesis is consistent with the possibility that culture influences the tendency to spontaneously apply analogies to less constrained tasks, but each cultural group is equally capable of analogical reasoning for tasks that require it. This hypothesis is also consistent with the finding that Easterners are less concerned with isolating specific causes and controlling their worlds (e.g., Presson & Benassi, 1996). That is, analogies may serve Easterners as a useful tool for explaining and gaining a sense of understanding, but Easterners may be no more likely than Westerners to detect analogies in the environment and use them to actively solve problems. Despite my initial hypothesis, results of Study 3 were mixed and at least partly support this latter possibility.

Participants

One hundred ninety-three Singaporean participants (M_{age} = 20.9, *SD* = 1.8; 61% female) were again recruited from a research mailing list at Nanyang Technological University in Singapore, and compensated approximately $10 USD per hour. Some participants may have also completed Study 2. The majority of Singaporean participants racially identified as Chinese (90%; Malay, Indian, or other Asian: 7%; Other: 3%), and the most common majors represented were business (36%) and engineering (24%). One hundred ninety-four American participants (M_{age} = 18.6, *SD* = 1.0; 62% female) were again recruited from the University of Virginia to participate in return for partial course credit. The majority of American participants racially identified as white (61%; Black: 8%; Chinese or other East Asian: 15%; Hispanic/Latino(a): 8%;

Other: 6%), and the most common majors represented were natural sciences (25%) and social sciences (23%).

General Procedure

Participants, in groups of up to eight, completed the three subparts of Study 3 (i.e., 3a, 3b, and 3c) in random order on a computer. After completing all parts, participants completed a short measure of IQ (as a control for Study 3a) and answered demographic questions.

Study 3a: Analogical Ability – The Raven's Progressive Matrices

In Study 3a, participants completed a non-verbal test of analogical reasoning. It was hypothesized that Singaporean participants would have higher scores on a non-verbal measure of analogical reasoning than their American counterparts when controlling for a measure of general IQ (as measured by the control problems discussed below).

Materials and Procedure

Raven's Progressive Matrices. Raven's Progressive Matrices (RPM) is a nonverbal test designed to measure basic cognitive functioning, and in particular the ability to use high-level schemata and pattern matching to help make sense out of complexity (see, e.g., Raven, 2000). It consists of several "visual analogy" problems (Carpenter, 1990, p. 4) and purports to measure the ability to "reason by analogy" (Raven, 1938, p. 12). The RPM tests consist of a series of images with one missing, and participants choose the correct missing one from eight choices. (See Figure 2 for an example.) Prior studies using the RPM as a measure of intelligence have found that Easterners scored higher on the RPM test than Westerners (e.g., Lynn & Vanhanen, 2002).

There are three versions of RPM, and the "Advanced" version was used because it is appropriate for adults with above-average intelligence (see Domino & Domino, 2006). Whereas the standard Advanced RPM consists of 48 items, to decrease time and participant fatigue,

participants completed a subset of 10 items from Set II in order of increasing difficulty (Matrices 5, 9, 15, 19, 21, 24, 25, 27, 31, 35). The items were presented on the computer and participants were given 10 minutes to solve as many as possible.

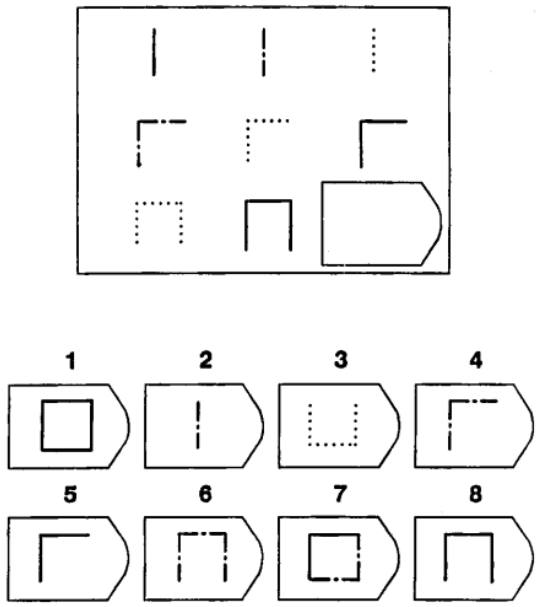

Figure 2. Example of a Raven's Progressive Matrices item.

IQ Control Questions: The Shipley. By including participants from top universities in both the United States and Singapore, I hoped to limit population differences in general intelligence (IQ) that could account for differential performance between Singaporean and American participants on the RPM. However, to partially control for any potential IQ differences between the samples, participants also completed a common measure of crystallized knowledge and fluid reasoning, the Shipley Institute of Living Scale ("the Shipley"; Shipley, 1940). The Shipley is a 20-item paper-and-pencil measure that is moderately to highly predictive of IQ as measured by longer tests, and is recommended when individual IQ testing is not feasible (Dalton, Pederson, & McEntyre, 1987; Zachary, Crumpton, Spiegel, 1985). Each

item of the Shipley lays out a short sequence (e.g., "1, 2, 3, 4, __", "white black, short long, down __"), and participants are tasked with filling in the blank.[4]

Results

Raven's scores were calculated by totaling the number of correct matrices each participant answered, such that a score of 10 indicated a perfect score. Contrary to expectations, average Singaporean scores (M = 5.41, SD = 2.44) were nearly identical to American scores (M = 5.40, SD = 2.11), $t(385) = -.054$, $p = .957$, $d < .01$.

To ensure that cultural differences in Raven's scores were not washed out by sample differences in overall IQ, I next examined whether controlling for IQ revealed cultural differences in Raven's scores. The IQ control measure, the Shipley estimate, was calculated by summing up the number of Shipley items participants correctly answered. One item was not included due to experimenter error, so a score of 19 indicated a perfect score. American participants (M = 15.57, SD = 2.10) scored slightly but significantly higher on average than Singaporean participants (M = 15.10, SD = 2.01), $t(380) = 2.34$, $p = .026$, $d = .23$. And Shipley scores significantly predicted Raven's scores, B = .39, SE = .052, $p < .001$, $r^2 = .13$. However, a hierarchical regression accounting for Shipley IQ (step 1), revealed that culture (Singapore versus US, step 2) still did not significantly predict Raven's scores, B = .19, SE = .22, $p = .391$, $r^2 < .01$.

Study 3b: Pairing by Analogy versus Object Similarity

Study 3b assessed the tendency to recognize and pair objects based on analogical relationships versus obvious object-based similarity. It was again hypothesized that Singaporean

[4] The Shipley is copyrighted so I am unable to share our copy publicly.

participants would be more likely than American participants to pair objects based on analogical relationships (versus based on object-based physical appearance).

Materials and Procedure

Pairing Task. As in Markman and Gentner (1993), participants saw an image that showed objects in some structured relationship (e.g., man giving a woman groceries from a food bank) and a second image that included an object from the first image and an analogous relationship (e.g., the woman giving a squirrel some food). An arrow pointed to the object in the first picture (e.g., the woman) that had both an analogical match (e.g., the squirrel) and a near-exact physical match (e.g., the woman) in the second image. (See Figure 3.) For eight image pairs, participants were asked "which object in the [first] picture goes with the objected pointed to in the [second] picture" and provided space to type their answers.

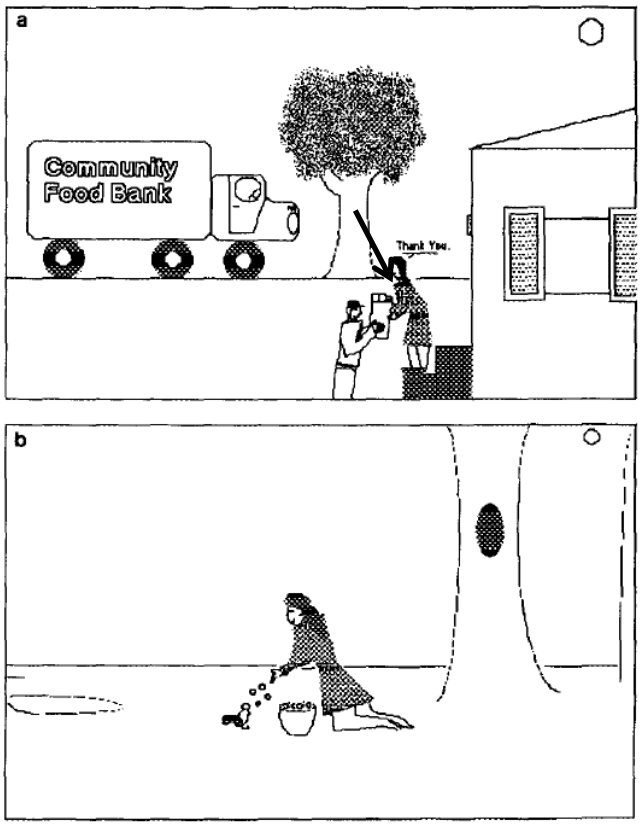

Figure 3. Sample image pair. (From Markman & Gentner, 1993.)

Results

The proportion of analogical matches was calculated, such that a score of 1 indicated that the participant provided the analogical match for every pair, whereas a score of 0 indicated that the participant provided the object match or some other non-analogical object for every pair.

Unexpectedly, again, Singaporean (M = .48, SD = .30) and US (M = .48, SD = .26) participants did not significantly differ in rates of matching based on analogical relationships, $t(384) = -.22$, $p = .924$, $d < .01$.

Study 3c: Analogical Problem Solving – The Duncker Tumor Ray Problem

In Study 3c, participants completed the Duncker problem, a test of using analogical reasoning to solve a problem (1945). It was expected that Singaporeans and Americans would not differ in their baseline rates of solving the problem. However, I hypothesized that when participants read a previous story that provided an analogous solution to a problem, Singaporeans would be more likely than Americans to later spontaneously generate the analogous solution to the Duncker problem.

Materials and Procedure

Replicating Gick and Holyoak (1980), American and Singaporean participants were randomly assigned to one of three conditions—control, analogy, or analogy plus hint. All participants began by reading and briefly describing in writing two of three short stories about people creatively solving problems. Participants in the control condition read two stories that did not provide analogous solutions for how to solve the Duncker problem. (One story was about twins who worked together to cheat in a race and the other about a merchant who used barrels of wine to float across a river.) Participants in the analogy conditions read one of the non-analogous stories plus a story that provided an analogous solution for solving the Duncker problem. The

analogous story was about how to invade a fortress surrounded by mines that would explode if a large force crossed them:

> [T]he general devised a simple plan. He divided his army into small groups and dispatched each group to the head of a different road. When all was ready he gave the signal and each group marched down a different road. Each group continued down its road to the fortress so that the entire army arrived together at the fortress at the same time. In this way, the general captured the fortress and overthrew the dictator.

(See Appendix D for full copies of this and the other two non-analogical stories.) After reading the prior stories, all participants were tasked with solving the Duncker ray problem. Participants in the analogy plus hint condition were also provided a hint (below in italics) immediately after being asked what procedure might be used (from Gick & Holyoak, 1980, Exp. 3):

> You are a doctor faced with a patient who has a malignant tumor in his stomach. It is impossible to operate on the patient, but unless the tumor is destroyed the patient will die. There is a kind of ray that can be used to destroy the tumor. If the rays reach the tumor all at once at a sufficiently high intensity, the tumor will be destroyed. Unfortunately, at this intensity the healthy tissue that the rays pass through on the way to the tumor will also be destroyed. At lower intensities the rays are harmless to healthy tissue, but they will not affect the tumor either.
>
> What type of procedure might be used to destroy the tumor with the rays, and at the same time avoid destroying the healthy tissue? *[In solving this problem, you may find that one of the stories you read before will give you a hint for a solution.]*

All participants were provided space to write out as many solutions as they could generate in 3 minutes.

Results

Coding of analogical solutions. Two condition-blind coders categorized solutions as analogical (i.e., analogous to the solution in the previously read story) if they included multiple lower-intensity rays converging on the tumor simultaneously. Some explanations did not specifically mention lower-intensity or simultaneous convergence but implied it—for example, describing several "spread out" rays "focusing on the tumor." Such solutions were coded as

analogous. The coders agreed 90%. Disagreements were resolved by the author. All solutions and their codings (where 0 = non-analogous and 1 = analogous) are available at https://osf.io/e6hb9/.

Effects of culture and condition on solving the problem. Consistent with previous findings (Gick & Holyoak, 1980), preliminary analysis using logistic regression found a main effect of condition, such that very few participants in the control condition solved the problem using the analogical solution (7%), but rates increased when participants had read the analogous story (18%) and when participants were also provided the hint (51%), B = 1.36, *SE* = .19, Wald = 51.07, $p < .001$. There was also an unexpected main effect of country, such that US participants were more likely than Singaporean participants to provide an analogous solution across conditions (Control: 14% versus 0%[5]; Analogous: 19% versus 17%; Analogous and hint: 60% versus 39%), B = -.80, *SE* = .27, Wald = 8.76, $p = .003$. See Figure 4.

Next I examined the primary hypothesis that, compared to the control condition, in the analogy condition Singaporeans would be more likely than Americans to spontaneously use the analogy to solve the problem.[6] As predicted, Americans were more likely (about 1.38 times) to propose the analogous solution when they had read the analogous story, and this increase was even larger for Singaporeans (about 16 times). Logistic regression revealed that the interaction between culture (American versus Singaporean) and condition (control versus analogy) approached significance, B = 2.15, *SE* = 1.16, Wald = 3.46, $p = .063$. There was no similar

[5] Of course it is not that the Singaporeans generated no solutions in this condition. Rather Singaporeans provided non-analogous solutions (e.g., putting a tube down the patient's throat).

[6] Because zero Singaporean participants used the analogous solution in the control condition, one dummy Singaporean participant was manually added and coded as having generated an analogical solution in the control condition, in order to avoid convergence failure (from having a 0 in the denominator) when calculating logistic regression (see Allison, 2008). This change should only underestimate any differences between Singaporean and American participants.

interaction between culture and condition when comparing the analogy condition to the analogy plus hint condition, B = -.66, *SE* = .58, Wald = 1.29, *p* = .256.

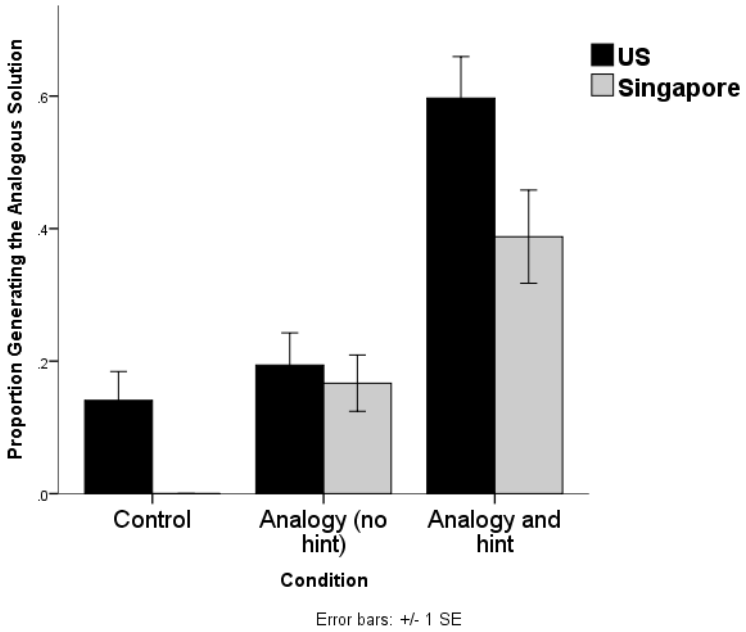

Figure 4. Proportion of participants solving the Duncker problem with the analogical solution, by culture and condition.

Summary of Study 3

Study 3 provides mixed evidence about whether Easterners are better than Americans at highly structured analogical reasoning. Easterners did not score higher on the Ravens' Progressive Matrices or Markman and Gentner's (1993) analogical image pairing task. Yet there is evidence that Easterners may be more likely than Westerners to spontaneously apply analogies to solve problems; being provided an analogous story (but no hint to use it) trended towards increasing Singaporeans' performance on the Duncker problem more than it did for Americans.

Together these results suggest that Easterners are not necessarily better at using analogical reasoning when it is required (i.e., for the Raven's Matrices) and they may not pair objects based on analogical relationships rather than obvious physical similarities more than Westerners do (e.g., for the image pairing task). Instead Easterners may simply be more likely to

rely on analogical reasoning when numerous reasoning strategies are available and no other is the obvious choice. It is also possible that Easterners do not actively identify and use analogies to solve problems and complete tasks any more than Westerners do, or at least not non-verbal tasks. This finding is consistent with research finding that, compared to Americans, Easterners are less concerned with isolating "correct" answers and controlling their environments (Norenzayan et al., 2002; Spencer-Rodgers, et al., 2010). Instead, Easterners may simply be more likely to use analogies to obtain a more flexible sense of understanding. These results also provide preliminary evidence that, compared to Westerners, Easterners may only rely more on verbal (as opposed to spatial or visual) analogical thinking.

Study 4

Cultural Artifacts

Overview and Hypotheses

Studies 1, 2, and 3 assess cultural differences in generating, preferring, and using analogies for individuals in a laboratory setting. But if cultures differ in their use of analogies to understand the world, then I should expect these differences to be reflected in cultural artifacts as well. Thus Study 4 analyzed real-world documents—specifically opinion pieces from newspaper articles and children's books—to see if they reflected cultural differences in the prevalence of analogical thinking. I believe these are two very important types of cultural artifacts. Opinion pieces in newspaper articles are designed to include arguments that readers would find persuasive and good. And in addition to reflecting their adult author's style of thinking, children's books can be used to enculturate new generations.

I predicted that cultural differences in the reliance on analogies to understand and explain the world would be reflected in the prevalence of analogies in children's books. Specifically I

hypothesized that opinion pieces and books by East Asian authors would be more likely to contain analogies than those written by Western authors. Given evidence from Study 3 that Easterners may not be more likely to apply overall structured analogies to a situation, however, it is also possible that Easterners will be more likely to include small, within-work analogies to explain a situation but not more likely to base entire works on analogies.

Power

Each cultural artifact (opinion piece or children's book) was treated as one data point. To ensure 80% power to detect cultural differences of a moderate effect size (d = .50), I aimed to collect 65 data points for each culture for each type of artifact (i.e., 65 East Asian opinion pieces, 65 Western opinion pieces; 65 East Asian children's books, 65 Western children's books).

Study 4a: Newspaper Opinion Pieces

Choosing Opinion Articles

Articles were chosen from the Opinion sections in the English-language version of three top-selling newspapers from East Asia (Japan's *Asahi Shimbun*, China's *China Daily*, and Hong Kong's *South China Morning Post*) and the West (Britain's *The Guardian*, the United States' *USA Today*, and Australia's *Sydney Morning Herald*). The front page of each newspaper's online Opinion section was reviewed for new articles every two to three days between March 20 and March 30, 2016, and every findable opinion piece was collected until at least 75 pieces from each culture had been compiled. Pieces were included in data analysis so long as they were opinion articles by a single author (as opposed to, e.g., interview transcripts or compilations of online tweets). East Asian articles were excluded if they were written by an author with a Western name who appeared white in online pictures. This left a total of 75 East Asian and 74

Western opinion pieces. (A list of all collected pieces including those excluded is available at https://osf.io/e6hb9/.)

Analogy Coding Procedure

The following definition of an analogy was used:

> An analogy explains or predicts something by comparing a relationship in one domain to a relationship in another domain. So a piece of advice or explanation alone would not be enough—to count as an analogy it has to include or imply a comparison of some relationship.

The definition was construed broadly, but it did not include merely creative descriptive or exaggerated explanations (e.g., "this could be the worst disaster in millennia"), comparisons that alone did not imply or rely on a novel or flexible inference (e.g., "it was about the size of a mouse"), simple metaphorical use of directions (e.g., "we're heading towards a recovery" or "inflation went up"), or common sayings that could be interpreted somewhat literally (e.g., "might makes right").

Additionally, analogies were categorized into four levels. The first level included brief, common "language-integrated" analogies (see, e.g., Landau, Meier, & Keefer, 2010). These included conventional expressions that are used regularly likely without special attention (e.g., "the economy is on track," "the Labor party has significant baggage," the "city's night-owls"). The second level included brief but uncommon or novel language-integrated analogies (e.g., "their knowledge about the economy is trapped in the late Qing Dynasty"). The third level included explicit analogies that were at least somewhat structured and explicated, rather than simply integrated into regular language (e.g., "Australia is fighting a battle with type 2 diabetes that it is losing. . . . Hospital wards are filled with the casualties," "just as many small streams make up a river, so many small actions can help the environment"). The fourth and final category included well-elaborated analogies that were a main point or overarching premise of the

article (e.g., using the Easter holiday's Christian bible story of resurrection as a metaphor for the good that comes from renewal, which provided the basis for an entire article on the importance of embracing change). A full list of each article and its categorized analogies (as well as questionable analogies that were not counted as analogies) is available at https://osf.io/e6hb9/.

Because opinion piece length may also vary across cultures, the number of words per article was also coded.

Results

Preliminary analysis revealed that Western opinion pieces (M = 727.4, SD = 183.9) were substantially longer on average than Eastern ones (M = 539.2, SD = 185.8), $t(147) = 6.21$, $p < .001$, $d = 1.02$. Thus the average number of analogies per 100 words was calculated for the four levels of analogy and used to compare prevalence across culture.

As shown in Table 7, combining across all levels of analogies, word-for-word, Eastern opinion pieces included more analogies that did Western ones, though this difference only trended towards statistical significance. See Table 7. The pattern of Eastern articles containing more analogies held across the first three levels individually, though prevalence was virtually identical at the fourth level (well-elaborated, major or overall analogies) and again these differences were not significant.

Table 7.
Prevalence of Analogies of Each Level (per 100 Words) in Eastern and Western Newspaper Opinion Pieces.

Level	Eastern Mean (and SD)	Western Mean (and SD)	t	p	d
Total (combining levels)	.71 (.47)	.61 (.36)	-1.49	.138	.24
1	.49 (.37)	.43 (.31)	-1.14	.256	.18
2	.10 (.16)	.08 (.11)	-.53	.595	.15
3	.10 (.23)	.08 (.11)	-.91	.366	.11
4	.02 (.06)	.02 (.05)	<-.01	.999	<.01

Study 4b: Children's Books

Choosing Books

The East Asian sample of children's books consisted of top-selling children's storybooks (for children aged 3-6 and 7-8) from the common Korean bookseller Kyobo Book (http://kyobobook.co.kr) in June 2015. The Western sample of books consisted of top-selling children's storybooks (for children aged 3-5 and 6-8) from the common US bookseller Amazon (http://amazon.com) in June and September 2015. Originally the top 140 books from Korea and top 160 from the US were compiled, but books were only coded if they were story books (e.g., not activity books, coloring books, or poetry compilations), available free either online or at a local library, and less than 75 pages long. The final sample consisted of 64 Korean books and 63 US books.

Analogy Coding Procedure

The definition of an analogy from Study 4a was used. The definition was again construed broadly, but it did not include merely creative descriptive or exaggerated explanations, comparisons that alone did not imply or rely on a novel or flexible inference, potential symbolism or meaning that was not relatively clear based on the text alone (e.g., maybe *Green Eggs and Ham* is about race relations), or animals or other objects acting as people.

Two levels of analogy were coded. The first level was whether individual analogies were used within the book, for example, if the author or a character said an analogy or if anything was described or explained using an analogy.[7] (A picture could count as an analogy.) The second level was whether the overall story was based on an analogy. The story of the tortoise and the hare would be such an analogy. In that story, the tortoise moving slowly but steadily to beat the

[7] Each individual analogy was also coded for how elaborate it was and whether the analogy was situational (i.e., based on an event or situation itself rather than words used to describe something) were also coded but not analyzed for this paper due to relatively low inter-rater reliability.

very fast hare in a race is an analogy for something like working steadily to succeed in life generally.

Two hypothesis-blind Korean speakers reviewed each of the Korean books, and two hypothesis-blind native English speakers reviewed each of the American books. Reviewers were instructed to record any potential analogies and, when in doubt, to err on the side of including anything that might be an analogy. The Korean coders agreed 73% of the time and the American coders agreed 74% of the time about the number of analogies per book. Final codings were determined by the author, who, when in doubt, coded potential analogies as analogies. A list of all recorded potential analogies (including those ultimately not coded as analogies) and links to the majority of the coded books are available at https://osf.io/e6hb9/. See Table 8 for samples of some analogies from the books.

Results

As predicted, Korean books used more individual analogies on average (M = 2.42, SD = 4.38) than did US books (M = .92, SD = 1.79), $t(125) = -2.52$, $p = .013$, $d = .45$. Because a handful of books had very high numbers of analogies (over eight), to ensure these cultural differences were not driven by a few positive outliers, the number of individual analogies was log10 transformed to reduce skew (from skew = 4.40 to 1.18). Analysis of the transformed data revealed that this difference was still significant (M_{Korea} = .35, SD = .36; M_{US} = .17, SD = .27), $t(124) = -3.13$, $p = .002$, $d = .57$.

Unexpectedly, however, US books were more likely to be based on overall analogies (16/63) than Korean books (7/64), $X^2 = 4.48$, $p = .034$.

Table 8.
Examples of Analogies and Non-counted Potential Analogies from the US and Korean Children's Books.

Counted as Analogies	**Not Counted as Analogies**

Individual
• "I wish you more umbrella than rain" (from *I Wish You More* by Amy Krouse)
• "strong as a shark" (from *The Pout-Pout Fish* by Deborah Diesen and Dan Hanna)
• A picture of a boat rocking someone to sleep like a crib (from *The Going to Bed Book* by Sandra Boynton)
• "beautiful flowers can blossom like stars" (from *Doggy Poo* by Jung-Seang Kwon)
	Individual
	• Descriptive language that was unique but used literally
	  ○ "it looked a little like a sausage" (this was used to describe feces in *The Story of the Little Mole Who Went in Search of Whodunit* by Werner Holzwarch)
	• Comparative language alone that did not imply potential other information
	  ○ "The sunlight's smell from the quilts is as good as my mom's" (from *Man-hee's House* by Kwon Yun-duck)

Overall
• Description: Cat keeps walking even though he keeps stepping in stuff that colors up his new white shoes.
  ○ Analogy: Whatever you step in : keep walking along :: When life gives you obstacles : Don't let it bother you and keep enjoying yourself (From *Pete the Cat: I Love My White Shoes* by Eric Litwin)
• Description: For entire book Sam offers strange-colored food to a friend who repeatedly says he will not like it. At the end the friend tries the food and likes it.
  ○ Analogy: Friend thinks he hates new/unusual food : But then tries it and it's good :: People think they like new/unusual things : Sometimes they would like them if they tried. (From *Green Eggs and Ham* by Dr. Seuss)
	Overall
	• Description: A stuffed bear wants a home and is sad when someone points out he looks bad because he is missing a button.
	  ○ (Potential) Analogy: Missing button may indicate incompleteness without home/family (from *Corduroy* by Don Freeman)
	• Animals or other things acting like people alone

Conclusion

In conclusion, across four studies I found evidence that Easterners at least sometimes rely more on analogical reasoning that Westerners do. Compared to Westerners, Easterners found it easier to generate analogical explanations for understanding an outcome (Study 1), preferred analogical to non-analogical explanations (Study 2), showed some evidence of being more likely to spontaneously apply analogical solutions to the Duncker problem (Study 3c), and tended to use more individual analogies in cultural products like children's stories (Study 4). Easterners, however, were not always better at recognizing and completing structured analogical patterns.

For example, Easterners and Westerners scored nearly identically on the Raven's Matrices (Study 3a) and on pairing objects in pictures based on analogical relationships versus object-based matches (Study 3b). Western children's books may even be more likely to base entire stories (e.g., the *Tortoise and the Hare*) on analogies than are Eastern books (Study 4b). These findings suggest that Easterners may not always use highly structured analogical reasoning more than Westerners do, but they may rely more on analogical thinking to gain a general sense of understanding.

Why Weren't Easterners better at Highly Structured Analogical Reasoning?

One open question is why Easterners were not better than Westerners at more structured analogical reasoning, specifically the Raven's Matrices and Markman and Gentner's (1993) relational pairing task, and why Western books actually contained more overarching analogies in children's books than did Eastern books. One possibility that explains the Raven's Matrices is that Easterners are not objectively more skilled at analogical reasoning than Westerners. Instead both groups may be equally able to reason analogically when required, but Easterners may simply prefer analogies as a "tool of choice" when multiple reasoning strategies are available (see, e.g., Norenzayan & Heine, 2005). Another possibility is that Easterners are generally less concerned with finding a single "correct" answer—or at least any preference for analogies did not develop in order to isolate specific answers. Thus Easterners may not use analogical reasoning any more than Westerners do when looking for objectively correct answers. Instead, a preference for analogical reasoning may have developed, for example, to assist indirect communication or to decrease the chance of offending anyone and to assist finding a "middle way" between extremes. Highly structured analogical thinking may even conflict with the preference for flexible, holistic processing (Spencer-Rodgers et al., 2010). Accurately solving

Raven's Matrices, for example, may require breaking down images into their component parts in order to assess patterns and thus may rely more on logical than relational thinking.

Similarly Easterners may be no more likely than Westerners to rely on analogical reasoning when it conflicts with intuition or alternative obvious solutions (e.g., Norenzayan et al., 2002; see the Cognitive Reflection Task used in Study 1 from Frederick, 2005), and the intuitive answer in the relational pairing task may have been the non-analogical match. In Markman and Gentner's (1993) images, often the object match may have appeared like the obvious answer; recognizing the relationships between small, computer-generated images showing sometimes-unusual events may have required additional slow, step-by-step processing. This methodological difference could explain why participants did not show cultural differences on Markman and Gentner's (1993) pairing task, even though East Asian children have been shown to be better at analogical pattern matching (e.g., Kuwabara & Smith, 2012; Richland et al., 2010) and Easterners repeatedly score more relationally (e.g., the Triad Task from Ji et al., 2004) on pairing tasks that do not have an obvious or intuitive object match.

Yet another possibility is that my participant sampling simply washed out real cultural differences in highly structured analogical reasoning. Previous work, for example, has found that East Asian countries typically score higher than Western countries on the Raven's Progressive Matrices (for a review see Lynn & Vanhanen, 2002, though notably the large majority of these studies only tested performance in children and some of the findings have failed to replicate and have been criticized for methodological problems, see, e.g., Wicherts, Dolan, Carlson, & van der Maas, 2010). The population was unique in a way that reasonably could affect performance on challenging tests like the Raven's Matrices and the Markman and Gentner's (1993) pairing task: they were highly educated and likely more intelligent than the

general population. Even the selections of children's books and newspaper articles were of "top" writers. Thus, though the participants were not at ceiling for any measures (except for the number of causal factors generated in Study 1) and did show differences on many of the measures, future work with more diverse populations may further refine our understanding of when cultural differences in use of analogy do and do not exist.

Why Do Analogies Provide a Sense of Understanding?

One question readers may have is how analogies provide a sense of understanding when they are so flexible and indeterminate, and why this would vary across cultures. Research on metaphors shows that people find metaphors to be helpful for gaining a sense of understanding complex concepts by linking them to more concrete, well-understood ones, which is mentally satisfying (see Landau, Meier, & Keefer, 2010). And of course analogies guide inferences to help people make educated guesses about less well-known domains. But this line of reasoning—basically that analogies help people grasp complex ideas or understand novel subjects—arguably should not differ by culture.

What may differ by culture, however, is whether people are able to fully recognize and appreciate the relationships within an analogy. Previous work finds that people may generate many extensions for a given analogical mapping. For example the setup "*abc* : *abd* :: *kji* : ___" could be solved with multiple answers, including *abd, kjd, kjh, and lji.* However, people rate solutions that rely on analogical relations (e.g., lji – which considers how abc change the lowest letter in the direction of the sequence) as more satisfying than those that do not (e.g., kjd – which just replaces the last letter with "d"). Solutions are rated even more positively when a relationship is explained or repeated across separate analogies (Burns, 1996; stimuli from Hofstadter, 1995). Thus, one possibility that could account for cultural differences is that

Easterners are more likely to see and more fully understand analogical relationships both within a single analogy and across time.

Relatedly, seeing analogical patterns may provide a sense that the world is structured and predictable and that one "fits in." For example, thinking that love is like a river ("On top it can be rocky, but underneath it is deep and calm," see Study 2a) may be a good analogy for someone with a tumultuous relationship, because it suggests that such imperfection is a normal, expected pattern in the universe (cf., e.g., Bohner, Bless, Schwartz, & Strack, 2006; Roese, 1997 (finding that unexpected, negative events prompt counterfactual and causal reasoning in Westerners)). This may be particularly satisfying to people who want to feel that they share in some larger meaningful pattern (see Heintzelman, Trent, & King, 2013), which may be especially likely for those who are collectivistic like Easterners. Westerners, however, may be less concerned with whether they fit in or match the world more generally—indeed people from individualistic cultures might even like to think they are unique. Future work may further examine these hypotheses to refine when and why people find analogies to be "good."

Limitations and Future Directions

Of course, this study only broadly begins to examine cultural differences in analogical reasoning and some limitations should be noted. First, I applied a very broad definition of analogy that often failed to differentiate among very disparate analogy types. Studies 1 and 4b, for example, treated simple metaphors (they were "night owls") and flexible analogies ("no river or sea can be formed without the streams") the same as more novel or elaborate ones when counting analogical production and prevalence. And the measures of analogical reasoning varied dramatically across studies. For example Study 3 used highly structured visual analogical reasoning tasks (e.g., Raven's Matrices) alongside less-exact verbal problem solving (the

Duncker Problem). But prior work shows that there are meaningful differences between types of analogies. For example, people prefer deeply connected relational structures to more superficially similar ones (e.g., Forbus & Gentner, 1989). It is even possible that some metaphors have become so common that people no longer process them in a way that shares relational information (Gentner, Bowdle, Wolff, & Boronat, 2001). Future work should more clearly and systematically differentiate among analogy types. It is possible, for instance, that different analogies serve different purposes (e.g., problem solving, making one feel part of a larger pattern, or allowing one to communicate indirectly) and thus may be tailored to be useful in different situations.

As noted earlier, I also used a highly educated, highly intelligent sample. Even the cultural artifacts in Study 4 were likely written by highly successful, likely very smart people. It is unclear, however, whether such people would be more or less likely to rely on analogical reasoning than their more average counterparts. Additionally, my Singapore population (the Eastern population for Studies 1-3) was comprised primarily business majors and engineers, who may be a unique population that has developed a relatively individualistic or analytic, Western-style subculture. And Singapore in general is sometimes considered to be a "bi-cultural" nation rather than a purely East Asian one, as the country's primary language is English (though nearly all ethnically Chinese people also speak Chinese) and the culture integrates British, Indian, and Malay influences. These sample issues would likely only underestimate any East-West cultural differences, but future work should expand the study of cultural differences to more diverse and representative samples.

Final Thoughts

To my knowledge, this is the first study to systematically assess cultural differences in adult analogical thinking and, more generally, how Easterners structure and explain their worlds if they are not relying on counterfactual reasoning. Better documenting these differences may help us improve reasoning and problem solving in both groups. For example if the Eastern style of thinking is better at analogical problem solving (e.g., the Duncker problem) and Easterners gain more satisfaction from analogical explanations, then teaching Westerners to integrate more holistic reasoning styles and consider relations more may increase their problem solving and well-being. Additionally, understanding cultural differences in analogical reasoning may even change our conception of what it means to be a holistic thinker. In the case of Kitayama et al.'s (2003) framed-line task, for instance, it is possible that, compared to Westerners, Easterners were not simply failing to ignore surrounding information, but rather that they were being influenced by the tendency to structurally map the original stimulus onto the new task. And, of course, simply a better understanding of how others think may aid business, political, and personal communication and relationships across cultures.

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Appendix A

Study 2a Analogical and Non-analogical Explanation Pairs

Analogical Version	Non-analogical version
Bandwidth B: Bandwidth in computer networking is like a series of highways, and information is cars on the highway. If there's only one car on the highway, that car will travel quickly and easily. If there are many cars, however, traffic can build up and slow things down. (68.5, 7.6)	Bandwidth A: Bandwidth in computer networking describes the amount of data that can be carried by a network. The amount of data that can be carried at any one time is limited. So if only one person is downloading one file, the transfer should happen fairly quickly. If several people are trying to download the same file, though, the transfer can be much slower. (65.6, 8)
Married couples fight B: Love is like a deep river. On top it can be rocky, but underneath it is deep and calm. (99.2, 1.8)	Married couples fight A: Even couples who experience a lot of conflict can still have good relationships, because they are still very committed to each other and content overall. (42.7, 13.5)
Cell Nucleus B A cell's nucleus is its brain. (103, .6)	Cell Nucleus A The cell nucleus regulates gene expression, thus controlling cell activity. (27.5, 11.9)
Procrastination B Procrastinating on an assignment is like driving a fast car and waiting until the last second to use the breaks before a light. (58.4, 10.8)	Procrastination A Procrastinating on an assignment causes people to feel out of control for a short period of time, and there is a chance procrastinators will not finish in time. (48.5, 13.5)
Exercise B Regular exercise is important, just like brushing your teeth. (47.3, 8.9)	Exercise A Regular exercise is important, as it helps your heart, lungs, and bones stay strong. (71.8, 6.7)

Note. Flesch-Kincaid Reading Ease score followed by Grade Level included in parentheses after each explanation (calculated using https://readibility-score.com).

Appendix B

Study 2b Analogical and Non-analogical Social Explanation Choices

Story 1- Breakup:
Imagine your best friend just broke up with their boyfriend or girlfriend of several months. They thought they had a really good connection with the person and are upset that they did not "see the breakup coming." You really want to comfort your friend and make them realize they will be ok and this is normal.

Which of the following two responses do you think would be best to say to your friend?

Response A (analogical):
Relationships are like stars. Some are bright but only live a short time.

Response B (non-analogical):
Sometimes even great relationships naturally end after a few months.

Story 2 – Car Loan:
Imagine you recently got married, and you and your spouse are looking to buy a car. You and your spouse do not have a lot of money, but you have been saving up for over a year and have enough to buy an inexpensive used car. Your spouse, however, would like to buy a somewhat more expensive new car, which would require you to take out a loan. You think it is wisest to choose the cheaper car so you do not have to take out a loan.

Which of the following two responses do you think would be best to say to your spouse, to explain why you think the inexpensive car is the best choice?

Response A (analogical):
Considering that we do not have a lot of money right now, it is best to stretch your arm no further than your sleeve will reach.

Response B (non-analogical):
Considering that we do not have a lot of money right now, it is best we buy the inexpensive car so we do not have to take out a loan.

Story 3 – Bird's Nest:
Imagine a young child asks you what a bird's nest is and why birds are always in the trees.

Which of the following explanations do you think would be best?

Response A:
Many birds are born in little houses called nests located in the trees. The rest of the tree is the bird's back yard, and birds often spend time there.

Response B:

Many birds are born in little nests made of twigs located in the trees. The rest of the tree helps protect the nest, and birds often spend time there.

Story 4 – Harming Advisor:
A few years ago a graduate student at a university stabbed his advisor to death. Newspapers around the world covered the story, and people were very upset.

Which of the following explanations do you find best for understanding why a graduate student would do that?

Response A:
Advisors are like fathers to their graduate students.

Response B:
The advisor failed to provide support for graduate student.

Story 5 – Losing Track of a Satellite
A few years ago the government was tracking a satellite falling from space. Up until the final moments, the satellite was expected to fall into the Pacific Ocean near the Tropic of Cancer. Shortly before ground fall, however, the satellite quickly changed course, landing 1,000 miles south of its expected course.

Which of the following explanations do you find best for understanding how the satellite could so quickly and dramatically change course?[8]

Response A:
Satellites falling through the atmosphere are like pennies in water—sometimes they go straight down, and sometimes they spin or radically change direction.

Response B:
Variations in the atmosphere—for instance, changes in wind patterns and air density—can radically affect the physical drag on the satellites and the way they fall through the atmosphere.

[8] Modeled after story in http://curry.virginia.edu/go/clic/nrrc/scin_ir7.html

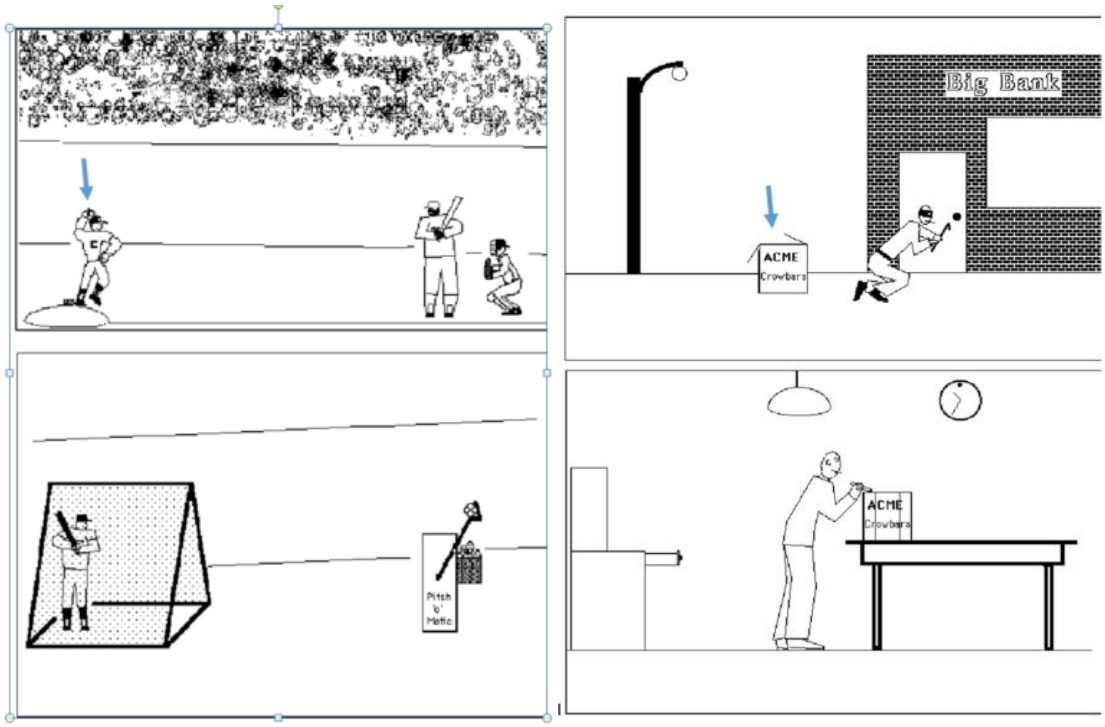
Appendix C

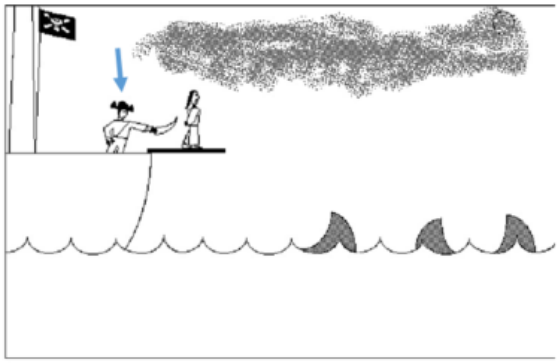
Study 2c Markman & Gentner (1993) Instructions and Images.

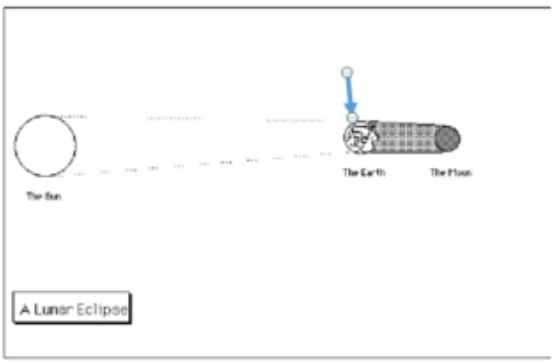
Instructions: “Next you will see pairs of images. An arrow will point to an object (a person or thing) in one picture. Your job is to say which object in the other picture goes with that object.”

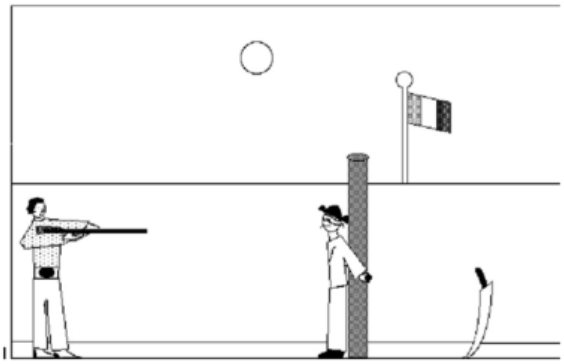
Response prompt (repeated after each image pair): “Please write which object in the lower picture goes with the object pointed to in the top picture.”

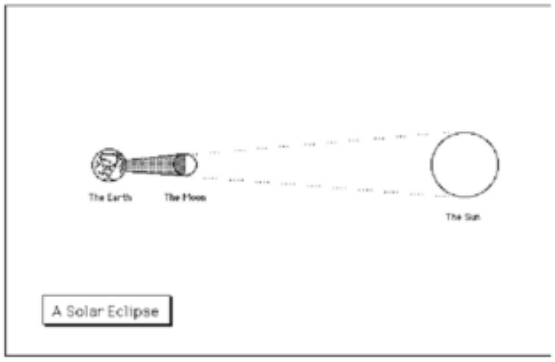
(Image pairs are presented next to each other below to save space. Participants, however, saw only one image pair (top and bottom) at a time.)

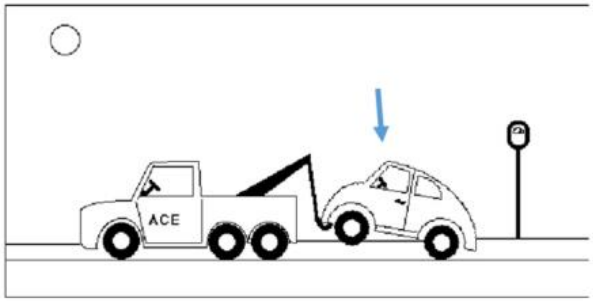


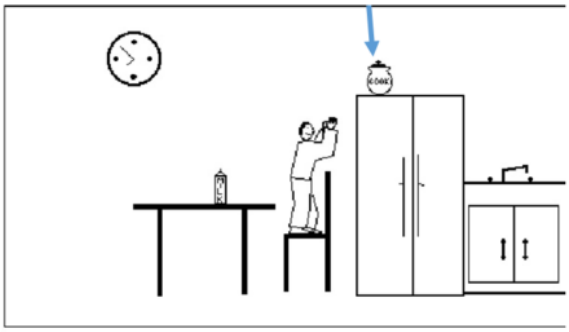


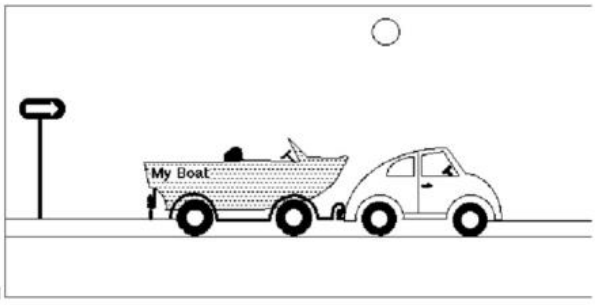

The Sun
The Earth
The Moon
A Lunar Eclipse

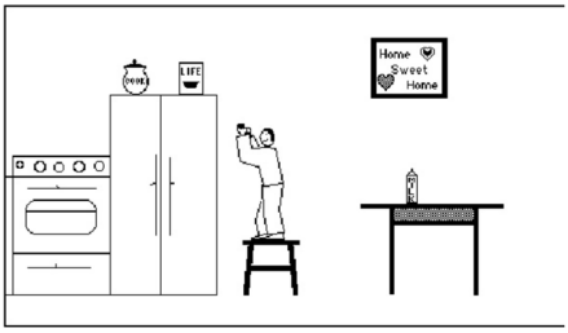


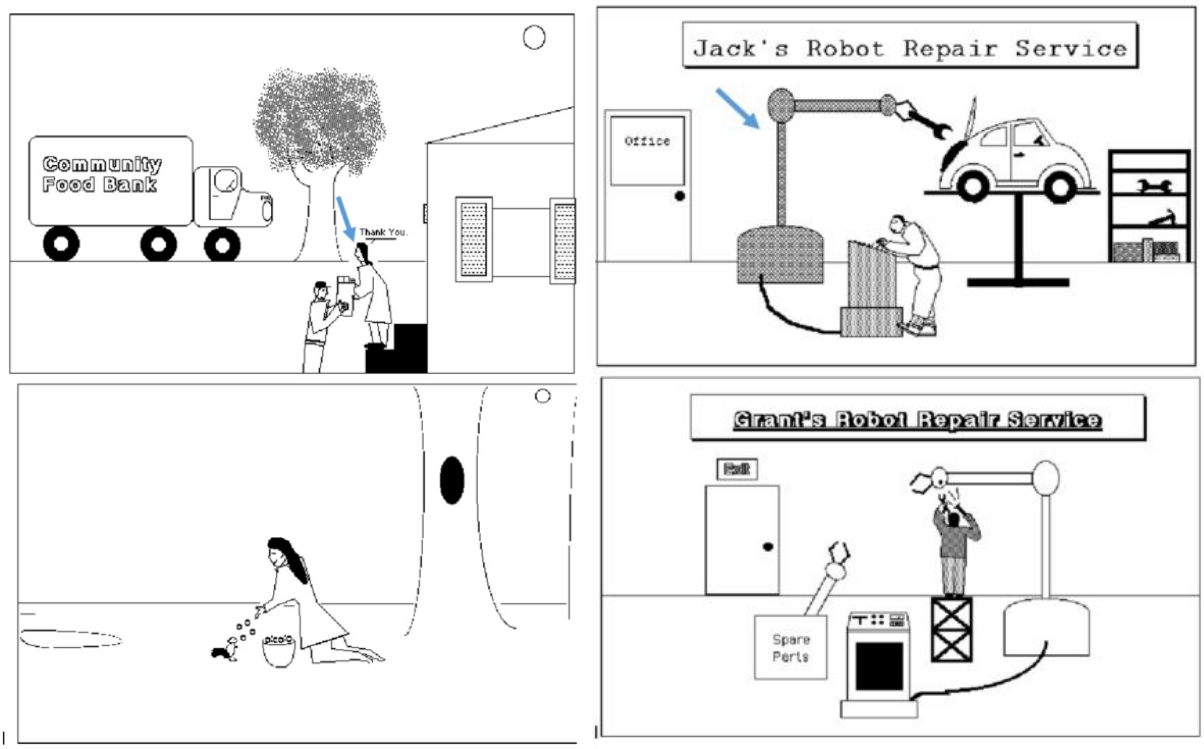

The Earth
The Moon
The Sun
A Solar Eclipse


ACE




My Boat


Home
Sweet
Home


Community
Food Bank
Thank You.
Jack's Robot Repair Service
Office
Grant's Robot Repair Service
Spare
Parts

Appendix D

Study 3c Duncker Problem Stories.

Instructions: “Next are some short stories. Please read each short story carefully. After you are finished reading the story, click forward to answer the questions about it.”

Summary prompt presented after each story along with space to type answer: “In your own words in one or two short sentences only, how would you summarize the story?”

(Analogous) Story: The General and the Fortress

A small country was ruled from a strong fortress by a dictator. The fortress was situated in the middle of the country, surrounded by farms and villages. Many roads led to the fortress through the countryside. A rebel general vowed to capture the fortress. The general knew that an attack by his entire army would capture the fortress. He gathered his army at the head of one of the roads, ready to launch a full-scale direct attack. However, the general then learned that the dictator had planted mines on each of the roads. he mines were set so that small bodies of men could pass over them safely, since the dictator needed to move his troops and workers to and from the fortress. However, any large force would detonate the mines. Not only would this blow up the road, but it would also destroy many neighboring villages. It therefore seemed impossible to capture the fortress.

However, the general devised a simple plan. He divided his army into small groups and dispatched each group to the head of a different road. When all was ready he gave the signal and each group marched down a different road. Each group continued down its road to the fortress so that the entire army arrived together at the fortress at the same time. In this way, the general captured the fortress and overthrew the dictator.

(Non-Analogous) Story: The Identical Twins

Once there were identical twins who were continually playing pranks on their family, friends, and teachers. The annual school picnic was always a big event for the twins. There were races and other athletic events in which the twins won lots of prizes. One year a new student arrived who was a star runner. The twins wanted to win the main event: the 2-mile race through the woods behind the school. So they secretly devised a plan which would enable them to outdo the newcomer.

The day of the race arrived. Each runner was to pick his own path through the woods to a clearing, where a teacher stood posted to determine the winner. One twin entered the race, while the other excused himself on the grounds that he had hurt his leg in an earlier broad jumping event. The race began and the students rushed into the woods. The twin rushed into the woods and waited until the others had passed out of sight. Then he went back to the school using a path hidden from the picnic area. Shortly after, the other twin, who had been hiding behind a rock near the finish line of the race, burst out and ran into the clearing ahead of the other runners. The teacher named him the winner and marveled at the speed of his running. Next year the twins switched places and thereafter maintained their status on this event.

(Non-Analogous) Story: The Wine Merchants

One day a rich man found that his wine cellar was empty. So he sent out messengers to announce a generous offer. The first person to bring the rich man a barrel of wine would be given a brick of solid gold. However, the offer would expire at sundown.

Two wine merchants heard the news. Each had a horse-drawn cart loaded with large barrels of wine. They both set out for the duke's palace at once. An hour before sundown they came to a place where the bridge had been washed out by a raging river. The first merchant drove his horses and cart into the flood in a desperate attempt to reach the other side. But the horses were already exhausted and could not fight the current. The cart overturned, and the horses, wine, and driver were washed way.

The second merchant tried a different tactic. He poured the wine out of all but one of his barrels, and lashed them together to form a raft; then he loaded the one full barrel, a horse, and himself on top. He set the raft adrift and floated downstream. In a few minutes the raft came to rest on the shore in front of the town where the rich man lived. The merchant disembarked, loaded the wine barrel on the horse, and led it to the rich man's house. He arrived just as the sun was setting, and collected the gold brick as a reward for his efforts.