ANALOGICAL REASONING IN CHINESE AND US ADULTS

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ABSTRACT

Minds differ across cultures. According to a long-standing dogma, Westerners are more capable of thinking abstractly than East Asians, who tend to be "more concrete in their conceptualizations" than Westerners (Moser, 1996, pg. 134). Here, we challenge this generalization by comparing Chinese and US adults on a paradigm case of abstract thinking: analogical reasoning. Chinese and US participants completed the most difficult subset of questions from Raven's (2003) Standard Progressive Matrices (SPM), a widely used test of analogy. Compared to US participants, Chinese participants produced significantly more correct answers on the SPM task, indicating more successful analogical reasoning. This cross-cultural difference remained significant when demographic factors including age, sex, and education were controlled. These results are inconsistent with the belief that East Asians are impaired in their ability to think abstractly; they are consistent, however, with a more recent proposal (Singh, Wang, & Casasanto, 2019) according to which East Asian's sensitivity to contextual relationships gives them an *advantage* over Westerners in various kinds of abstract thinking, including analogy. Further studies are needed to evaluate whether Chinese participants' superior performance on Raven's SPM extends to cognitive tasks in general, or whether the cross-cultural difference we report here is selective for cognitive tasks that require using abstract concepts or discerning abstract relationships.

Keywords: Cultural psychology, Raven's Progressive Matrices, Analogy, Abstract thought.

BIOGRAPHICAL SKETCH

Shikun Su was from Fushun, in Liaoning Province, China. She graduated from Franklin and Marshall College in 2019 for a double degree in psychology and German literature and culture. She pursued and completed a master degree in Human Development at Cornell University in 2020. Outside the academics, she wrote novels in Chinese and the books were published in China. She traveled to 20 countries for studying abroad, engaging in cultural communications and activities, and traveling. She played African drumming for 3 years and participating in plenty of concerts before. She treasured her experience at Cornell University and moving forward for more challenging life.

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Introduction

Cultures differ in their social orientations, which correspond to differences in thinking. Specifically, Western thinking reflects the heritage of ancient Greek thought, which encourages an individualistic mindset and an analytic style of perception (Hamilton, 1973; Markus & Conner, 2014; Markus & Kitayama, 1991; Nisbett, Peng, Choi, & Norenzayan, 2001; Norenzayan, Smith, Kim, & Nisbett, 2002). In comparison, East Asian thinking reflects Confucian values, which encourage an interdependent mindset and a holistic style of perception (Markus & Kitayama, 1991; Nisbett, Peng, Choi, & Norenzayan, 2001). Whereas analytic perception requires a focus on the objects being perceived, holistic perception requires attention to relationships between the objects, and between objects and their context (Nisbett et al., 2001).

Do people from East Asian and Western cultures differ in their tendency to think abstractly or concretely? According to one suggestion by Nisbett and colleagues (2001) East Asians are disadvantaged compared to Westerners in formal reasoning: a paradigm case of abstract thinking which underlies many endeavors in mathematics, science, and engineering. In a test of this proposal, East Asians were more likely to use intuitive strategies to complete experimental tasks, whereas Westerners were more likely using formal rule-based strategies (Norenzayan, Smith, Kim, & Nisbett, 2002). The results of this influential psychological study are consistent with a longstanding dogma in linguistics and anthropology according to which members of some non-Western cultures are trapped in a concrete world and unable to reason on subjects that cannot be apprehended with the senses (e.g., Wallace, 1870). In particular, the Chinese language has been characterized as a barrier to thinking abstractly (Moser, 1996). Consistent with this dogma, Nisbett, Peng, Choi, and Norenzayan (2001) suggested that Westerners "should be more capable of reasoning based on abstract rules" than East Asians (pg. 970; see also Nisbett & Miyamoto TiCS 2005).

However, the idea that Westerners tend to think more abstractly than East Asians *in general* has been challenged by Singh, Wang and Casasanto (2019). Chinese and Caucasian Americans responded to the behavioral identification form (BIF) developed by Vallacher and Wegner (1989). The BIF questionnaire consists of 25 questions that measures the abstract and concrete action construal. Participants read the names of actions (e.g. painting a room) and chose either an abstract description focusing on the action's goals (e.g. making the room look fresh) or a concrete description focusing on the action's mechanical details (e.g. applying brush strokes). In Singh et al.'s (2019) study, Chinese people tended to choose more abstract descriptions, indicating that they construe events more abstractly than Westerners.

Yet, Singh, Wang, and Casasanto's study only tested one kind of abstract thinking (i.e. hierarchical construal of events) using only one measure (the BIF questionnaire). It is still unclear whether the East-West cultural differences extend to other notions of abstract and concrete thinking. The present study compares East-West thinking patterns on another paradigm case of abstract thinking: analogical reasoning (Gentner, 1983; Gentner & Kurtz, 2005; Morsanyi & Holyoak, 2010). We used Raven's (2003) Standard Progressive Matrices (SPM), a well-validated measure of analogical reasoning, to test for East-West differences in the ability to discern abstract analogical relationships among stimuli.

Raven's SPM tests consist of five sets of picture puzzles (Raven, 2003). Participants must indicate which picture, out of the multiple choices, best completes each visual pattern (Raven & Court, 1996). For the more difficult items, finding the solution requires participants to discern analogical relationships that can only be discovered by looking beyond the individual pictures and considering the pictures in the context of a series of images. Discovering such contextual relations is a hallmark of abstract thinking (Gentner, 1983; Gentner & Kurtz, 2005; Morsanyi & Holyoak, 2010); we posit that East Asians should have an advantage over Westerners in finding the correct analogical relations because of their

greater propensity to be sensitive to relationships in the physical and social world, more broadly (Brewer & Gardner, 1996; Markus & Kitayama, 1991; Nisbett et al., 2001).

Multiple studies, conducted over several decades, have compared East Asian and Western *children* on versions of Raven's Progressive Matrices (Huang & Hanley, 1995; Lynn, 1991; Lynn, Chan & Eysenck, 1991; Lynn, Pagliari & Chan, 1988; Ma & Leung, 1991; Raven, 2000). In general, the results show that East Asian children score higher than Westerners children. However, we are not aware of any studies comparing Raven's SPM in East Asian and Western *adults*.[1] Thus, it is possible that the cross-cultural differences in Raven scores measured in children are due to cross-cultural differences in parenting or educational practices (Chan, 1994; Chen & Chen, 1988), and that these differences may not be maintained into adulthood.

Raven's SPM test is often used as a measure of general intelligence (Carpenter, Just, & Shell, 1990; Brouwers, Van de Vijver, & Van Hemert, 2009; Laidra, Pullmann, & Allik, 2007; Lynn, Chan, & Eysenck, 1991; Van den Broek & Bradshaw, 1994), and as a non-verbal test to measure Spearman's g (Mackintosh & Bennett, 2005; Spearman, 1946, p.127). Our goal here is not to compare intelligence across cultures, but rather to use the SPM as an operationalization of analogical reasoning.

If East Asians (e.g. Chinese people) tend to think more abstractly than Westerners (e.g. Caucasians in the U.S.), as suggested by Singh et al. (2019), then Chinese people should produce more correct answers on the Raven's SPM. Alternatively, if Westerners tend to think

[1] Previous studies using Raven's SPM in adults either used only a small subset of questions extracted from Raven's SPM (Bayliss, Jarrold, Gunn, & Baddeley, 2003; Bilker, Hansen, Brensinger, Richard, Gur, & Gur, 2012; Civelli & Deck, 2017), or used Raven's SPM in combination with other intelligence tests to compute a composite score (Van der Elst, Ouwehand, van Rijn, Lee, Van Boxtel, & Jolles, 2013); to the best of our knowledge, no previous study reports complete SPM scores that are broken out from a larger composite score in Western and East Asian adults.

more abstractly than East Asians, as suggested by Nisbett and colleagues (2001; 2005), Caucasian US adults should produce more correct answers on the Raven's SPM. If East Asian and Western adults do not differ systematically in their capacity for abstract thought, as indexed by a test of analogical reasoning, then the rate of correct answers on the Raven's SPM should not differ between Chinese and Caucasian US adults.

Method

Participants

Chinese participants in China (N = 432) were recruited via wjx.cn, a Chinese survey website, and U.S. participants (N = 402) were recruited via Amazon Mechanical Turk. Following pre-registered exclusion criteria (http://aspredicted.org/blind.php?x=zt4ru9) we excluded participants who did not report being native monolingual speakers of Mandarin (n = 15) or English (n = 7), and those who did not report that their country of birth was China (n = 0) or the US (n = 1), were not Caucasians (n = 61) in the US sample and not Asian in the Chinese sample (n = 3). Further participants were excluded because, on one or more questions: they took less than 3 seconds to respond (China: n = 78; US: n = 59; consistent with responses from an automated 'bot'); they took more than 3 minutes to respond (China: n = 43; US: n = 11); on some trials they took less than 3 seconds and on other trials more than 3 minutes to respond (China: n = 9; US: n = 3); they did not answer the sample question correctly (n = 49); they reported having done the SPM previously (n = 81); they gave incomplete or nonsensical answers on demographic questions (n = 9); they did not meet our a priori participation criteria for Amazon Mechanical Turk workers (n = 5). After these exclusions, 224 Chinese participants (mean age = 30.25 +/- 7.85) and 176 Caucasians in the US (mean age = 39.44 +/- 11.17) remained; their data are analyzed below. Volunteers were paid for their participation (Chinese: 4.05 RMB; US: 1.25 USD).

Materials

Participants completed Set E from Raven's SPM. Raven SPM tests consist of five sets (labeled Set A through Set E) of 12 questions. Each set consists of 12 puzzles that become progressively more difficult within the set; the puzzles also become more difficult across sets (Raven, 2003). According to Raven and Court (1996) analogical reasoning is not essential for solving the puzzles in Sets A and B, or for the easier puzzles in Sets C and set D; these easier

puzzles can be completed using non-analogical strategies (e.g., perceptual pattern completion). The problems in Set E are the most reliant on analogical reasoning. Since our goal was specifically to test analogical reasoning we administered only the 12 questions from Set E, presented in their canonical order.

All participants completed the study online, using Qualtrics software. US participants completed the study in English, and Chinese participants completed it in Mandarin (using simplified Mandarin characters). The English instructions were adapted from the standard instructions in the Manual for Raven's Standard Progressive Matrices (Raven & Court, 1996); we updated some wording of the questions to reflect contemporary US English, and adapted the pencil-and-paper instructions for use online. We constructed a Mandarin version of the instructions by translating our US English instructions. One native Mandarin speaker translated the US English instructions into Mandarin, and a second native Mandarin speaker back-translated the (new) Mandarin instructions into English. Any discrepancies between the back-translation and our US English instructions were discussed and resolved by the two Mandarin speakers before the Mandarin version of the instructions was finalized.

Procedure

Participants were given the detailed instructions and then answered a sample question from an easier SPM set (question A1). Participants were given the correct answer in the instructions for the sample question; their job was to select this answer from the options provided. As such, the sample question served both as a tutorial and as a manipulation check: Participants who answered the sample question incorrectly were excluded from analyses.

After the sample question, participants completed SPM Set E. For each question, a matrix 'puzzle' was shown, with one puzzle piece missing. Below the matrix (visible on the same screen) were 8 possible completions to the puzzle, each with a corresponding radio button. Participants were instructed to select the option that best completed each puzzle, and to

respond as quickly and accurately as possible. After completing the SPM, participants answered study-relevant demographic questions about their age, sex, education, income, country of birth, occupation and the languages they speak; they also answered other standard demographic questions that were not expected to be relevant to this study, about their handedness and (for US participants, only) their political affiliation.

Results

A mixed effects logistic regression model was run to predict Raven's SPM responses for each question (correct or incorrect) as a function of culture (Chinese, US), with subjects and items as random effects. Chinese participants produced more correct answers (M = 8.57, SE=0.19) than Caucasians US participants (M = 5.98, SE = 0.24; $\chi 2$ (1) = 22.58, OR = 4.91 [95%CI:3, 8.04], $p = 2.01 \times 10^{-6}$, figure 1).

Subsequent analyses tested for effects of culture controlling for demographic variables that could potentially affect abstract thinking: sex, education, and age. The difference between Chinese and US SPM scores remained highly significant when controlling for sex ($\chi 2$ (1) = 22.61, $p = 1.98 \times 10^{-6}$), age ($\chi 2$ (1) = 19.83, $p = 8.474 \times 10^{-6}$), and education ($\chi 2$ (1) = 22.53, $p = 2.059 \times 10^{-6}$).

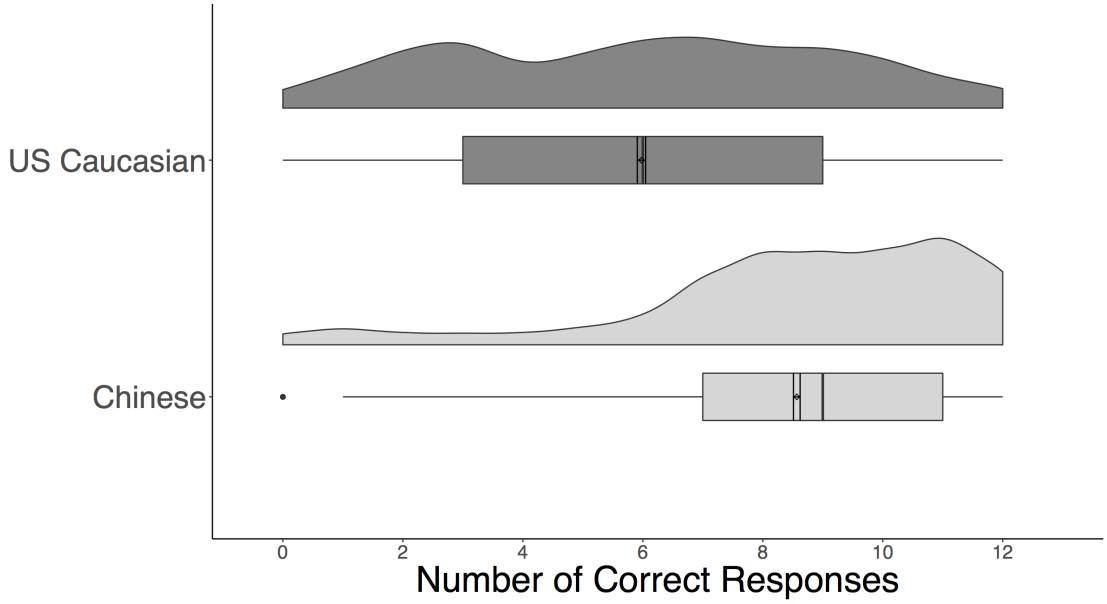

Figure 1. The mean number of correct responses (out of 12) in Caucasian adults in the US (top: N = 176) and Chinese Adults in China (bottom: N = 224) for Set E of Raven's SPM. The diamond shows the means, the double lines show standard errors of the means, and the bold

line shows the medians for each sample. The shaded areas above the boxplots are half-violin plots showing smoothed histograms of the response frequencies.

Discussion

Chinese participants produced more correct responses on Ravens' SPM task than US participants. These results support the hypothesis that, compared to US participants, Chinese participants have an advantage in analogical reasoning, consistent with their propensity to discern or construct relationships in the physical and social world (Brewer & Gardner, 1996; Kitayama et al., 2003). The difference between Chinese and US performance on the SPM task remained significant when the effects of age, sex, and education were controlled. These results are inconsistent with a longstanding dogma in the social sciences (e.g., Wallace, 1870; Moser, 1996), which extends even into 21st century cultural psychology (Nisbett et al., 2001; Nisbett & Miyamoto, 2005; Norenzayan et al., 2002), according to which Chinese people are "more concrete in their conceptualizations" (Moser, 1996, pg. 134) than Westerners, and are "indifferent to abstraction" (ibid., pg. 7). By contrast, in the present study Chinese participants had a clear advantage over US participants in analogical reasoning: a paradigm case of abstract thinking insomuch as it requires discerning invisible, intangible relationships among objects that cannot be observed in any of the individual objects, per se. A previous set of studies suggested that Chinese people think more abstractly than US Caucasians as indexed by their tendency to construe events at a higher, more abstract level of description (Singh et al., 2019). The present results extend the evidence that Chinese people tend to think more abstractly than US Caucasians, as indexed by their superior performance on a standard test of analogical reasoning.

To the best of our knowledge, these data provide the first direct comparison of analogical reasoning between East Asian and Western adults, but they are consistent with tests of Raven's Progressive Matrices in East Asian and Western children. For example, children in Hong Kong scored higher on the Raven's task than British children (Lynn, Chan, & Eysenck, 1991; Lynn, Pagliari, & Chan, 1988). Our results are also broadly consistent with other tests

of intelligence in Easterners and Westerners. In general, East Asians have been found to score higher on IQ tests than Westerners around the world (Rushton & Jensen, 2005). We note, however, that East Asians and Westerners may have different conceptions of intelligence, making this complex construct difficult to compare across cultures (Sternberg, 1984). Our claims here are limited to the finding of a clear cross-cultural difference in one measure (Raven's SPM) of one aspect of high-level cognition (analogical reasoning). Raven's SPM has the advantage of being entirely pictorial, relying on simple non-representational shapes and patterns; since the SPM puzzles and their solutions are free of language and other culture-specific artifacts, this task is more culture-neutral than many other widely used tests of intelligence, making the results are easier to compare across cultures.

Thus far, we have interpreted our results as evidence of East-West differences in *abstract* thinking in particular -- since this is the kind of thinking that Raven's SPM measures. However, on the basis of these data, alone, it is possible that East Asians may be advantaged in cognitive tasks more generally, and not just in those tasks that tap abstract abilities such as analogical reasoning. If so, the present results would be consistent with the broad pattern of cross-cultural differences in intelligence mentioned above (Rushton & Jensen, 2005). Although we cannot determine the specificity of the differences between Chinese and US adults on the basis of these results, future experiments could provide leverage on this question. For example, now that we have established a substantial difference in Raven's SPM performance between Chinese and US adults, we plan to replicate this study with the addition of "low-abstraction" cognitive tasks, for comparison. In one such task, participants will memorize strings of numbers and perform a two-alternative forced choice working memory task. Unlike the Raven's SPM task, this memory task does not require any abstraction: only rote memorization. If Chinese adults are superior on all cognitive tasks, then they should perform better than the US participants on the Raven's SPM test and the working memory

task, alike, yielding a main effect of Culture. Alternatively, if Chinese people are advantaged for abstract thinking in particular, then their scores should be better than US participants' selectively for the Raven's SPM task, yielding a Culture by Task interaction. The results of such a study, which compares East Asian and Western people on cognitive tasks *with* and *without* the requirement for abstraction will allow us to determine whether East Asians have an advantage for thinking abstractly, or for cognitive tasks more broadly.

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