HHS Public Access
Author manuscript
J Appl Res Mem Cogn. Author manuscript; available in PMC 2022 March 01.

Published in final edited form as:
J Appl Res Mem Cogn. 2021 March ; 10(1): 33–43. doi:10.1016/j.jarmac.2020.08.016.

Cross-Cultural Differences in Memory Specificity: Investigation of Candidate Mechanisms

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Abstract

Previous research has revealed that people from Western cultures tend to remember more details of objects and events in autobiographical memory compared to people from Eastern cultures. The present experiments tested whether differences in pattern separation – the process by which new, but potentially similar, exemplars are discriminated from previously-encountered exemplars – account for these cultural difference in object memory. In two experiments, we investigated the extent to which North Americans and East Asians differ in pattern separation and whether these effects are related to cultural values. We also examined the role of response bias. These results revealed it is unlikely that pattern separation is the sole mechanism underlying cross-cultural memory specificity differences, as broader memory mechanisms, such as differences in memory resolution for previously-encoded items, could account for the differences observed between groups.

General Audience Summary

Culture influences many cognitive processes, including memory. Previous research has revealed that people from Western cultures tend to remember more details of objects and events in autobiographical memory compared to people from Eastern cultures. This study investigates how individuals from North American and East Asian cultures differ in how well they recognize previously-studied objects and discriminate them from objects that look similar. We expected cross-cultural differences specifically in the ability to discriminate similar objects from those that had already been studied. Instead, our results showed cross-cultural differences across multiple types of memory decisions. This kind of cross-cultural work is important because it challenges generalizations about human psychology that have historically been based on very homogenous – and often Western – populations.

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Author Contributions
A.G. and K.L. conceived of the presented ideas and further developed the theory. K.L. and A.G. oversaw data collection. K.L analyzed and interpreted the data under the supervision of A.G.. K.L. wrote the manuscript with significant feedback from A.G.

Keywords

culture; recognition memory; pattern separation; cognition; cross-cultural

Throughout an individual's lifespan, culture dictates one's values, goals, and behaviors, making it likely to shape cognitive processes such as memory and attention. These experiments aim to investigate how Eastern and Western cultures contribute to diverging performance in recognition memory tasks, by testing the role of specific mechanisms, including pattern separation and cultural values.

Cultural differences in social and cognitive processes have tended to focus on the role of values in individualistic cultures, encompassing Western countries such as the United States, and collectivist cultures, such as East Asian countries (Markus & Kitayama, 1991; Nisbett, Peng, Choi, & Norenzayan, 2001; Masuda & Nisbett, 2001). Even though consistent cultural differences emerge based on these groupings, it should be acknowledged that individual differences do exist, such that cultural groups have overlapping distributions on individualism and collectivism, rather than extreme differences.

Beyond socio-cultural factors, the differences between North Americans and East Asians extend to cognitive processes. In terms of the cognitive domain of memory, accumulating evidence identifies cultural differences in what and how information is remembered. In studies of autobiographical memory, the childhood recollections of North American young adults were more specific and self-focused whereas the memories of East Asian young adults centered more on collective activities; these cross-cultural memory specificity differences emerge as early as pre-school age (Wang, 2001; Wang, 2004; Wang 2006). Cultural differences also extend to memory for objects, in laboratory experiments that control what information is presented to participants. For example, encoding images of everyday objects and completing a memory test on them reveals cultural differences. Although both groups had equivalent general memory, that is, memory for items that does not require precise memory for object details North Americans had higher levels of specific memory, which requires memory for specific details about object features (Millar, Serbun, Vadalia, & Gutchess, 2013). This suggests that culture impacts the amount of perceptual details that is encoded and/or retrieved in memory. Investigating the underlying processes that shape these detailed memory representations is the primary aim of this study.

One such memory process to consider is pattern separation, by which similar stimuli are given orthogonal mental representations and thus able to be recognized as distinct from one another despite their overlapping features (e.g., knowing that a red apple and a green apple are two separate apples despite sharing physical traits and semantic associations) (Yassa & Stark, 2011). This process contrasts pattern completion, which is the process that strengthens the overlap between similar representations. Although both processes can be useful for long-term memory retrieval, the distinct representations created through pattern separation allow individuals to avoid false endorsements of similar objects or events (Davidson, Vidjen, Trincao-Batra, & Collin, 2019). Pattern separation could contribute to the specificity of memory, such that the contents of distinct mental representations may inform the discrimination of target and lure items. Pattern separation ability can vary across groups, with older adults, and particularly those at risk for dementia, performing poorer on pattern separation than younger adults (Stark, Yassa, Lacy, & Stark, 2013; Stark, Stevenson, Wu, Rutledge, & Stark, 2015). Thus it is possible that individual differences in pattern separation, which encompass the *tendency* to pattern separate (vs. pattern complete) (Duncan, Sadanand, & Davachi, 2012), could occur across other groups, including cultures. If pattern separation is indeed the mechanism underlying differences in memory specificity across cultures, then we would expect to see cross-cultural differences in pattern separation that mirror previously observed differences in memory specificity.

Although effects of culture on the specificity of memory for objects have been investigated in a number of studies (Millar et al., 2013; Paige et al., 2017a, 2017b; Mickley Steinmetz et al., 2018), research to date has not identified the mechanisms underlying these effects. Much of the work on cross-cultural differences in cognition focus on social explanations, conceptualizations of the self, or cultural traditions of thought, though these have not been shown to account for all cultural differences in memory (as discussed in Gutchess & Sekuler, 2019). The following experiments replicate the prior work and extend it by testing the contribution of pattern separation to memory performance, considering measures of memory sensitivity and response bias. Additionally, by also considering measures of self-construal and values, we are able to conduct exploratory analyses investigating the extent to which memory differences may be linked to values such as independence and interdependence that have traditionally defined prior work comparing Eastern and Western groups. Identifying such cognitive mechanisms and any relationships they may have with sociocultural values ultimately contributes to a deeper understanding of cross-cultural memory and cognition.

Experiment 1

To investigate cultural differences in pattern separation, we tested North American and East Asian participants with a widely-used pattern separation task (Kirwan, Jones, Miller, & Stark, 2007; Stark et al., 2013). Participants viewed images of everyday objects and then in a memory test, they were asked to discriminate those previously seen objects from objects similar to them as well as from completely novel objects. We predicted that North Americans and East Asians would have comparable performance on old and novel items, but North Americans would be more accurate in discriminating similar from old items. This pattern of performance would lead North Americans to have higher pattern separation scores, providing support for cultural differences in this precise mechanism of memory. We also used the Singelis Self-Construal Scale (Singelis, 1994) and the Schwartz Value Survey (Schwartz, 1992) to measure self-construal and personal values in order to test relationships between these values –predicted to differ across culture – and performance on the pattern separation task.

Method

Participants.

Thirty North American (25 female) and 32 East Asian (27 female) participants remained in the final sample after an additional 6 North American and 5 East Asian participants were excluded for performance that indicated a lack of comprehension of task instructions (e.g., below chance in performance across conditions or failed to use response button appropriately). No outliers were identified; that is, no participant demonstrated performance exceeding two standard deviations above or below the mean for all three test conditions averaged. The sample size was selected based on a power analysis conducted for a 2 × 3 repeated measures ANOVA using the software G*Power (Faul, 2007). The analysis recommended samples of 31 participants per cultural group to detect an interaction, based on assuming a medium effect size of Cohen's d= 0.4, 1-β = 0.8, and alpha = 0.05. The effect size was based on prior findings of interactions of culture and memory performance across conditions (Millar et al., 2013). Participants were recruited from the Brandeis University campus and surrounding Boston area. "North Americans" were defined as individuals who were native to the United States and had lived no more than five years abroad. "East Asians" were individuals native to an East or Southeast Asian country who were non-native speakers of English and who had lived in the United States for less than 5 years. Asian North Americans, individuals of Asian ethnicity who were born in the US or other Western nations, were excluded; this was verified by examining the demographics forms completed by participants. The purpose of this selection criterion was to ensure we did not have participants with mixed cultural upbringings as both cultures may influence these individuals' cognitive processes. The average length of time residing in the US for East Asian participants was 2.44 years (SD = 1.99). Participants were asked to rate their fluency in speaking, reading, writing, and listening to English on a 1–5 scale, with 5 being fluent. Every North American gave a fluency rating of '5' across the different language modalities. Means and standard deviations for East Asians are as follows: speaking = 4.50 (0.51), reading = 4.53 (0.51), writing = 4.47 (0.51), and listening = 4.62 (0.49). These ratings, combined with the fact that participants were completing coursework in English at a school in the United States, gave us confidence that they could be tested in English. All experimental instructions were presented in writing, self-paced by the participant, as well as read out loud by the experimenter in order to encourage questions from the participants.

Before beginning the experiment, participants gave their written consent and then completed a demographics questionnaire asking about age, sex, education, ethnicity, country of origin, and language fluency. They received either course credit or $10 cash for participating. The protocol was approved by the Brandeis University Institutional Review Board.

Materials.

Pattern separation was measured using the Mnemonic Similarity Task (MST), a commonly used measure of pattern separation ability (Kirwan et al., 2007; Stark et al., 2015). The Windows executable version of the task was used after downloading directly from the task developer's site (https://faculty.sites.uci.edu/starklab/mnemonic-similarity-task-mst). The task contained six different sets of images of everyday objects (e.g., a calculator, balloons, a pair of shoes) which were counterbalanced across participants, and each item's condition at test (i.e. old, similar, or new) was randomly assigned for each participant. The images were drawn from the standard image sets provided by the MST creators. Each item and its similar lure had been labeled with a value 1–5 indicating the level of similarity between the two items; these values had been assigned based on item similarity experiments conducted by the original task creators (Lacy et al., 2011). Participants saw an equal number of items from each of the five similarity levels.

In addition to the main pattern separation task, participants completed a demographics questionnaire, which asked about sex, age, education, nationality, race, and language fluency. A pattern matching control task was used as a speed of processing measure. In this task, participants matched an abstract drawing to its identical counterpart among four presented options, completing as many of these problems as they could in two 30-second sections. The purpose of this was to verify equivalent general cognitive ability between the two cultural groups. Participants also completed the Singelis Self-Construal Scale (Singelis, 1994) in which they read statements about themselves and their relations to others (e.g., “I enjoy being unique and different from others in many respects”, “I act the same way at home that I do at school (or work)”), and then indicated using a scale of 1 (strongly disagree) to 7 (strongly agree) how much they agreed or disagreed with the statement. This provided a measure of an individuals’ levels of independence and interdependence. Additionally, participants completed the Schwartz Value Survey (Schwartz, 1992) where they rated values such as “equality” and “sense of belonging” on a scale of −1 (opposite of what I value) to 7 (extremely important). The results of this measure were intended to assess which facets of identity and values relate to individual differences and the effects of culture on pattern separation ability.

Procedure.

Participants gave informed consent and completed the demographics survey before completing any experimental tasks. Participants then began the encoding phase of the MST, where they viewed images one at a time for a duration of 2 seconds with 0.5 seconds of a blank screen between stimuli. They were shown 128 unique images, each shown once. To ensure participants’ attention during this encoding phase, they were asked to indicate with the keyboard whether the current object on the screen belonged indoors or outdoors. They were unaware that there would be a subsequent memory test.

Immediately after the encoding phase, they began the recognition phase. In this test phase they were shown some of the same images from the encoding phase as well as images that were similar (e.g., a cake topped with strawberries if a cake topped with raspberries was previously seen during encoding) and images that were completely novel. 64 images of each test condition (i.e. Old, Similar, and New) were presented in a randomized order of 192 total trials. Participants indicated using the keyboard whether the image was “old” (seen before during encoding), “similar” (same semantic label but not identical to the image seen during encoding) or “new” (completely novel items). They had 2 seconds to make their response while the stimulus was on the screen with 0.5 seconds of blank screen between stimuli.

Analyses.

In addition to proportion correct, an additional measure of interest was used in analyses of the MST. The *Behavioral Pattern Separation* (BPS) score is calculated by subtracting p(“similar”|New) from p(“similar”|Similar) and is intended to measure ability to correctly identify similar items while correcting for “similar” response bias.

Results

Self-Report Measures and the Pattern Matching Control Task.

Three North Americans and seven East Asians did not complete the questionnaires and thus were not included in these analyses or any correlations using these values described below. Measures of independence and interdependence did not differ across the two cultural groups. Of the ten values assessed with the Schwartz Values Survey, the groups significantly differed on three after a Bonferroni correction for multiple comparison: Benevolence, Universalism, and Power. We corrected for 13 group comparisons, which required at p-value < 0.004 for significance. There was a significant difference between groups for the Pattern Matching Control Task such that East Asians had a higher number of correct responses (M = 20.75, SD = 3.72) than North Americans (M = 17.88, SD = 4.63, t(61) = 2.70, p = 0.01, Cohen's d = 0.74)[1]. See Supplemental Table 1 for the complete list of traits and averaged scores.

Proportion Correct and Behavioral Pattern Separation Measure across Test Conditions.

A 2 (culture group: North American, East Asian) × 3 (condition: old, similar, new) ANOVA revealed a significant main effect of culture such that North Americans exhibited higher proportion correct than East Asians (F(1, 61) = 4.83, p = .03, η_p^2 = 0.08,). There was a significant main effect of test condition (F(1,61) = 383.22, p = < 0.001, η_p^2 = 0.83), but no significant interaction between culture group and test condition (F(1,61) = 1.68, p = 0.20, η_p^2 = 0.03). Figure 1 illustrates task performance across conditions and cultural groups.

As per prior experiments using this paradigm to investigate pattern separation, a *Behavioral Pattern Separation* (BPS) measure was derived by subtracting the proportion of incorrect "similar" responses to novel items from the proportion of "similar" responses given correctly to similar items. This score represents the ability to correctly acknowledge similar items as similar – indicating successful pattern separation – correcting for response bias. In line with our predictions, there was a statistically significant difference between cultural groups, with North Americans' average BPS score (M = 0.39; SD = 0.21) significantly higher than East Asians (M = 0.24; SD = 0.18), t(61) = 3.14, p = 0.003, Cohen's d = 0.71).

The rationale for subtracting "similar"|New in the BPS measure is to correct for response bias (Stark et al., 2013). As such, we thought it important to examine the breakdown of the proportion of responses for each test condition (Table 1). We tested whether there were cultural differences in the components that made up the BPS measure (e.g. "similar"|Similar and "similar"|New). There was a statistically significant difference between groups for proportion of correct "similar" responses, with North Americans exhibiting higher levels of accuracy (t(61) = 2.28, p = 0.03, Cohen's d = 0.56). There was also a statistically significant difference between groups in the proportion of "similar" responses given incorrectly to new items, such that North Americans made fewer of these errors (t(61) = 3.04, p = 0.004, Cohen's d = 0.71).

Looking at the pattern of cultural differences across the different conditions (see Table 1) reveals that culture differences are not limited to the "similar" conditions; rather, North

1 Adding Pattern Matching score as covariate to analyses of the memory data did not change the pattern of results for Experiment 1

Americans tends to perform at a higher level on correct "old", "similar", and "new" responses. This pattern is consistent with the finding of a main effect of culture in the analysis of proportion correct, rather than an interaction with condition such that cultural differences were magnified for the Similar condition.

Correlations Between MST Task Performance and Self-Report Measures.

To test for potential relationships between cultural values and memory performance, BPS scores were correlated with scores of independence, interdependence, and each of the values comprising the Schwartz Values Scale (see Supplemental Table 1 for list). None of the measures reached the threshold for significance (Bonferroni correction threshold required a p-value < 0.004) either when collapsing across cultural groups (*r*s < 0.34, *p*s> 0.01) or conducting correlations separately for each cultural group (*r*s < 0.46, *p*s> 0.02) (See Supplementary Table 3 for full table of correlations and uncorrected p-values). Given the stringency of Bonferroni corrections for multiple comparisons, we also analyzed the data by controlling for false discovery rate according to procedures described by Bejamini & Hochberg (1995). Again, none of the effects reached significance (*p*s > 0.16 when collapsing across cultural group, *p*s > 0.10 when conducting corrections separately for each cultural group). See Supplemental Table 1 for the complete list of traits and averaged scores.

Effects of Difficulty on Similar Trials.

Based on previous experiments by the task developers (Lacy et al., 2011), each of the items in the MST stimuli set was assigned a bin number from 1 (most difficult) to 5 (least difficult) based on the similarity between the target and lure pictures for a given object. As an exploratory analysis, we investigated whether there was an interaction between similar trial difficulty and culture. A 2 (culture: North American, East Asian) × 5 (similarity bins: 1–5) ANOVA revealed a main effect of bin ($F(4, 61) = 50.14$, $p < .001$, $\eta_p^2 = 0.46$) in which performance across groups on Bin 1 was significantly lower than on Bin 5 ($t(61) = 7.60$, $p < 0.001$, Cohen's $d = 1.20$). There was a main effect of culture such that North Americans had higher BPS scores across conditions ($F(4, 61) = 6.79$, $p = 0.01$, $\eta_p^2 = 0.10$). There was no significant interaction between culture and bin ($F(4,61) = 1.05$, $p = 0.38$, $\eta_p^2 = 0.02$). These results are illustrated in Supplementary Figure 1.

Discussion

The goals of this first experiment were to evaluate cross-cultural differences in pattern separation and to investigate the extent to which self-construal and personal values contributed to memory differences across cultures. Consistent with prior work, we found that North Americans had higher memory performance than East Asians when discriminating same from similar and new items. Although some evidence indicated cultural differences in pattern separation performance, cultural differences were not limited to this condition. Thus, the group differences across the test conditions suggest that pattern separation does not account for cultural differences in memory performance. Furthermore, none of the individual difference measures were strongly correlated with pattern separation scores, failing to provide evidence that specific values contribute to memory processes across cultures.

As predicted, the data provide some support for the first goal, in that North Americans demonstrated higher performance than East Asians, including in the similar test condition, and had significantly higher BPS scores. The differences across cultures are further reflected in our analysis of performance in the Similar condition as a function of trial difficulty (i.e., the similarity of the lures to their previously-encoded partners). North Americans had greater proportion correct than East Asians across the bin levels. Though the BPS scores were higher for North Americans, typically interpreted as reflecting superior pattern separation performance, further probing the data revealed that the cultural differences in BPS scores reflected both higher levels of correct usage of the "Similar" label *and* lower levels of incorrect usage of the label to new items by North Americans compared to East Asians. This calls into question whether cultural differences actually reflect differences in pattern separation ability or more general memory deficits. Thus, although we find evidence for cultural differences in memory performance, we did not find conclusive evidence that differences in pattern separation underlie those differences.

Analyses of the self-construal and values scales revealed that only a few traits differed across cultures (Power, Benevolence, and Universalism), none of which significantly related to pattern separation ability. If cultural values accounted for cultural differences in memory specificity, or pattern separation more precisely, we would have expected to see relationships such that higher scores on measures of North American ideals, such as independence or self-direction, were associated with higher BPS scores. Alternatively, higher scores on ideals from East Asian cultures, such as interdependence or conformity, could be linked to lower BPS scores. Despite the difficulty interpreting null effects, including our potentially limited sample sizes for comparing individual differences across groups, we failed to find evidence for these possibilities.

We conducted a second experiment to further probe the nature of cultural differences in memory, with the aim of replicating our finding of cultural differences in memory, as well as adjusting a few aspects of the design. First, we wanted to address the possibility that cultures differently interpreted the "similar" response. "Similar" responses could represent a low confidence old judgement ("I may have seen that cake, but I am not sure"; Liu et al., 2016) or reflect accurate memory of originally studied items (e.g., "I remember the cake that I encoded, and it was not this one"), such as in a recall-to-reject strategy (Clark, 1999; Rotello, Macmillan & Van Tassel, 2000; Gallo, 2004). To address the potential ambiguity of the similar response, we removed the "similar" response option, employing a two-choice old/new decision in a second experiment. This change in the paradigm also facilitated the use of signal detection analyses, making it more straightforward to compare cultures on both memory discrimination and response bias. Because one prior study identifies cultural differences in response bias for memory specificity (Paige et al., 2017a), this factor is important to measure.

In addition, we considered whether stimuli were culture fair. Although our results largely converge with prior work that used familiarity ratings to select stimuli and conducted analyses to assess the role of familiarity in memory (Millar et al., 2013; Paige et al., 2017b), the MST stimulus set was created by US researchers and was not explicitly developed for cross-cultural research. In order to ensure the observed memory effects are not driven by cross-cultural differences in familiarity with the stimuli, the second experiment uses a more culture-fair stimulus set.

Experiment 2

In an attempt to replicate our findings from Experiment 1, Experiment 2 modifies the task by allowing two choices during the test phase (“old” or ”new”; no “similar” option) and eliminating stimuli determined to be culturally-biased. We predicted that East Asians would have more difficulty discriminating between Old and Similar items. The same measures of self-construal and personal values were also used in this experiment in order to further investigate the relationship between these traits and differences in memory across cultures.

Method

Participants.

A power analysis conducted for a 2(culture: North American, East Asian) × 3(condition: Old, Similar, New) repeated measures ANOVA using the software G*Power (Faul, 2007) assuming a medium effect size of Cohen’s d= 0.5, 1-β = 0.80, and alpha = 0.05 indicated sample sizes of 21 participants per cultural group would be needed to detect an interaction. After the removal of 9 North American and 8 East Asian participants due to experimental software errors, 36 North American participants (31 female), and 36 East Asian participantss (31 female) remained in the final analyzed sample. Participants were recruited in the same manner as Experiment 1. No outliers (e.g. performance two standard deviations above or below the mean) were identified based on memory task performance. The eligibility criteria were the same as in Experiment 1. East Asian participants in Experiment 2 had been residing in the United States for an average of 2.01 years (SD = 1.56). Participants were asked to rate their fluency in speaking, reading, writing, and listening to English on a 1–5 scale, with 5 being fluent. Every North American gave a fluency rating of ‘5’ across the different language modalities. Means for East Asians are as follows: speaking = 4.64 (0.48), reading = 4.57 (0.50), writing = 4.57 (0.50), and listening = 4.60 (0.50).

Materials.

Materials in Experiment 2 were identical to Experiment 1 with the exception of the Mnemonic Similarity Task. The stimuli for the revised version of the MST were drawn from the original stimulus sets used in the previous experiments but in order to reduce potential cultural bias, stimuli that were incorrect for every East Asian participant during Experiment 1 were removed from the set (due to the low numbers of participants – no more than 4 – who viewed each stimulus, this was determined to be the most appropriate cut-off). 445 images were removed out of a total 1,142 images across 6 sets. Examples of images removed include a spork, a chocolate cream pie, and a stack of magazines with English writing. From the remaining images, three sets of stimuli were compiled, and these sets were ensured to have a balanced number of stimuli from each lure difficulty bin. The three sets were counterbalanced across participants. The stimulus viewing duration at study was also extended to 3 seconds and at test, the participants had unlimited time to make their responses. Prior work has demonstrated that MST performance remains stable even during self-paced retrieval (Stark et al., 2015), and our choice to switch to this modality was motivated by a desire to improve participant comfort. The most notable change from the previous paradigm was the removal of the “similar” responses, so that the only responses were “old” or “new”. Participants still saw items from all three conditions (Old, Similar, and New), but were instructed to identify similar items as “new”. The task presented on the computer using PsychoPy experiment software (Peirce et al., 2019).

Procedure.

Besides the changes to the MST outlined in the previous section, the procedure in Experiment 2 was identical to Experiment 1. Demographics questionnaire, main experiment task, speed of processing control task, self-construal scale, and values survey were all presented in the same order across experiments. This protocol was approved by the Brandeis University Institutional Review Board.

Analyses.

As with Experiment 1, proportion correct was a measure of interest. Additionally, *d’* and *c* response bias measures were calculated for each pairwise discrimination of the three test conditions (old targets, similar lures, and novel foils). The *Lure Discrimination Index* (LDI) – calculated by subtracting p(“new”|Similar) - p(“new”|Old) – was also a measure of interest in this second experiment and is intended to measure correct rejection of Similar items when correcting for overall forgetting and tendency to reject (Reagh & Yassa, 2014). ANOVAs and t-tests of these measures as well as correlations with cultural values scales were conducted using IBM SPSS Statistics for Windows version 26.0.

Results

Pattern Matching Control Task and Self-Report Measures.

The traits that showed significance after a Bonferroni correction for 13 comparisons were Benevolence, Universalism, and Power, which converged with findings from Experiment 1, and Tradition, Independence, and the difference between Independence and Interdependence scores, which emerged as significant only in Experiment 2. There was also a significant difference between groups in the Pattern Matching Control Task, with East Asians having more correct responses (M = 20.69, SD = 2.65) than North Americans (M = 18.30, SD = 3.86, t(71) = 3.06, p = 0.003, Cohen’s d = 0.68)[2].

Proportion Correct Across Test Conditions.

A 2 (culture: North American, East Asian) × 3 (condition: Old, Similar, New) ANOVA revealed significant main effects for culture (F(1,71) = 12.35, p < 0.001 η_p^2 = 0.15), with North Americans showing greater proportion correct than East Asians. The ANOVA also revealed a main effect of test item condition (F(2, 71) = 297.19, p < 0.001, η_p^2 = 0.81) in which performance across groups on the “Similar” condition was lower than both “Old” (t(71) = 14.65, p < 0.001, Cohen’s d = 2.64) and “New” (t(71) = 22.25,p < 0.001, Cohen’s d = 1.75). Performance on “New” items were also significantly higher than performance on “Old” items (t(71) = 6.36, p < 0.001, Cohen’s d = 1.38). However, there was no significant

2 Adding Pattern Matching score as a covariate to analyses of the memory data did not change the pattern of Experiment 2 results.

interaction between culture and test condition ($F(2, 71) = 0.42$, $p=0.66$, $\eta_p^2 = 0.01$). Figure 2 displays MST performance by group and test item condition.

A *Lure Discrimination Index* (LDI) was calculated by subtracting p("new"|Similar) - p("new"|Old). There was a statistically significant difference between groups with North Americans having a higher LDI ($M = 0.45$; $SD = 0.13$) than East Asians ($M = 0.34$; $SD = 0.13$, $t = 3.41$, $p = 0.001$, Cohen's $d = 0.73$). Breaking down the component responses reveals no significant differences between groups on correct "new" responses to Similar items ($t = 1.79$, $p = 0.08$, Cohen's $d = 0.40$), but there were differences for incorrect "new" responses to Old items ($t = 2.24$, $p = 0.03$, Cohen's $d = 0.50$), such that East Asians committed this error more than North Americans.

Signal Detection Analyses.

In order to test for cultural differences in both sensitivity and response bias, signal detection analyses were used. This was done according to the methods described in Stark et al. (2015) in which three different d' types were calculated. In measuring Target-Foil d', "Old"|Target responses were counted as hits while "Old"|Foil responses were considered false alarms, measuring ability to discriminate Old from New items. Lure-Foil d' measures ability to discriminate between Similar and New items, counting "Old"|Lure as a hits and "Old"|Foil as false alarms. Though the hits in the Lure-Foil d' measure are not actually the correct response, the use of the "Old" response on Similar items indicates influence from the relatedness of the items to previously studied ones (e.g., a d' score of 0 would suggest that the similar and new items were considered equally "new" by participants). The Target-Lure d' ("Old"|Target = hit, "Old"|Lure = false alarm) was the d' type of most relevance to the question of pattern separation, as it directly measures the ability to discriminate between Old and Similar items.

A 2 (culture: North American, East Asian) × 3(d' type: Target-Foil, Lure-Foil, Target-Lure) ANOVA revealed a main effect of d' type ($F(2, 71) = 387.10$, $p < 0.001$, $\eta_p^2 = 0.85$) in which Target-Foil d' values were higher than both Lure-Foil d' ($t(71) = 12.97$, $p < 0.001$, Cohen's $d = 2.17$) and Target-Lure d' ($t = 18.01$, $p < 0.001$, Cohen's $d = 3.02$). Target-Lure d' was significantly lower than Lure-Foil d' ($t = 5.76$, $p < 0.001$). There was also a significant main effect of culture ($F(1, 71) = 7.46$, $p = 0.008$, $\eta_p^2 = 0.10$) for which North Americans' d' scores across measurement types were higher than East Asians'. There was a significant interaction between culture and d' type ($F(1,71) = 3.51$, $p = 0.03$, $\eta_p 2 = .05$). North Americans and East Asians did not differ significantly in the Lure-Foil d' ($t(71) = 0.72$, $p = 0.47$, Cohen's $d = 0.18$), but they did differ significantly in the Target-Foil ($t(71) = 2.73$, $p = 0.008$, Cohen's $d = 0.66$) and Target-Lure d's ($t(71) = 3.18$, $p = 0.002$, Cohen's $d = 0.76$). Figure 3 presents d' scores for these conditions for each cultural group.

Response bias measure c was also calculated for each of the three different pairwise discriminations and summarized in Table 2. This measure assesses differences in the tendency to respond "Old" or "New", with positive values indicating a response bias toward responding "New" (reflecting a more conservative bias in the case of remembering) and negative values indicating a bias toward "Old" (reflecting a more liberal bias). A 2(culture: North American, East Asian) × 3(discrimination type: Target-Foil, Lure-Foil, Target-Lure)

ANOVA revealed a significant main effect of discrimination type, with Target-Foil showing the strongest "Old" (liberal) response bias in both cultural groups ($F(1,71) = 387.10$, $p < 0.001$, $\eta_p 2 = 0.85$). There was a significant main effect of culture, with North Americans demonstrating stronger "Old" (liberal) response bias across conditions ($F(1,71) = 7.46$, $p = 0.008$, $\eta_p 2 = 0.10$). There was also a significant interaction between culture and discrimination type ($F(1,71) = 3.51$, $p = 0.03$, $\eta_p 2 = 0.05$). T-tests comparing between groups (see Table 2) reveal that in both the Target-Foil and Target-Lure d' measures, there were significant group differences indicating North Americans were more biased toward responding liberally with "Old".

Correlations Between MST Task Performance and Self-Report Measures.

Because Target-Lure d' was the primary measure of pattern separation ability, this measure was correlated with scores of independence, interdependence, and each of the values comprising the Schwartz Values Scale (see Supplemental Table 2 for a list). None of the measures reached the threshold of $p < 0.004$ for significance when correcting for multiple comparisons (*r*s < 0.30, *p*s > 0.01). When conducting correlations separately for each cultural group, there were no significant correlations between Target-Lure d' and self-report measures for North Americans (*r*s < 0.22, *p*s > 0.12) or East Asians (*r*s < 0.42, *p*s > 0.01) (See Supplementary Table 4 for full table of correlations and uncorrected p-values).Given the stringency of Bonferroni corrections for multiple comparisons, we also analyzed the data by controlling for false discovery rate. None of the measures reached significance when controlling for false discovery rate (*p*s > 0.14 when collapsing across cultural groups, *p*s > 0.13 when conducting correlations for each group separately).

Effects of Difficulty on Similar Trials.

As in Experiment 1, we conducted an exploratory analysis investigating whether there was an interaction between the difficulty level of similar trials and culture. Figure 4 presents the Target-Lure d' measures for North Americans and East Asians for each of the bins. A 2 (culture: North American, East Asian) × 5 (difficulty bins: 1–5) ANOVA revealed a main effect of bin ($F(4, 71) = 110.59$, $p < 0.001$, $\eta_p 2 = 0.61$) in which, as would be expected, performance on Bin 1 (most difficult) was significantly lower than on Bin 5 (least difficult) ($t(71) = 12.36$, $p < 0.001$, Cohen's $d = 1.44$) and a significant interaction between culture and bin ($F(4, 71) = 4.10$, $p = 0.003$, $\eta_p 2 = 0.06$) in that there was no significant difference between groups on Bin 1 items ($t(71) = 0.30$, $p = 0.76$, Cohen's $d = .07$), but groups did differ significantly on the easiest bin ($t(71) = 3.08$, $p = 0.003$, Cohen's $d = 0.68$), the least difficult items. There was a main effect of culture ($F(1, 71) = 9.85$, $p = 0.002$, $\eta_p 2 = 0.123$), such that North Americans' memory performance was higher than that of East Asians.

Discussion

A major aim of this experiment was to apply measures of discrimination ability and response bias to investigate cross-cultural differences in pattern separation ability in memory. Results were in line with our prediction that North Americans would demonstrate higher levels of pattern separation ability. North Americans did exhibit a higher Target-Lure d' score, indicating group-level differences in the likelihood of correctly choosing "Old" for an Old item versus incorrectly calling a Similar item “Old”. However, the groups also differed on the Target-Foil d’, the measure for discriminating between Old and New items. As both these d’ measures count “Old”|Old responses as hits, it may be the case that East Asians are less accurate on the Old condition than North Americans, rather than cultural differences being restricted to the Similar items. This is further supported by North Americans’ higher LDI being driven primarily by lower false alarms to old items rather than cultural differences in the Similar condition. Thus, the present study implicates target (old) items as the primary condition in which memory differs across cultures, converging with the results of Experiment 1. North Americans additionally exhibited a stronger response bias to call items “Old”, as seen in the group differences in c. Furthermore, cultural differences in performance on Similar items differed by item difficulty. On the items classified as most difficult to discriminate (e.g., targets most similar to the lures), performance between the two groups was equivalent, whereas for the items classified as easiest to discriminate, North Americans performed better than East Asians.

Many of these findings converge to suggest that North Americans may have more detailed representations of previously studied items than East Asians. The cultural differences in d’ for conditions that included target (old) items may reflect poorer encoding or retrieval of information by East Asians compared to North Americans. When considering difficulty, the data indicate that during trials for which the lures are highly similar to old items, discrimination was so difficult that North Americans did not have an advantage. As the difference between lures and old items became more pronounced, however, North Americans showed greater improvement in memory, perhaps using their more detailed memory to increasing advantage. This explanation is in line with previous work suggesting that cultures differed on specific memory, but not on general item memory (Millar et al., 2013). This is because even if general item memory is equivalent across cultures that does not necessarily mean that cultures have the same amount of detail available in memory to discriminate Old from Similar items.

Another possibility is that strategy usage differs across cultures. If using a “recall-to-accept” strategy, the weaker memory of East Asians’ would lead them to be more likely to fail to correctly endorse previously-seen items as old. On the other hand, employing a “recall-to-reject” strategy, a recollective mechanism that supplements familiarity judgments, would require a sufficiently detailed memory of the previously-encoded item in order to correctly reject lures. Based on this interpretation, it might be the case that East Asians use a “recall-to-accept” strategy less than North Americans.

It is also possible that the threshold of evidence required to call an item “Old” differs across cultures. Such an explanation would be in line with our finding of cultural differences in response bias (c) measures, with North Americans having a more lenient threshold than East Asians for calling items “old”. Another study (Paige et al., 2017a) found cultural differences in response bias rather than in sensitivity. The present study finds differences in measures of both sensitivity and response bias, helping to connect prior studies that emphasized one or the other (e.g., Millar et al., 2013; Paige et al., 2017a). This evidence for response bias differences supports our ultimate conclusion which is that mechanisms besides pattern separation contribute to cross-cultural differences in memory specificity.

All of these potential explanations are in line with prior work. Future work can further probe cultural differences in the candidate processes (e.g., detail of representations, memory strategies, and the threshold for deeming something to be "old") discussed here.

General Discussion

Both experiments revealed cultural differences in line with prior work showing differences in memory specificity. The present work advances our understanding by suggesting that cultural differences may be most pronounced in the recognition of old items, rather than in distinguishing similar items from studied ones. Although we suggest that cultures may differ in how detailed representations are in memory, additional work is needed to further substantiate this claim, including considering cultural differences in memory strategies and thresholds for accumulating evidence. In addition, our findings do not clearly support pattern separation as being the sole mechanism underlying cultural differences, as North Americans' performance benefit extends across multiple conditions.

Another aim was to investigate potential socio-cultural mechanisms that could underlie cognitive differences between groups. We measured self-construal and a range of personal values and expected traits which differed between cultures to also correlate with task performance, in terms of the ability to distinguish Old from Similar items. However, no significant correlations were found between any of the measured traits and the ability to discriminate between Old and Similar items, although multiple comparisons corrections and our sample size limited the ability to detect relationships. There are potential limitations due to our samples. Although our samples were mostly female, the skew in gender was equivalent across cultures; thus gender is not confounded with culture effects. The lack of notable cross-cultural differences in values and self-construal is not unique to this study (Goto et al., 2010; Gutchess et al., 2018), and in fact, individual difference findings cannot always be equated to group differences (Na et al., 2010). Given that the East Asian sample is drawn from international students who have chosen to study at an North American university, their values and self-construal may be more similar to North Americans'. Although acculturation could reduce any differences in cultural values measures and subsequent correlations with memory task results, living up to five years in the United States during adulthood still represents a significantly different cultural experience than being native to the United States and residing there for the majority of one's life (see Schwartz et al, 2010 for a review of acculturation at different stages in the lifespan). Extending this research to test East Asians in their native countries may help to assess how cultural differences in traits relate to memory by exaggerating the difference between our two groups.

Beyond the cognitive processes investigated in this experiment, cross-cultural differences may affect other facets of attention and memory at all levels, from basic visual perception to the ability to recall past events. Cultural differences could have profound effects on memory in everyday life, such as how eyewitnesses remember crimes or the effectiveness of strategies for interviewing witnesses (Anakwah et al., 2020). A limitation of this study is that we only evaluated memory for neutral objects, but the task could be adapted with complex stimuli, such as scenes (see Stark & Stark, 2017; see also Millar et al., 2013 Exp 2 for a cross-cultural comparison of memory specificity of items on backgrounds) or emotional items. Such work would be critical in determining whether the cross-cultural effects seen this study are robust across stimulus complexity and understanding the extent to which contexts exert protective effects or are subject to the same type of cultural differences in memory. Although this experiment focused on North Americans and East Asians, it is important to note that these are not the only groups for which a culturally-mediated difference in cognitive processes could be observed. Even considering the multitude of cultural groups that exist in the United States alone (e.g., immigrants, multicultural families, rural vs. urban populations, ethnicities, religions), there is great potential for variation in cognitive abilities due to cultural background. Acknowledging such possibilities is critical for interpreting the results of experiments as well as for understanding cognitive processes that are universal compared to those are sensitive to different aspects of group identity.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

The authors gratefully acknowledge support from the National Institute of Health, grant NIH R01AG061886 (to A.G.), as well as the Brandeis University Provost Research Award (to A.G.) and the National Institute of General Medical Sciences Brain, Body, & Behavior Training Grant (T32-GM084907; supporting K.L.). We thank Jennifer Gutsell for her helpful comments on early drafts of this manuscript. We also thank Katherine Lawson, Rachel Snyderman, Grace Hoefs, Maayan Sofer, Lauren Puglisi, Gabriel del Carmen, and Rachel Gerber for their assistance in data collection. Data are available at https://osf.io/z7em6/. The studies were not pre-registered.

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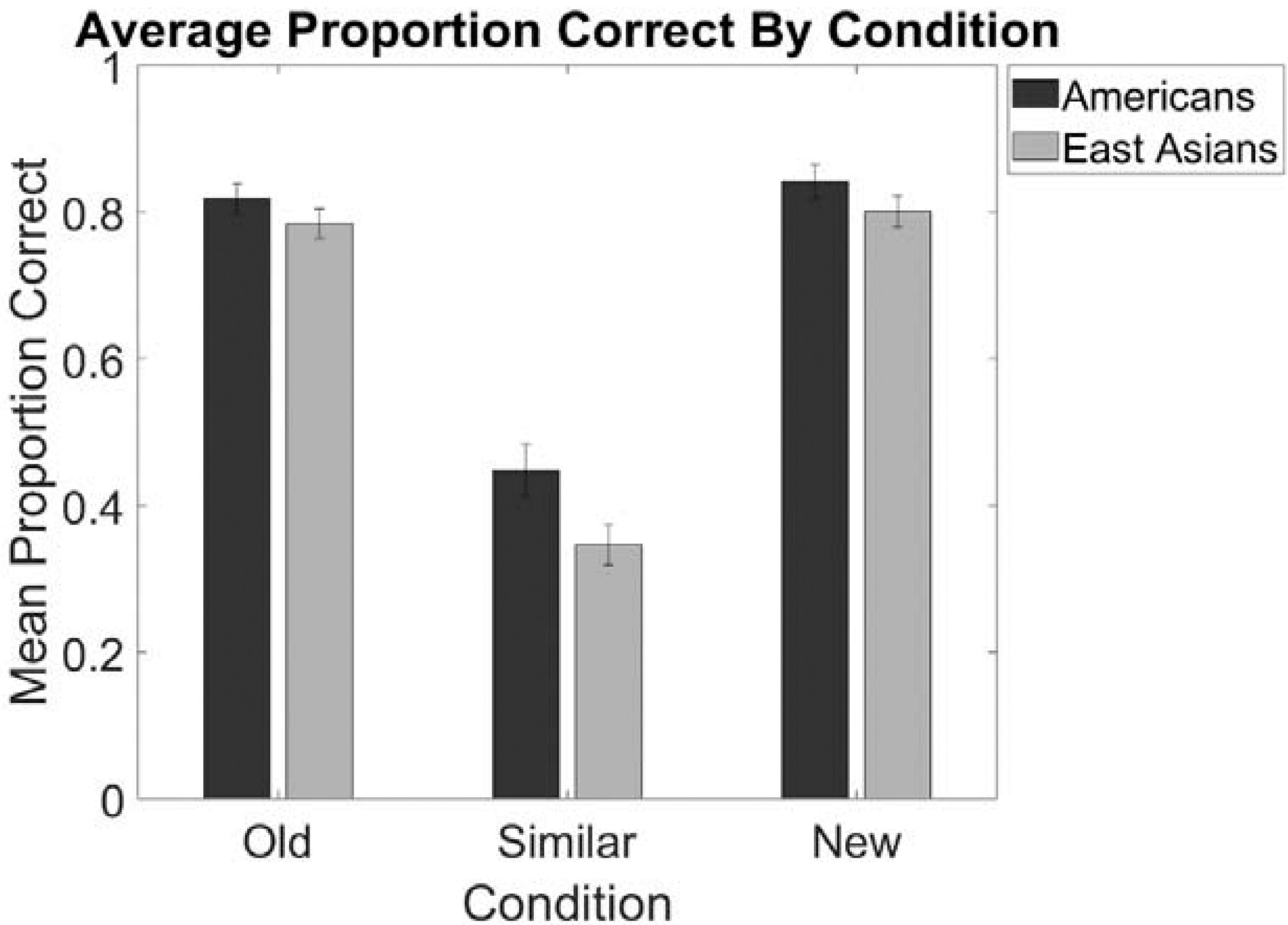

Figure 1.
Average proportion correct in each test item condition for North Americans (black) and East Asians (grey) for Experiment 1. Error bars represent standard error of the mean.

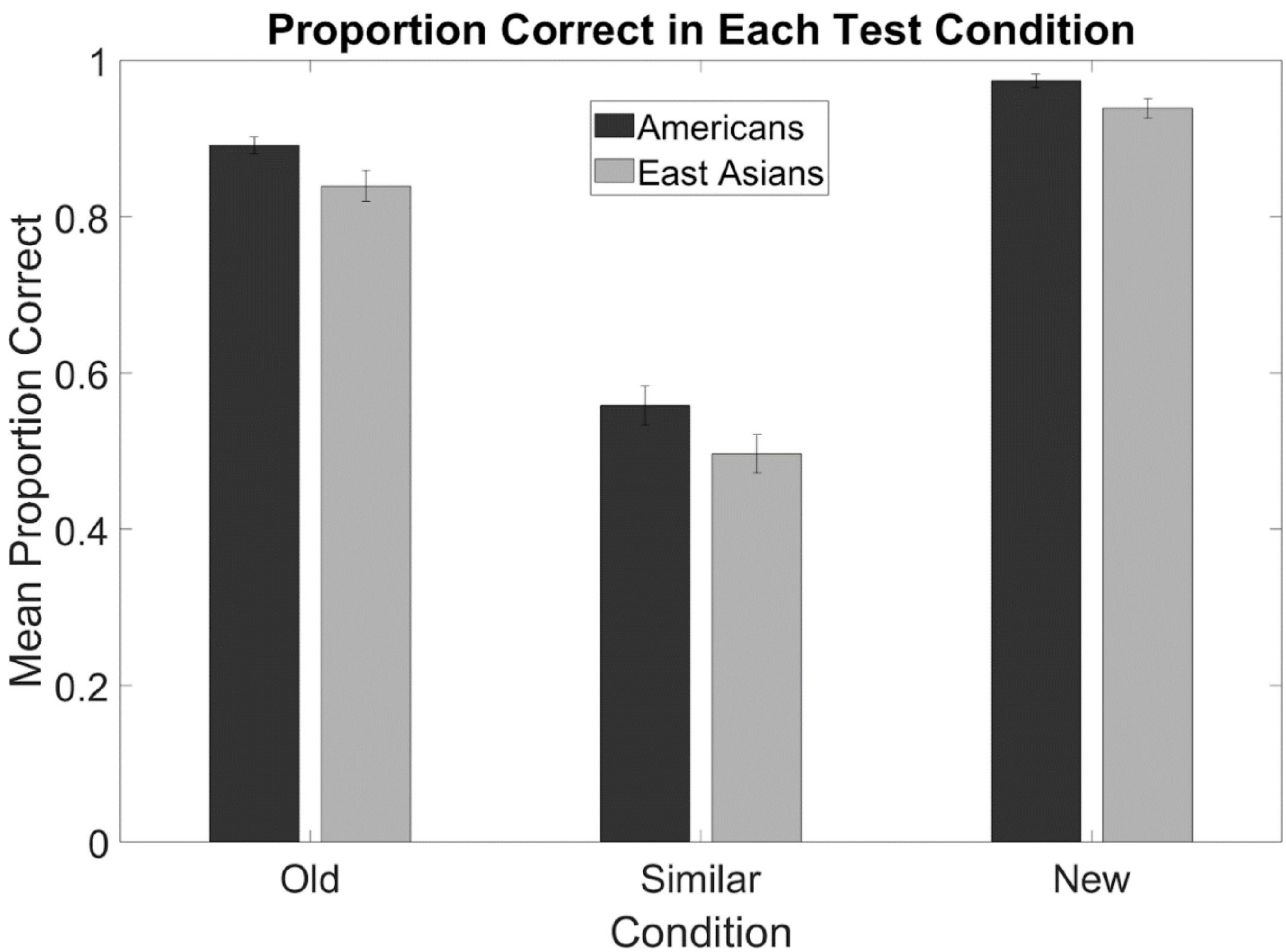

Figure 2.
Average proportion correct in each test item condition for North Americans (black) and East Asians (grey) for Experiment 2. Error bars represent standard error of the mean.

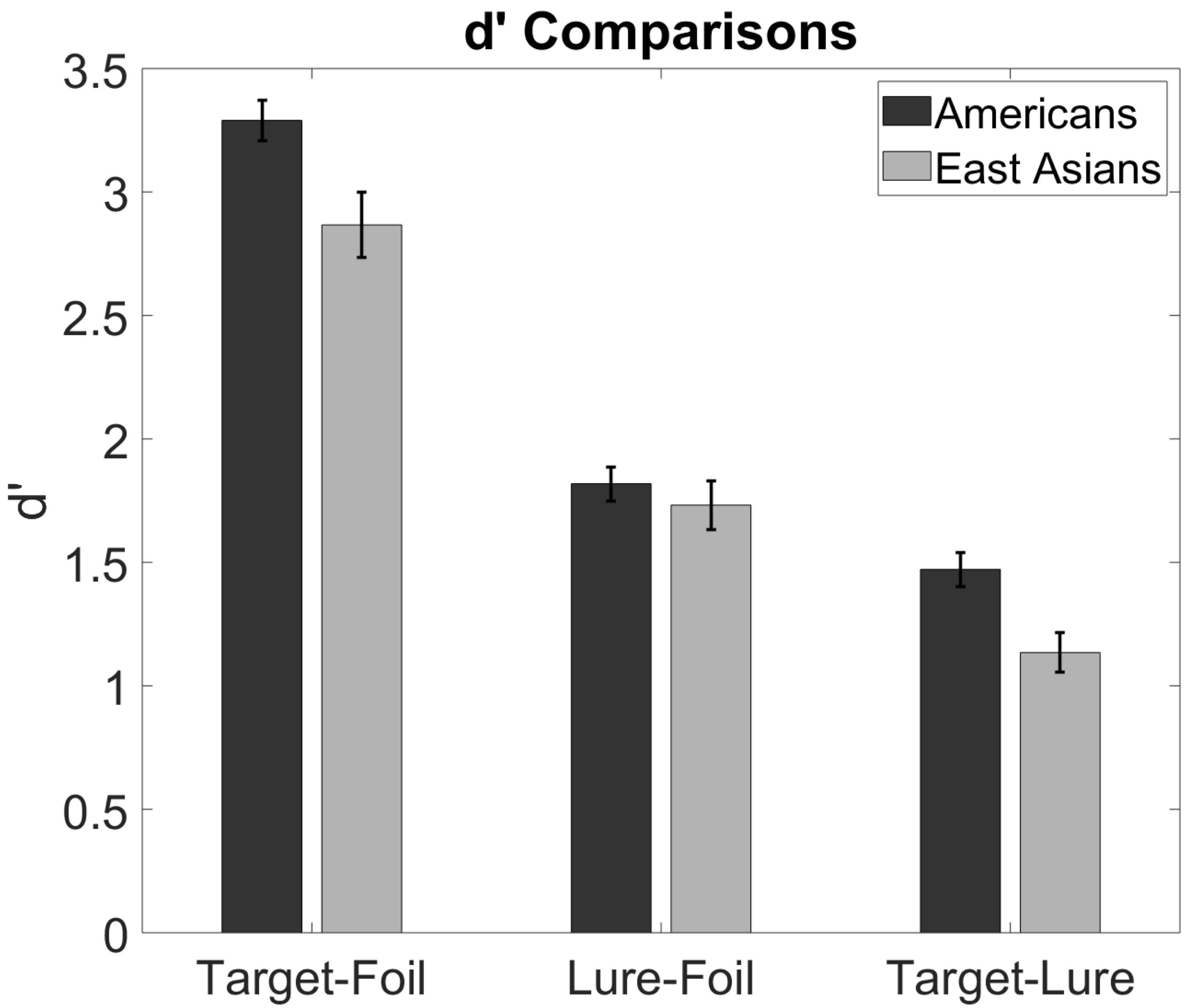

Figure 3.
Mean d' values for each of the different pairwise discriminations by cultural group. Error bars represent standard error of the mean.

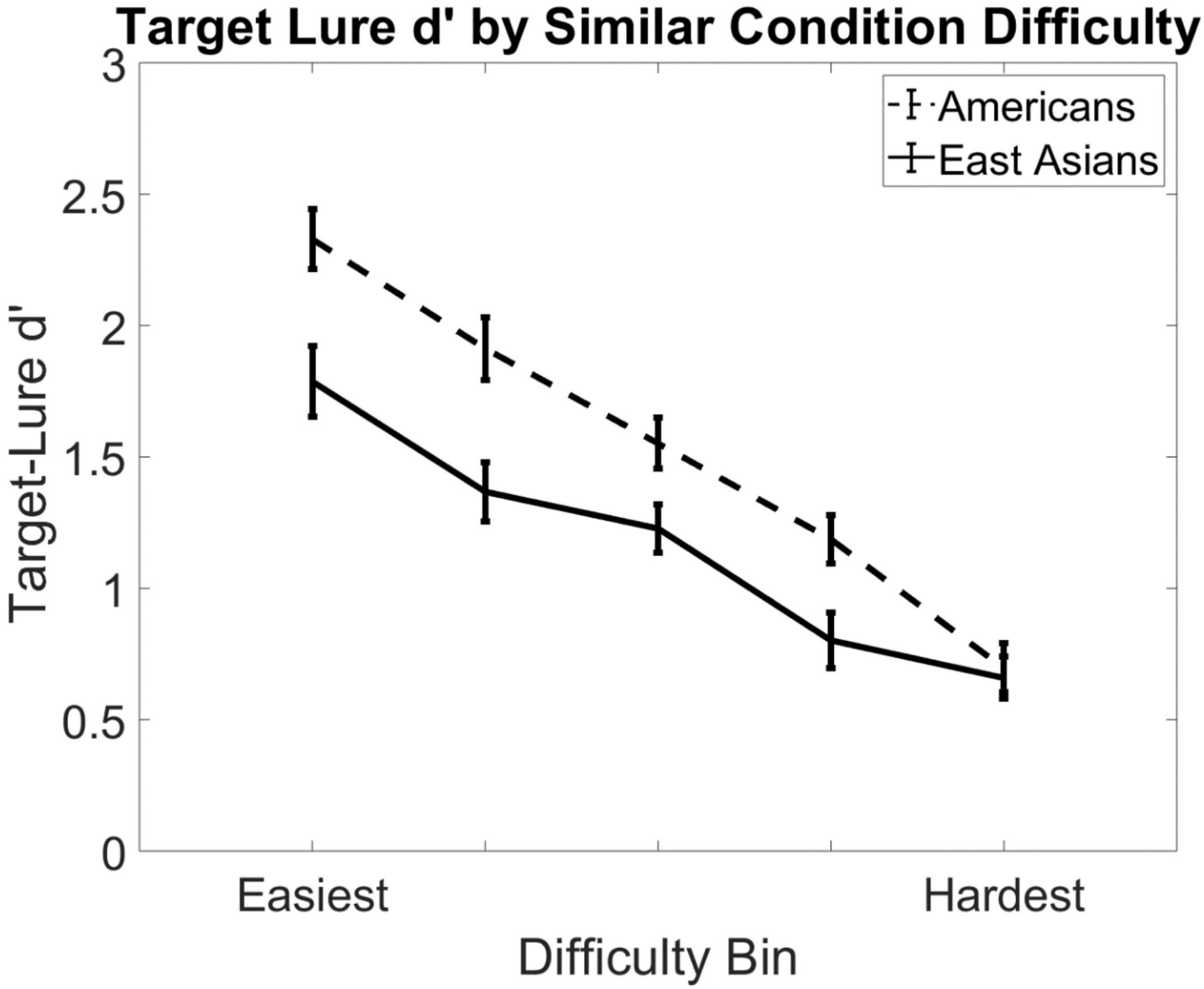

Figure 4.

Average Target Lure d’ for each of the difficulty bins in Experiment 2. The difficulty was measured based on how similar the target and its paired lure image were. Error bars represent standard error of the mean.

Table 1

Proportion of Response Types Given to Each Test Condition M(SD)

Response Type	"Old"	"Similar"	"New"
North Americans			
Old	0.82 (0.11)	0.37 (0.14)	0.05 (0.07)
Similar	0.37 (0.14)	0.45 (0.19)	0.10 (0.09)
New	0.05 (0.07)	0.05 (0.04)	0.84 (0.12)
East Asians			
Old	0.78 (0.12)	0.40 (0.13)	0.08 (0.07)
Similar	0.40 (0.13)	0.35 (0.16)	0.20 (0.12)
New	0.05 (0.06)	0.11 (0.09)	0.80 (0.12)

Table 2.

c Response Bias Measures for Each d' Type M (SD)

	North American	East Asian	t	p
Target-Foil	−1.64 (0.24)	−1.43 (0.40)	2.73	0.008 **
Lure-Foil	−0.91 (0.21)	−0.87 (.030)	0.72	0.47
Target-Lure	−0.74 (0.21)	−0.57 (.024)	3.18	0.002 **