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Do cultural differences emerge at different levels of representational hierarchy?

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Abstract

In prior research, Eastern and Western culture groups differ in memory specificity for objects. However, these studies used concrete object stimuli, which carry semantic information that may be confounded with culture. Additionally, the perceptual properties of the stimuli were not tightly controlled. Therefore, it cannot be precisely determined whether the observed cross-cultural differences are generalizable across different stimulus types and memory task demands. In prior studies, Americans demonstrated higher memory specificity than East Asians, but this may be due to Americans being more attuned to the low-level features that distinguish studied items from similar lures, rather than general memory differences. To determine whether this pattern of cross-cultural memory differences emerges irrespective of stimulus properties, we tested American and East Asian young adults using a recognition memory task employing abstract stimuli for which attention to conjunctions of features was critical for discrimination. Additionally, in order to more precisely determine the influence of stimulus and task on culture differences, participants also completed a concrete objects memory task identical to the one used in prior research. The results of the abstract objects task mirror the pattern seen in prior studies with concrete objects: Americans showed generally higher levels of recognition memory performance than East Asians for studied abstract items, whether discriminating them from similar or entirely new items. Results from the current concrete object task generally replicated this pattern. This suggests cross-cultural memory differences generalize across stimulus types and task demands, rather than reflecting differential sensitivity to low-level features or higher-level conjunctions.

Keywords Cross-cultural · Object memory · Recognition memory · Memory specificity · Representational-hierarchical account

Introduction

Despite the great deal of research that has investigated how perception and memory operate, there has been little consideration of how cultural background could influence these processes. Recent work identifies how perception, attention, and memory can differ across members of Eastern and Western cultures. Easterners (generally defined as those from East or Southeast Asian countries) pay more attention to and prioritize contextual information and relationships (Boduroglu et al., 2009; Masuda & Nisbett, 2001) whereas Westerners (including Americans) have better memory for specific details and features (Leger & Gutchess, 2021; Millar et al., 2013; Paige & Gutchess, 2017; Paige, Ksander, et al., 2017a, b; Wang, 2001). Across these different domains of cognition, neuroimaging studies have revealed the neural underpinnings of these group differences (Gutchess & Indeck, 2009; Gutchess et al., 2006; Kitayama & Uskul, 2011; Ksander et al., 2018; Paige et al., 2017a, b). Although there is ample evidence for the existence of cultural influence on cognitive processes, the exact mechanisms by which these differences emerge are still unclear. The present study extends previous research on cultural differences in memory by manipulating object properties and conjunctions of features. In doing so, we assess the stage of visual or mnemonic processing at which cultural differences emerge.

Cultural differences have traditionally been explored within a framework that contrasts the more collectivistic East and Southeast Asian nations (e.g., China, Taiwan,

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Japan, South Korea) with more individualistic Western nations (e.g., USA, Canada, Australia), and cognitive differences are posited to be a result of these diverging cultural values (Markus & Kitayama, 1991; Masuda & Nisbett, 2001; Nisbett et al., 2001). However, it is unlikely this framework tells the complete story. Even in studies that demonstrate significant group differences on experimental tasks, measures of cultural values and self-construal do not consistently align with differences in task performance (Gutchess et al., 2018; Leger & Gutchess, 2021). Additionally, an orthogonal relationship between independence and interdependence cannot be assumed (Goto et al., 2010; Schimmack et al., 2005). Furthermore, East-West differences in these measures are not as large or as systematic as commonly assumed (Oyserman et al., 2002). These prior findings further limit our interpretations of how these measures relate to cognitive differences across cultures. Recent work has theorized that lower-level perceptual processes may also play a role in these differences alongside the more traditionally studied social influences (Gutchess & Sekuler, 2019). It is likely that both perceptual and social factors act in concert with one another, with higher-level influences dictating priorities in perception, and those perceptions in turn influencing higher-order values.

Cultural differences have been found in the type of information that is preferentially attended to and remembered. In studies of autobiographical memory, the childhood recollections of American young adults were more specific and self-focused than the memories of East Asian young adults, which centered more on collective activities; these cross-cultural differences in memory specificity emerge as early as preschool age (Wang, 2001, 2004, 2006). Beyond autobiographical memory, these memory specificity differences also extend to concrete objects (i.e., objects that exist in the real world and have semantic meaning; e.g., bicycles, flowers). Americans, compared to East Asians, demonstrate higher levels of object memory performance even when controlling for congruency with background scene and emotional intensity of the object (Mickley Steinmetz et al., 2018). One study tested Americans' and East Asians' memory for studied objects, and found that both groups had equivalent general memory, that is, memory for items that does not require precise memory for object details. However, Americans had higher levels of specific memory, which requires memory for specific details about object features, than East Asians (Millar et al., 2013). Another study with a similar paradigm replicated this finding of cultural differences in specific memory and further reported that the effect was particularly striking in conditions where objects were most visually dissimilar (i.e., conditions where there was greater opportunity to draw on memory for perceptual details to make discriminations) (Leger & Gutchess, 2021). In addition, cultural differences in response bias may contribute to cultural differences (Leger & Gutchess, 2021; Paige et al., 2017a, b). Taken together, these studies suggest that culture impacts the extent to which perceptual details are encoded and/or retrieved from memory, but the exact process by which these differences emerge is not clear.

Understanding the specific task demands and stimulus conditions that elicit these cultural differences is an important step towards characterizing the underlying mechanisms. The objective of this study is to determine whether the differences in memory that have been observed in prior studies generalize across levels of stimulus complexity. In prior studies, it has been found that Easterners tend to attend to the context or the *relations* between items, whereas Westerners attend to individual items (Masuda & Nisbett, 2001; Nisbett et al., 2001; Norenzayan et al., 2002). We hypothesized that, for any given stimulus set and memory task in which participants could perceive the items either holistically or in a more atomistic way, East Asians would attend to the higher, more holistic level of complexity available while Americans would attend to the lower, more atomistic level available. Here, we sought to test this hypothesis at lower levels of the visual hierarchy than in prior studies. To that end, we constructed stimuli that provide the holistic level in terms of whole (conjunctive) objects, and the atomistic level in terms of individual features of those objects (shape/color). We ask whether, at this lower level, East Asians still apply a holistic strategy by focusing on the conjunction of features that defines a whole object, whereas Americans still apply an atomistic strategy by focusing on individual features. Prior work with concrete object stimuli, for which the degree of feature-level and conjunction-level discriminability are not well defined, cannot answer these questions. The current study aims to address this knowledge gap by using stimuli that more precisely assay these different levels of stimulus complexity. The study also provides insights not always available from past research by using stimuli that are devoid of semantic information. Prior work testing object memory in older and younger adults found that between-group differences were reduced when tested on stimuli without semantic meaning compared to semantically meaningful stimuli (Kouststaal et al., 2003). This suggests the presence of semantic meaning in stimuli can modulate the strength of memory differences between groups. Thus, it is critical that culture effects previously observed with semantically meaningful stimuli (e.g., concrete objects) are also tested in abstract stimuli without semantic meaning, as this allows for tests of the robustness of cultural differences across various types of stimuli while eliminating potential cultural differences in the semantic meaningfulness of the stimuli.

It has been well known since Hubel and Wiesel's famous experiments that visual perception is organized hierarchically in the brain (Felleman & Van Essen, 1991; Hubel & Wiesel, 1965; Kobatake & Tanaka, 1994). However, there is also evidence that long-term memory processes draw upon the same structures. The Representational-Hierarchical (R-H) account proposes a unified model of memory and perception in which both processes rely upon ventral visual cortex and the medial temporal lobes (MTL), and the functions of these regions are best understood not in terms of the processes they perform, but in terms of the stimulus representations they contain (Bussey & Saksida, 2002, 2005, 2007; Cowell et al., 2010a, 2019). Memory and perception, rather than being organized into separate neuroanatomical modules, are predicted to rely upon the same brain regions, and the demands of the task determine which regions would be engaged. For example, hippocampus is activated during part-cued recall of scenes, whereas perirhinal cortex is engaged during part-cued recall of objects (Gardette et al., 2022; Ross et al., 2018). The R-H model has been instantiated with computational models (Bussey & Saksida, 2002; Cowell et al., 2006, 2010b; Sadil & Cowell, 2017) and evidence in support of this has been found in both human (Barense et al., 2005, 2007, 2010, 2012; Lee et al., 2005a, b, 2006) and non-human animal experiments (Bartko et al., 2007a, b, 2010; Bussey et al., 2002, 2003; Winters et al., 2004).

A framework that seeks to explain the organization of cognition in terms of the complexity of representations, rather than in terms of separable modules for memory and perception, serves as a novel lens through which we can view cross-cultural differences. Though cross-cultural differences have been demonstrated in studies using concrete objects, it is unclear whether the greater object memory precision often observed in Americans is greater memory for the whole object or instead reflects greater memory for specific, discriminating features. In prior studies, these memory specificity differences have been attributed to preferences for object-focused processing (Mickley et al., 2018) and higher quality memory for previously viewed items (Leger & Gutchess, 2021). However, it may also be the case that preferences are related to hierarchical complexity – for example, a preference for features over the identity of the whole, regardless of whether that conjunctive whole is a concrete object with semantic meaning, or an abstract item devoid of semantic meaning and defined by conjunctions of lower-level features. Americans may have better memory for specific features of an item (e.g., remembering specific colors or specific striped fill patterns from studied items), but East Asians may better remember the conjunctive whole (e.g., remembering the specific pairings of colors with stripes).

Cultural preferences for different levels of visual complexity could account for the differences that have been observed in prior work. In these prior studies, single objects have typically been used as stimuli, but the objects are sufficiently distinct that the task can be solved on the basis of individual features (e.g., two apples must be discriminated from each other, but one of the apples is red and one is green). Thus, prior cross-cultural studies showing that Americans had higher levels of memory specificity for objects suggest that Americans are more attuned to lower-level perceptual features. However, for a task that contains feature-level ambiguity (in which individual features considered in isolation do not provide a solution to the task; Bussey & Saksida, 2002), discrimination requires more holistic, conjunction-based representations, and East Asians might be predicted to have an advantage over Americans. Although prior studies have examined East Asians' holistic processing of focal objects and context (Masuda & Nisbett, 2001; Nisbett et al., 2001; Norenzayan et al., 2002), the extent that this cognitive style preference extends to the conjunctions between features in a single object has yet to be studied. By directly testing memory for conjunctive relationships between features comprising a single object, our study is a novel contribution to the literature investigating how analytic versus holistic cognitive processing accounts for cultural differences in memory. Furthermore, the memory processes that differ across cultures, resulting in differences in memory specificity, have not been well delineated. Prior work testing the contribution of pattern separation, the ability to create representations for similar information that is new, suggested that this process did not clearly support, or was not the sole process responsible for, cultural differences in memory (Leger & Gutchess, 2021; Leger et al., 2023). The present study adopts a visual hierarchy approach to test for cultural differences at various levels of the hierarchy (e.g., features vs. conjunctions).

To test for cultural differences, this experiment uses lures that share features with studied items, but in which the features are re-combined in novel ways, such that attention to the *conjunction* of features (rather than to individual features) is required to solve the task. Mirroring prior tasks that have been used to measure memory specificity, items are studied and then presented at test along with similar lures and novel foils. However, unlike prior tasks, lure stimuli are manipulated such that interference (i.e., overlapping stimulus properties) occurs primarily at the feature level, and memory for conjunctions of features is critical for discriminating lures from studied items. Given prior work showing Easterners tend to have a more holistic processing style than Westerners (Masuda & Nisbett, 2001; Nisbett et al., 2001; Norenzayan et al., 2002), we predicted patterns of cross-cultural differences for this task that are opposite to the prior findings with concrete objects. That is, East Asians should demonstrate a greater ability to discriminate between studied items and similar lures (which share features with studied items) than Americans, reflecting the fact that the two cultural groups are preferentially attuned to different levels of the visual hierarchy: Americans to features and East Asians to conjunctions.

Method

Preregistration

The study hypotheses, sample size, data exclusion criteria, and analysis plan were pre-registered on the Open Science Framework (OSF; https://osf.io/k4pwa).

Participants

Thirty-six American (eight male) and 31 East Asian (ten male) younger adults completed the study and were included in analyses. Data were collected from an additional three Americans and seven East Asians, but they were discarded from analyses for below chance performance on discriminating between old and new items. Below chance performance on this discrimination task likely suggests inattentiveness or failure to follow task instructions, and this criterion was set as part of our pre-registered data analysis plan.

A post hoc sensitivity analysis was conducted using G*Power 3.1 (Faul et al., 2007) to determine the interaction effect size that we have 80% power to detect, given the parameters of the present study: 2 x 3 repeated-measures design, $\alpha = .05$, and n = 67. The results of this analysis indicate the present study is sufficiently powered to detect a within-between interaction of effect size Cohen's f = 0.16, equivalent to $\eta p^2 = .03$. This is comparable to effect sizes in reported in prior studies that examined interactions between culture and object memory test condition (Leger & Gutchess, 2021; Millar et al., 2013).

Participants were recruited from the Brandeis University campus and surrounding Boston area. "Americans" were defined as individuals who were native to the USA and had lived for no more than 5 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 USA for less than 5 years. Asian Americans, individuals of Asian ethnicity who were born in the USA or other Western nations, were excluded because we would not be able to clearly identify which culture had the stronger influence on these individuals' cognition.

The majority of the American sample identified themselves as White/Caucasian (n = 30) while the remaining participants identified as Black/African American (n = 5) or mixed race (n = 1). The East Asian sample included individuals from China (n = 25), Vietnam (n = 4), Malaysia (n = 1), and Taiwan (n = 1). East Asian participants had resided in the USA an average of 1.80 years (SD = 1.53) and all indicated either "fluent" or "functional" when surveyed on ability to read, write, listen to, and speak English. See Materials section for a description of demographic and language fluency questionnaires. Given all participants were taking university courses in the USA and participants could navigate written task instructions at their own pace, we had minimal concern that language ability would influence task performance. The samples were of comparable age (American M = 18.75 years, SD = 0.94 years; East Asian M = 19.68 years, SD = 2.12 years), and had similar years of formal education (American M = 13.45 years, SD = 1.21 years; East Asian M = 15.71 years, SD = 2.04 years), though the East Asians were significantly older (by approximately 1 year), $t(66) = 2.37$, p = .02, Cohen's $d = 0.58$) and correspondingly, had completed more years of education than the Americans, $t(66) = 5.60$, $p < .001$, Cohen's $d = 1.37$. Groups also significantly differed on a speed of processing task (see Materials), $t(66) = 2.55$, p = .01, Cohen's $d = 0.63$, such that East Asians had more correct responses. Performance on this task was not correlated with memory task performance (see Online Supplemental Material (OSM) Table 1).

Materials

Tasks to characterize samples

Participants completed a demographics questionnaire which asked about age, sex, race, years of education, nationality, years spent in native country, years spent in the USA, and language fluency. For the language fluency questions, participants were asked to state which languages they knew and to indicate fluency in reading, writing, listening, and speaking. They responded for each domain separately using the following scale: None, Very Limited, Limited, Functional, Fluent, and Proficient.

A pattern-matching control task was used as a speed of processing measure (Salthouse, 1991). 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-s sections; scores on the two sections were averaged to produce a score. Due to the manipulation of object color in the main experiment task, all participants were required to pass a color blindness screening using Ishihara plates (Ishihara, 1918).

Abstract objects recognition task

The primary task in this experiment was an abstract object recognition task comprising an encoding phase and a testing phase. The abstract stimuli that participants studied had three binary features: shape, color, and spatial frequency of stripes. Three different sets of images were generated, and each set had feature values that were unique to that

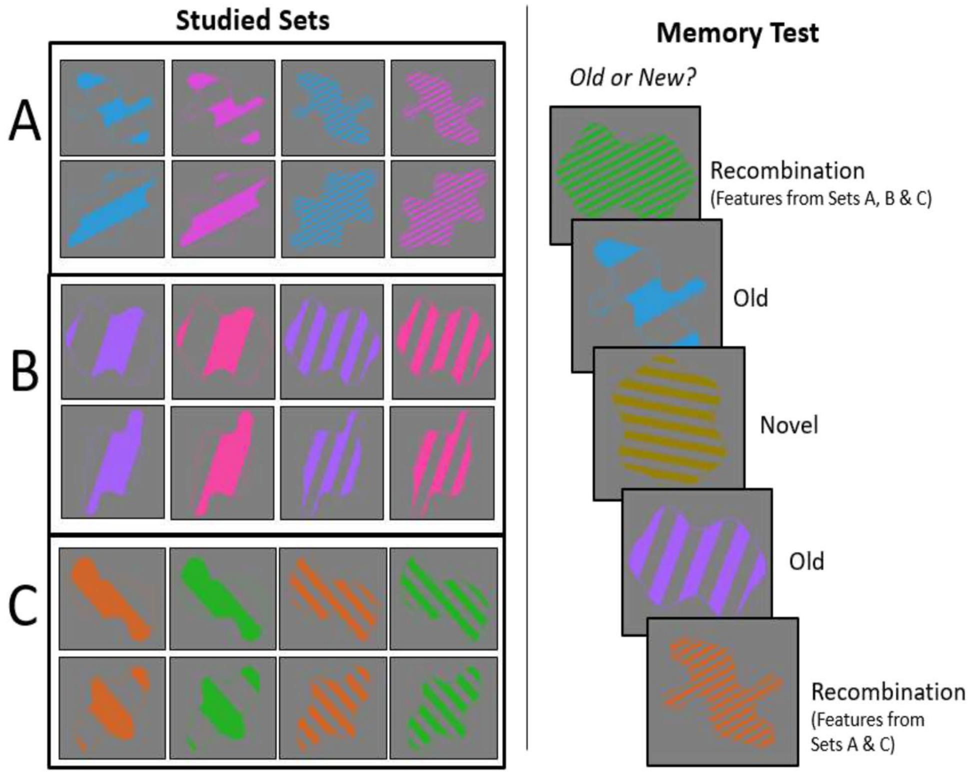

Fig. 1 Example stimuli for the abstract memory task. Sets of images used as Old stimuli were generated with three binary features: shape, color, and stripes. Feature values were exclusive to each set of objects, and during a 1-back incidental encoding task, participants learned these associations. During test, participants made Old/New judgments for: previously-seen Old items, Recombinations that contained previously-seen features combined in novel ways, and Novel items with features not seen previously (see main text for creation of Novel stimulus sets). Three-Set Recombinations comprised features from all three studied sets. Two-Set Recombinations comprised features from just two sets so that two of the object's features had been seen together during encoding, but one feature derived from a different set

set (e.g., one set had exclusively pink and purple objects; another set had green and orange objects). This created a total of 24 unique study objects. Seventy-two recombination stimuli were generated from those three sets. Forty-eight of the Recombinations, called Three-Set Recombinations, had each of its three feature values derived from each familiar set, and the remaining 24 Recombinations, called Two-Set Recombinations, had two feature values from one set and the remaining value from another. These two different types of recombinations allowed for some variation in discrimination difficulty, with Three-Set Recombinations, having no features together from the same set, being easier to discern as new (Leger, 2018). These Recombinations were chosen in such a way that each set, and the possible combinations of features coming from the same set, were represented equally. Novel stimuli were constructed in a similar, but not identical, manner to the study stimuli: novel stimuli were composed of four features – shape, spatial frequency of stripes, color, and orientation of stripes – wherein shape and spatial frequency had four possible values, while color and orientation had two. This resulted in a total of 64 unique novel objects. During the encoding phase, participants completed six runs of a 1-back task with each of the 24 study stimuli presented thrice in pseudo-random order, so each stimulus was viewed a total of 18 times in the study phase. Stimuli appeared one at a time on the screen for 2 s followed by 1 s of fixation before the next stimulus was presented. Figure 1 shows three study sets along with the Recombinations and New objects that would subsequently be shown at test.

Participants then immediately completed a surprise recognition test in which they were shown previously studied items (Old), items that contained previously-seen features combined in novel ways (Recombination), and items composed of features not seen at all during encoding (New). Forty-eight Recombinations drew features from all three stimulus sets while 24 Recombinations drew features from only two sets, allowing for different difficulty levels in discrimination (Leger et al., 2023). Items appeared in pseudo-random order one at a time on screen, and participants were instructed to indicate using the keyboard whether items were "old" (previously-studied) or "new" (recombinations or completely novel). The test phase was self-paced with 1 s of fixation between trials.

Fig. 2 Example studied items and tested lures in the Mnemonic Similarity Task. Studied concrete object images that appear in the incidental encoding task (top) and their tested lure counterparts (bottom) are displayed

Concrete objects recognition task (MST)

A central goal of this study is to test the idea that Americans are more attuned to lower-level features while East Asians are more attuned to global conjunctions. To fully investigate how culture affects memory at different stimulus complexity levels, we included an additional, well-studied recognition memory task which will allow us to better interpret the influence of culture on the novel abstract objects task. Following completion of the Abstract Objects Recognition Task, participants completed the Mnemonic Similarity Task (Kirwan et al., 2007; Stark et al., 2015). Procedures and stimuli were identical to the two-choice version of the task described in Leger and Gutchess (2021), which tested a similar sample of American and East Asian young adults. The task began with an initial study phase during which images of concrete objects (e.g., a balloon, a car) were encoded. This was followed by the test phase during which participants discriminated between previously studied old items, similar lures, and completely novel items. Figure 2 shows examples of studied objects and their test lure counterparts.

Procedure

All study procedures, consent forms, and stimuli were approved by the Brandeis University Institutional Review Board. Participants gave informed consent and completed the demographics survey and color blindness screening before beginning any experimental tasks. Participants then began the abstract objects recognition task. They first completed the encoding phase in which they were presented with abstract images on a computer screen and instructed to indicate using the keyboard whether the current item was the same or different from the item immediately before (i.e., a 1-back task). Following six runs of this task, participants then began the test phase. Instructions appeared on the screen informing participants there would be a memory test. They completed practice trials to ensure they understood the distinction between Old, Recombinations, and New items and when to use "Old" and "New" button responses. During the memory test, participants were shown Old, Recombinations, and New abstract objects, and were instructed to indicate whether the current item on the screen was "Old" or "New." Old items were to be called "Old," and Recombinations and New items were to be called "New." The memory test was self-paced.

Upon completion of the abstract objects memory task, participants completed the concrete objects memory task. As with the procedures for the abstract objects task, participants began with an encoding phase. During this encoding phase, participants viewed images of concrete objects on the computer screen one at a time and were asked to indicate with the keyboard whether they thought the current object belonged indoors or outdoors. Upon completion, they were told they would now be tested on the objects they just saw. During this memory test, participants were shown Old, Similar, and New abstract objects and were instructed to indicate whether the current item on the screen was "Old" or "New." Old items were to be called "Old," and Similar and New items were to be called "New." As with the abstract objects, this memory test was self-paced.

Results

Abstract objects recognition memory task

Signal detection analyses

Our primary analysis of interest investigated cross-cultural differences in discriminability of abstract items. The main measure of interest was discriminability, *d'*, distinct from response bias, between previously studied Old and Recombination items. Discriminability measures were calculated according to the procedures described by Stark et al. (2015), using these formulas:

$$Target - Foil\ d' = z(\varepsilon old\varepsilon|Old) - z(\varepsilon old\varepsilon|New)$$
$$Target - Lure\ d' = z(\varepsilon old\varepsilon|Old) - z(\varepsilon old\varepsilon|Recombinations)$$
$$Lure - Foil\ d' = z(\varepsilon old\varepsilon|Recombinations) - z(\varepsilon old\varepsilon|New)$$

We conducted a 2 (culture: American, East Asian) x 3 (*d'* type: Target-Foil, Lure-Foil, Target-Lure) ANOVA. There was a main effect of *d'* type, $F(1, 66) = 123.85$, $p < .001$, $\eta p^2 = 0.66$. Participants' Target-Foil d' was higher than both Lure-Foil d', $t(66) = 11.09$, $p < 0.001$, Cohen's $d = 1.35$, and Target-Lure d', $t(66) = 15.43$, $p < 0.001$, Cohen's $d = 1.89$. Lure-Foil d' scores were significantly higher than Target-Lure d' scores, $t(66) = 6.12$, $p < 0.001$, Cohen's $d = 0.75$. In terms of the critical effects of culture, there was a significant main effect, $F(1, 66) = 13.40$, $p < 0.001$, $\eta p2 = 0.16$, such that Americans' d' scores ($M = 1.65$) were higher than East Asians' ($M = 1.13$). There was also a significant interaction between culture and d' type, $F(2, 66) = 3.48$, $p = .04$, $\eta p^2 = 0.05$. Simple effects comparisons indicated that Americans' Target-Foil *d'* was higher than the East Asians' by 0.78 ($p < .001$, 95% CI of the difference = 0.34 to 1.22). In contrast, Americans' Lure-Foil *d'* was higher than East Asians' by only 0.43 ($p = .02$, 95% CI of the difference = 0.09 to 0.77) and their Target Lure *d'* was higher by 0.35 ($p = .01$, 95% CI of the difference = 0.09 to 0.60). Discriminability scores for each culture are plotted in Fig. 3.

To determine more precisely the extent to which conjunction overlap (between targets and lures) affects discriminability performance across cultures, we compared Target-Lure *d'* from Two-Set and Three-Set Recombinations. These conditions differed in how much their conjunctions of features were shared by the studied Old items, so comparing culture groups' performance on these conditions might reveal how different amounts of conjunction overlap affect performance. A 2 (culture: Americans, East Asians) x 2 (Recombination type: Two-Set, Three-Set) ANOVA revealed a main effect of Recombination type, with Target-Lure discriminability for Three-Set Recombinations being higher than for Two-Set Recombinations, $F(1, 66) = 57.97$, $p < .001$, $\eta p^2 = 0.47$. There was also a main effect of culture, such that Americans' Target-Lure *d'* scores ($M = 0.90$) were overall higher than East Asians' ($M = 0.55$), $F(1, 66) = 7.72$, $p = .007$, $\eta p^2 = 0.11$. There was no significant interaction between culture and Recombination type, $F(1, 66) = 2.33$, $p = .13$, $\eta p^2 = 0.04$.

We also conducted exploratory analyses of the response bias measure, *c*. Although we did not include hypotheses about response bias in our pre-registration, it is typical to report this measure alongside d'. In addition, some prior studies have shown cultural differences in response bias during object memory tasks (Leger & Gutchess, 2021; Paige et al., 2017a, b); we present response bias analyses to contextualize findings from behavioral performance measures. Response criterion *c* was calculated by averaging the *z*(Hits) and *z*(False Alarms) and then multiplying the result by -1. 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: Americans, East Asians) x 3 (*c* type: Target-Foil, Lure-Foil, Target-Lure) repeated-measures ANOVA revealed a main effect of *c* type, $F(2, 66) = 285.94$, $p < .001$, $\eta p^2 = 0.82$. Target-Lure *c* was significantly lower than both Target-Foil *c*, $t(66) = 15.43$, $p < .001$, Cohen's $d = 1.89$, and Lure-Foil *c*, $t(66) = 17.83$, $p < .001$, Cohen's $d = 2.18$. There was no significant main effect of culture, $F(1, 66) = 0.08$, $p = .78$, $\eta p^2 = 0.001$, but there was a significant interaction between culture and *c* type, $F(2, 66) = 9.66$, $p < .001$, $\eta p^2 = 0.13$. Simple effects comparisons did not show any significant cultural differences within each *c* type. The results of this analysis are displayed in Table 1.

Proportion correct

Although the signal detection analyses reported above are the main focus, because they separate memory discrimination from response bias, we also report raw proportion correct data for completeness. Cross-cultural differences in proportion correct for the abstract objects task were assessed using a mixed 2 (culture: American, East Asian) x 3 (test condition: Old, Recombination, New) repeated-measures ANOVA. This analysis revealed a significant main effect of test condition, $F(1, 66) = 54.54$, $p < .001$, $\eta p^2 = 0.46$. Performance on New items was significantly higher than both Old items, $t(66) = 8.87$, $p < .001$, Cohen's $d = 1.08$, and Recombination items, $t(66) = 13.59$, $p < .001$, Cohen's $d = 1.66$. There was a significant main effect of culture, $F(1, 66) = 8.97$, $p = .004$, $\eta p^2 = 0.12$. Americans had a higher proportion correct across conditions, compared to East Asians. There was no significant interaction between culture and test condition, $F(2, 66) = 1.66$, $p = .20$, $\eta p^2 = 0.03$. Figure 4 displays the proportion correct in each test condition for each culture group.

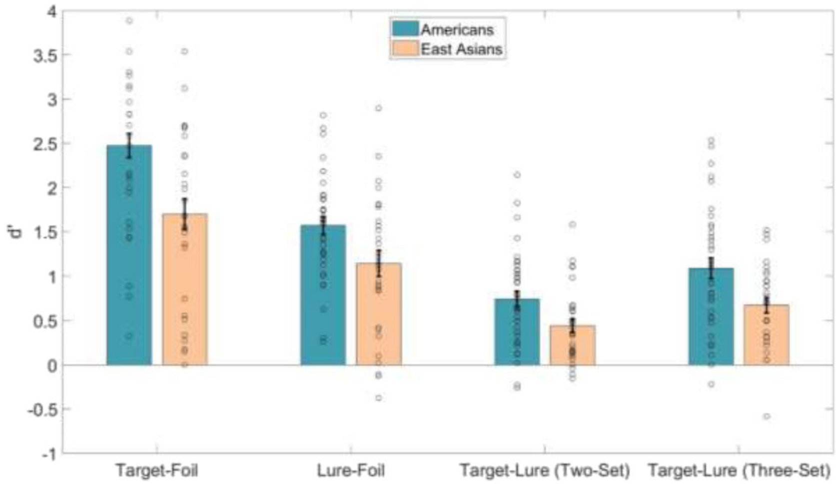

Fig. 3 Discriminability in the abstract object memory task. *d'* scores for each culture group are plotted separately. Americans demonstrated higher discriminability than East Asians in all conditions, with the effect size (i.e., group difference) being highest for the Target-Foil discrimination. Error bars represent standard error of the mean between subjects

Table 1 Response criterion (c) values for the abstract object task

Discrimination type	Americans		East Asians		Mean difference	*p*	95% CI
	M	SD	M	SD			
Target-Foil	.56	.43	.52	.42	.04	.67	-.16 – .25
Lure-Foil	1.01	.50	.80	.43	.22	.06	-.01 – .45
Target-Lure	-.22	.58	-.05	.50	-.17	.21	-.10 – .44

We further broke down the Recombination into Two-Set Recombinations and Three-Set Recombinations. We conducted a 2 (culture: American, East Asian) x 2 (Recombination type: Two-Set, Three-Set) repeated-measures ANOVA. There was a main effect of Recombination type such that performance on Three-Set Recombinations was higher than for Two-Set Recombinations, $F(1, 66) = 59.34$, $p < .001$, $\eta p^2 = 0.48$. There was no main effect of culture, $F(2, 66) = .02$, $p = 0.98$, $\eta p^2 < .001$, nor an interaction between culture and Recombination type, $F(1, 66) = 2.15$, $p = .15$, $\eta p^2 = 0.03$.

Concrete objects recognition memory task

We also aimed to replicate the pattern of cross-cultural differences seen in prior work using the concrete objects task (Leger & Gutchess, 2021) to support the interpretation of findings from the novel abstract objects task.

Signal detection analyses

We conducted signal detection analyses for the concrete objects task, to determine whether our sample replicates prior findings of cultural differences in discriminability and response bias (Leger & Gutchess, 2021; Paige et al., 2017a, b). Signal detection results, including *d'* discriminability scores and c response criterion scores, are summarized in Table 2. Signal detection analyses were conducted in the same manner as those done for the abstract objects task, with Similar items being analogous to Recombinations.

To determine the effects of culture on memory discriminability we conducted a 2 (culture: Americans, East Asians) x 3 (*d'* type: Target-Foil, Lure-Foil, Target-Lure) repeated-measures ANOVA. There was a significant main effect of *d'* type, $F(2, 66) = 617.24$, $p < .001$, $\eta p^2 = 0.91$. Target-Foil *d'* was higher than both Lure-Foil *d'*, $t(66) = 17.77$, $p < .001$, Cohen's $d = 2.17$, and Target-Lure *d'*, $t(66) = 25.10$, $p < .001$, Cohen's $d = 3.07$. There was no significant main effect of culture, $F(1, 66) = 2.12$, $p = .15$, $\eta p^2 = 0.03$, nor a significant interaction between culture and test condition, $F(2, 66) = 2.64$, $p = .08$, $\eta p^2 = 0.04$.

We also analyzed the *c* response bias measure for each of the pairwise discrimination types. As with the abstract object response bias analyses, these concrete object response bias analyses were exploratory and were not included in the pre-registration for this study. To determine the effects of culture on response bias we conducted a 2 (culture: Americans,

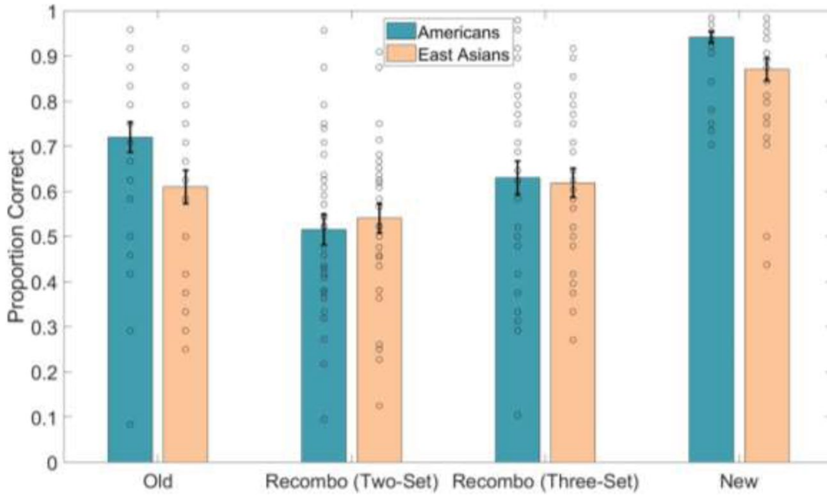

Fig. 4 Proportion correct for each abstract object test item condition. Performance for Americans and East Asians are plotted separately. There was a significant main effect for culture such that, collapsing across conditions, Americans had higher proportion correct than East Asians. Error bars represent standard error of the mean between subjects

East Asians) x 3 (*c* type: Target-Foil, Lure-Foil, Target-Lure) repeated-measures ANOVA. There was a main effect of *c* type, $F(1, 66) = 629.15$, $p < .001$, $\eta p^2 = 0.91$. Target-Lure *c* was significantly lower (reflecting a bias toward "old") than Target-Foil c, $t(66) = 25.10$, $p < .001$, Cohen's $d = 3.07$, and Lure-Foil c, $t(66) = 28.03$, $p < .001$, Cohen's $d = 3.43$. There was a main effect of culture, $F(1, 66) = 6.35$, $p = .01$, $\eta p^2 = 0.09$. Americans had lower *c* values collapsing across conditions ($M = 0.20$), reflecting a less conservative usage of the "old" response than East Asians ($M = 0.40$). There was no significant interaction between culture and *c* type, $F(2, 66) = 2.27$, $p = .11$, $\eta p^2 = 0.03$.

Proportion correct

The proportion of correct responses for each condition is summarized for each culture group in Table 2. Proportion correct across conditions was analyzed using a 2 (culture: American, East Asian) x 3 (test condition: Old, Similar, New) repeated-measures ANOVA. There was a significant main effect of test condition, $F(2, 66) = 125.77$, $p < .001$, $\eta p^2 = 0.66$. Performance for New items was significantly higher than for both the Old items, $t(66) = 5.20$, $p < .001$, Cohen's $d = 0.64$, and Similar items, $t(66) = 18.83$, $p < .001$, Cohen's $d = 2.30$. There was no significant main effect of culture, $F(1, 66) = 0.81$, $p = .37$, $\eta p^2 = 0.01$, but there was a significant interaction between culture and test condition, $F(2, 66) = 4.25$, $p = .02$, $\eta p^2 = 0.06$. Simple effects comparisons indicated that Americans' proportion correct for Old items was higher than the East Asians' by 0.10 (p = .02, 95% CI of the difference = 0.02 to 0.18). In contrast, Americans' proportion correct did not differ from East Asians' for Similar (p = .45) or New (p = .32) items.

Supplemental analyses

We conducted additional analyses to determine the appropriateness of including any covariates in abstract object task analyses. Results of correlation analyses for abstract object *d'* values with concrete object Target-Lure *d'* and speed of processing scores are shown in OSM Table 1. Results of a linear regression model with Target-Lure *d'* as the outcome variable and culture, concrete object Target-Lure *d'*, and speed of processing as predictor variables are shown in OSM Table 2. Though we determined that including additional covariates in the primary analyses would not be appropriate, the supplemental linear regression analyses support our findings that the memory differences across cultures is apparent in both abstract and concrete object tasks.

Table 2 Proportion correct and signal detection values for the concrete objects task

Measure	Americans		East Asians	
	M	SD	M	SD
Proportion correct				
Old	.89	.09	.79	.22
Similar	.56	.16	.59	.14
New	.94	.10	.96	.03
Discriminability (*d'*)				
Target-Foil	3.07	.78	2.76	.92
Target-Lure	1.48	.57	1.18	.63
Lure-Foil	1.58	.53	1.59	.50
Response criterion (*c*)				
Target-Foil	.22	.28	.47	.38
Target-Lure	-.57	.32	-.32	.54
Lure-Foil	.96	.39	1.06	.32

Discussion

The aim of this experiment was to determine whether previously observed cross-cultural differences in memory specificity were driven by culture-specific preferences for holistic versus atomistic properties of stimuli (i.e., conjunctive relationships or individual features). We hypothesized that East Asians would have higher performance on a task where attention to conjunctive relationships is advantageous. This result would have indicated that previously observed patterns of memory specificity differences were in fact driven by Americans' preferential attention to and memory for low-level perceptual details (individual features) that distinguish studied items from similar lures, rather than greater memory specificity across high-level stimulus properties. Our results do not support this hypothesis. Instead, they suggest that cross-cultural differences in object memory are driven by Americans' tendency to successfully recognize previously seen items at a higher level than East Asians, regardless of stimulus type (e.g., abstract vs. concrete), and regardless of the complexity of stimulus representation (e.g., feature vs. conjunction) that best distinguishes the items. This finding is novel in illustrating that the cultural differences in memory occur for the conjunctions of low-level perceptual features, in addition to the features themselves.

Our main results of interest were cross-cultural comparisons of object memory performance using a signal detection approach for the abstract objects task. We predicted that East Asians would have higher performance on this task – specifically, on Target-Lure mnemonic discriminations that require memory for conjunctions – compared to Americans, suggesting that cross-cultural memory specificity differences are driven by each group's attention to different levels of the visual hierarchy. The pattern of group differences in memory performance would therefore depend upon which level of the visual hierarchy is most critical to task demands (i.e., East Asians performing better for the abstract objects task where attention to conjunctions is advantageous; Americans better on the concrete objects task where attention to features is advantageous). However, our findings did not support this hypothesis. Across test item conditions, Americans' proportion correct and discriminability for the abstract objects task was significantly higher than East Asians'. Proportion correct measures allow us to investigate cultural differences in performance for each test condition (with the caveat that response bias may influence results, in addition to memory); our results showed that, across test conditions, Americans demonstrated higher performance that East Asians. However, our primary measure of interest was memory discriminability, which factors out response bias and represents memory sensitivity when discriminating between different test item conditions. Americans had higher *d'* scores than East Asians in all conditions. This difference was most pronounced for the discriminability between Old and New items, aligning with both prior work and the present concrete objects results, suggesting that memory differences are not specific to discriminability between old and similar items, but rather, they reflect a difference in mnemonic discrimination that is consistent across stimulus representation levels. That is, the different *d'* types (Target-Foil, Target-Lure, and Lure-Foil) in the abstract object task can be interpreted as measuring memory for different levels of stimulus representation. Target-Lure discriminations rely on "conjunction memory" because the stimulus items differ in familiarity only in terms of their conjunctions (all features of both stimulus types are familiar, but Target conjunctions are familiar while Lure conjunctions are novel); Lure-Foil discriminations rely on "feature memory" because the stimuli differ in familiarity only in their features (the conjunctions of both stimulus types are novel, but features of Lures are familiar while features of Foils are novel); Target-Foil discriminations measure both conjunction and feature memory combined, because both types of memory can aid discrimination. As such, the greater mnemonic discrimination scores by Americans for all *d'* types point to stronger object memory regardless of discrimination type.

Our results breaking down different Recombination types also align with this interpretation. We had predicted that East Asians would have especially greater performance than Americans on the Three-Set Recombinations. This result would have suggested East Asians are better able to use judgment of Recombinations to overcome feature-level interference. However, there was no significant interaction between culture and Recombination type. This is in line with our overall interpretation that cross-cultural object memory differences are generally influenced by memory for all discrimination types, rather than differential attention to features or conjunctions.

Response bias analyses for the abstract objects task also point to cultural differences in criterion for determining whether an item is old. There was a significant cross-cultural difference in *c* value for Lure-Foil discrimination. Though both test conditions comprising this measure are technically "new," this score represents the criterion for discriminating between new items that should hold some familiarity (Recombination lures) versus completely novel items (new foils). While there was no group difference for frequency of responding "old" to Recombination items, East Asians were more likely than Americans to respond "old" to New items. This indicates that, at least in one comparison condition, East Asians have a more lenient threshold for declaring abstract objects old. We note, however, that response bias results should be interpreted with caution because the signal detection analysis assumed equal variance of Targets and Lures, and yet, in this dataset, this assumption was likely to be violated (see Mickes et al., 2007).

In order to have a more complete understanding of cultural differences across different stimulus types, we replicated prior work with concrete objects in the same participants that completed the abstract memory task. Results from this task suggest that cross-cultural differences in object recognition are driven by differences in memory responses for Old items, which may reflect differences in memory representations or differences in the criterion for calling objects "old." Americans, compared to East Asians, had higher proportion correct for Old items, while there was no such difference in the other test conditions (but we note that false alarm rates for New items were close to floor in both groups, potentially making any difference difficult to detect, and that, numerically, Americans were more likely to call New items "old" than East Asians). In the present study, the interaction between *d'* and culture was non-significant. The fact that participants in the present study completed the concrete objects memory task after completing the similar abstract objects memory task may have reduced the strength of effects compared to prior studies (e.g., Leger & Gutchess, 2021; Millar et al, 2013; Paige et al., 2017a, b). That is, having already undergone a memory test, participants may have anticipated another test during encoding of concrete objects. Although the concern of sequential and practice effects limits our ability to interpret the concrete object task results, our chosen task order ensures the main abstract objects task is not affected by such issues. By examining previously reported findings while also addressing novel questions about culture and object memory specificity, the present study contributes to further understanding how task and stimulus factors influence culture effects. However, future work is needed to further assess the robustness of culture effects in object mnemonic discrimination.

Response bias analyses indicate that, for concrete objects, Americans have a more lenient threshold for determining an item to be Old. This criterion difference is consistent with prior work using similar concrete object memory paradigms and cross-cultural samples (Leger & Gutchess, 2021; Paige et al., 2017a, b). It is notable that this pattern differs from findings from the abstract objects task, in which there was a trend towards East Asians using a more lenient threshold than Americans for Lure-Foil discriminations. This divergence suggests stimulus type (i.e., concrete or abstract) and critical stimulus properties (i.e., features or conjunctions) may interact with culture in determining the response criterion for deeming information to be old. We again also note that our ability to interpret response bias findings is limited by likely inequality of variance between targets and lures.

Results of this study suggest that cultural differences in object memory are driven by a general mechanism that impacts recognition for both features themselves and their conjunctive relationships. It may be the case that the perceptual details are of higher resolution for Americans than East Asians and therefore support more accurate memory judgments at retrieval. A limitation of the concrete objects task is that the stimuli are not precisely controlled for the extent to which studied and lure objects share features. While we assume that feature-level discriminability is critical for these objects as they share semantic labels, future studies should employ stimuli which more explicitly control for the extent to which task success depends on feature-level discriminations. Retrieval monitoring processes may also contribute to cross-cultural differences; this possibility would align with our interpretation that a mechanism agnostic to different stimulus types is driving object memory differences. Response bias results, which show differences across cultures in each task, suggest cultures may also differ in decision-making strategies when making old/new determinations. Future studies are needed to investigate the extent to which encoding resolution and/or higher-order cognitive processes play a role in cross-cultural object memory differences. It is critical that, just as we have done in this present study, future work looking at the role of retrieval monitoring and decision-making also tests whether patterns of results are generalizable across different stimuli and task demands.

This experiment, using a variety of stimulus properties and task structures, represents an important advance in our understanding of cross-cultural memory differences. By testing cultural differences in two distinct tasks, we have greater confidence that object memory differences reflect divergence in the stimulus details that cultural groups remember, rather than effects induced by culturally-biased stimuli. Although our hypothesis that East Asians, compared to Americans, would have higher levels of memory performance for conjunctions was not supported, our results are still informative in that they suggest the mechanism underlying Americans' higher levels of memory specificity persists across different levels of the visual hierarchy. The results of the present study inform future work concerned with identifying the mechanism(s) underlying cultural differences in memory. As the field of cross-cultural psychology continues to grow, we emphasize the need to investigate whether theorized differences manifest in cognitive domains such as memory, attention, and perception. It is especially critical to also examine the extent to which cross-cultural differences in these domains interact with and influence each other. In doing so, we will gain a more accurately nuanced picture of how one's culture influences how we perceive, think about, and remember the world around us.

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Authors' contributions A.G. and K.L. conceived of the presented ideas and further developed the theory. R.C. and K.L. conceived of the abstract objects recognition task experimental paradigm and oversaw stimuli creation and piloting. 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. and R.C.

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Data availability Dataset, materials, and pre-registration for this study are available on the Open Science Framework project page for this study (https://osf.io/a4mfq).

Code availability Not applicable.

Declarations

Conflicts of interest The authors have no conflicts of interest to report.

Ethics approval All study procedures, consent forms, and stimuli were approved by the Brandeis University Institutional Review Board. This study was performed in line with the principles of the Declaration of Helsinki.

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent for publication Participants signed informed consent for publishing their de-identified and aggregated data.

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